DIGITAL AT WORK

Snapshots from the first thirty-five years

Edited by
Jamie Parker Pearson

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digital

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Foreword

The job of a leader is to be sure every task is assigned, budgeted and scheduled. Those tasks which no one else is going to do, the leader must do. He must never claim credit for them, he is supposed to be getting everybody else to work, and if you pick up some of the pieces, you should never brag about it.

When people are tempted to brag about what they did, I tell them a fable that used to be in *The Second Grade Reader,* called "The Turtle that Wanted to Fly." A turtle talked some crows into putting a stick between their mouths. He then held onto the center of the stick with his mouth and flew with them. Once, someone on the ground said, "That's a clever idea. Who thought of it?" The turtle couldn't keep his mouth shut, and had to say, "It was me."

My advice to people who want to be leaders is, the task of a leader is not to claim credit, but to be the leader and get the job done.

This is a book about Digital, written by some people who have worked at Digital and gotten the job done. There are many others.

— Ken Olsen
April 1992

Preface

This is a book about many people, written by many people.

When we discussed the idea of a book about Digital, it seemed that the best and most honest way to show what working at Digital was like would be to let people tell their own stories, in their own words.

This is not a formal history, a systematic account, or a comprehensive analysis. Elements of analysis are here, and the raw material of history. Words and remembrances provide insight into Digital's culture and help to explain how it became the company it is today. We conducted more than three hundred interviews for this book. Some people were close at hand, still working at Digital. Others were several careers away. All, regardless of their roles, knew personally what it is to work at Digital. We gathered far more material than we could possibly use, and found that many people remembered different things, differently. Yet they all talked about the same things, many having shared common experiences. We hope it presents a candid picture of Digital's working environment.

In developing what may be considered the first volume, we felt there were some separate areas of the story worth researching: the roots of the company, the development of the style of interactive computing, the initial contact with customers and the early days of sales and service, how we have manufactured over the years, our engineering philosophy, and how the company is organized and how it operates.

At the beginning of each part of the book is an illustrated section, providing a visual history of the product and business milestones of the period. Part I covers the period from the 1950s through the introduction of Digital's first computer, the PDP-1, in 1960. Part II spans the growth years, from the mid-1960s through the late 1980s, introducing the PDP-11 and the VAX family of systems. Part III looks at the development and internal use of Digital's family of networking products, linking the use of the network to the dynamic operating environment.

I am grateful to many people who supported this effort. It has offered me a rare opportunity to look closely at Digital. In particular, I would like to thank Ken Olsen, Win Hindle, and John Sims. For their roles as advisors and sounding boards, I would like to acknowledge Henry Crouse, Russ Doane, Gary Eichhorn, Jim Fleming, Peter Jancourtz, Ann Jenkins, Ted Johnson, Peter Kaufmann, Dallas Kirk, Bob Kucharavy, Randy Levine, Linda Lindgren, Al Mullin, Richard Seltzer, Geoff Shingles, Tom Siekman, and Ron Smart, who reviewed drafts and ideas, offering insight and advice.

The collective creativity of the team who produced this effort was extraordinary. For the writing, I would like to acknowledge the late Bob Hofmann, Bob Lindgren, Bob Lynch, and Patrick Pierce, who weaved together many people's words and provided the chapters. Patti Polisar and Patrick Murphy were careful and ruthless editors. Janice Moore and Laraine Armenti collaborated on the design, providing an elegant format for the words and pictures. Mark Sniffen handled print production, keeping us honest with our budget. Two students from WPI, Ken Spark and Aran Anderson, provided the glossary, a valuable source for readers. Digital Press provided editorial advice and publishing experience.

Through the efforts of many people who generously shared in this telling emerges a mosaic of hundreds of points of view. I would like to thank all concerned. By knowing the past, we gain an understanding of the present, and a basis for moving into the future.

— Jamie Parker Pearson
April 1992

Contents

Part I

Digital's Beginnings

An icon of interactive computing: Spacewar!, developed in 1960 by Steve Russell, J.M. Graetz, and Wayne Wiitanen of MIT, and played on Digital's PDP-1.

Massachusetts Institute of Technology, Cambridge, Massachusetts

1 Foundations of Interactive Computing

It was 1950, the beginning of the transistor revolution. Only four years earlier the first electronic digital computer had been unveiled at the University of Pennsylvania. To calculate artillery-aiming tables for the U.S. Army, ENIAC, also known as "the electronic brain," manipulated decimal rather than binary numbers. The actual storing of programs was still a long way off.

Earlier, from British universities in Manchester and Cambridge came the Williams tube, which made random access memory practical, while from Bell Labs in New Jersey came the point-contact transistor that forever changed electronics and computer design.

The magnetic drum soon offered greater storage capacity than delay lines and Williams tubes, and the first short programs, called subroutines, were stored on punched paper tape on the EDSAC computer. By 1951, UNIVAC was used to predict U.S. presidential results, and the junction transistor replaced vacuum tubes and revolutionized electronics.

When Digital opened its doors, computers were a mystery to the general public—a steel-cased UNIVAC that dwarfed Walter Cronkite on the evening news. For years they remained a mystery to all but a corps of specialists who could operate them. Even scientists who spoke of approaching one directly were eyed with suspicion.

But the engineers who formed Digital were among those who saw it differently. If you could make these machines approachable, it would make the difference between a diatribe and a conversation.

Fortune magazine's report in the late 1950s that no money was to be made in computers suggested the word itself be avoided in Digital's first business plan. No mention was made of modules, a staple of electronics manufacturing and the building blocks of computers of the day. So Digital began with a plan it could back with confidence, to produce modules until the new venture turned a profit. At that moment, the new company would begin putting its proven commodity into the riskier business of manufacturing interactive computers.

In 1959, Digital hired a young hardware engineer named Ben Gurley to design the company's first computer. Three and a half months later, the prototype of Digital's first Program Data Processor, the PDP-1 system, was complete. "Kind of spectacular" is how Ed Fredkin—an engineering master in his own right who bought the first PDP-1—describes this achievement.

The PDP-1 reflected the MIT tradition, with system modules patterned directly after the circuits of Lincoln Laboratory's TX-0 and TX-2, two of the earliest transistorized computers.

Specifications

Whirlwind

Operational
1950

Word Length
16 bits

Speed
16 microseconds, maximum

Primary Memory
2K word addressable core

Secondary Memory
Revolving drums, tapes

Instruction Set
32 instructions

Input/Output
I/O initiation and
completion testing by bits

Size
50′ × 50′ × 20′

Software
Assembly/machine language
Programmed primarily in OCTAL

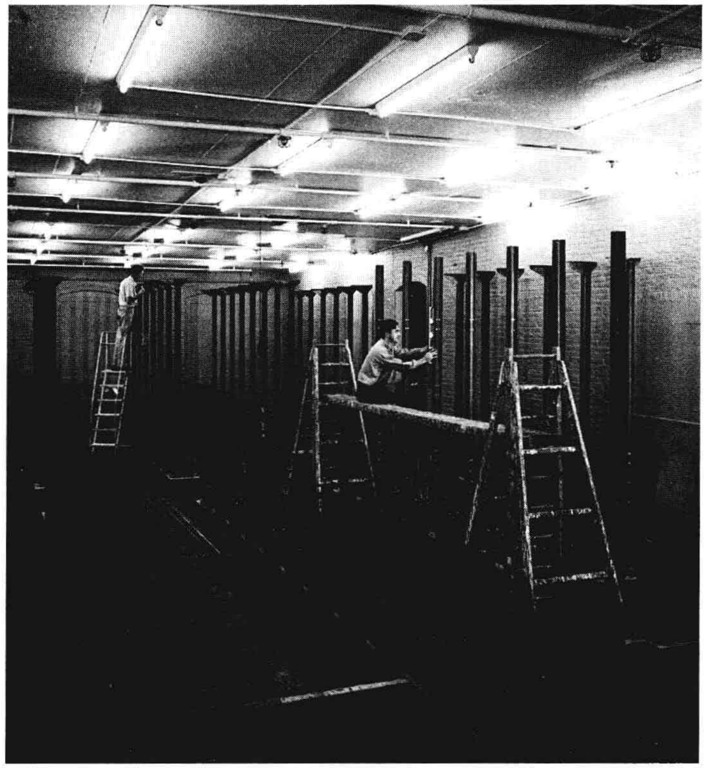
Number Produced
1, originally at MIT's
Digital Computer Laboratory

Architecture
Fixed word machine

Technology
First generation
15,000 vacuum tubes

Power
150,000 watts

History
Begun in 1947,
completed in 1957



Computer room construction

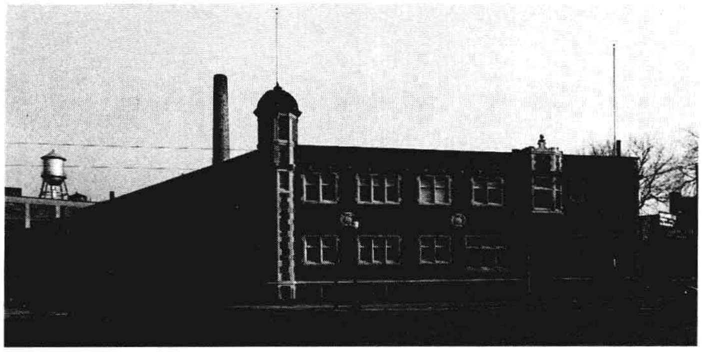
MIT and the Whirlwind Tradition

The Whirlwind project, initiated at MIT in 1944 to develop a simulator to help train naval flight crews, progressed far beyond its original goals. By 1953, the design team, led by Jay Forrester and Robert Everett, had built a high-speed digital computer to control an air defense system.

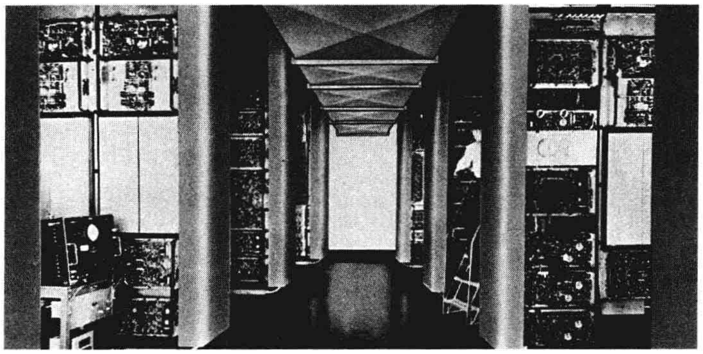
The Whirlwind computer occupied 2,500 square feet on the second floor of MIT's Barta Building. So great was this computer's appetite for electrical power that when it was turned on, the lights in Cambridge were said to have dimmed.

Whirlwind was the first large-scale, real-time control system. From early work tracking aircraft by digital computer, an experimental Cape Cod system linked a network of 16 radar sites. Each site could feed data to and interact simultaneously with the Whirlwind as the control element. The Whirlwind computer was one of the first practical applications of time-sharing and originated techniques that were incorporated into the SAGE (Semi-Automatic Ground Environment) air defense system.

Few on the Whirlwind project team could have guessed that their efforts would help transform the computer from a highly specialized scientific instrument to a tool as practical and popular as the typewriter.



The Barta Building at MIT



The computer room in 1952

Jay Forrester with magnetic core memory

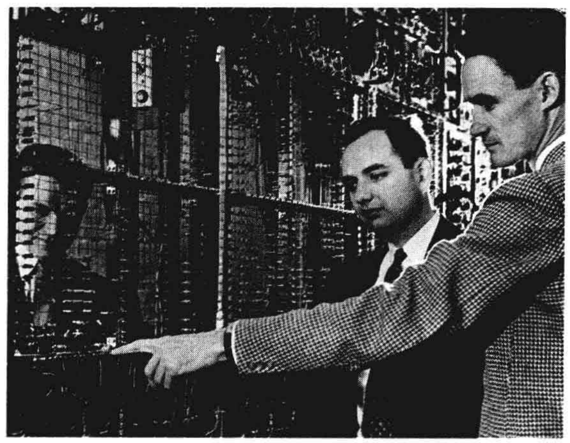
Storing Information

For primary storage, some early computers relied on magnetic core memory. Each tiny doughnut-shaped core could store one bit, or unit, of information. Storing large amounts of information required thousands of cores, which took up considerable space in the system. To store 12,000 characters of information, for example, a system needed 96,000 cores: 8 for each character, or byte, of information.

The expense of production was not in the cores themselves but in the labor required to manufacture the complete memory. Cores were strung together on fine wire by hand and mounted on a frame or board. By 1974, core memory would be replaced by the semiconductor chip.

Whirlwind pioneered the use of electronic core memory. The first bank of core storage—with a capacity of 2,048 words—was wired-in in August of 1953. The two banks that were ultimately added gave Whirlwind a total of 6K words of memory.

The invention of core memory is credited to Jay Forrester. Faster and more reliable than other memory devices of the time—mercury delay lines, electrostatic tubes, and rotating magnetic drums—magnetic cores reduced access time on the Whirlwind from 25 microseconds (with tube storage) to 9 microseconds.



Norman Taylor (behind panel), Bob Everett, and J.A. O'Brien at the Whirlwind control matrix

Specifications

TX-0

Lincoln Test-Experimental
Computer Model 0

Operational
1957

Word Length
18 bits

Speed
83,000 additions/second
Programmed multiply and divide

Primary Memory
64K word magnetic core memory
Additional parity bit
6 microseconds read-rewrite time

Instruction Set
3 addressable instructions
1 programmable instruction

Input
250 lines/second photo reader;
manual Flexowriter and toggle switch

Output
10 characters/second Flexowriter;
CRT display

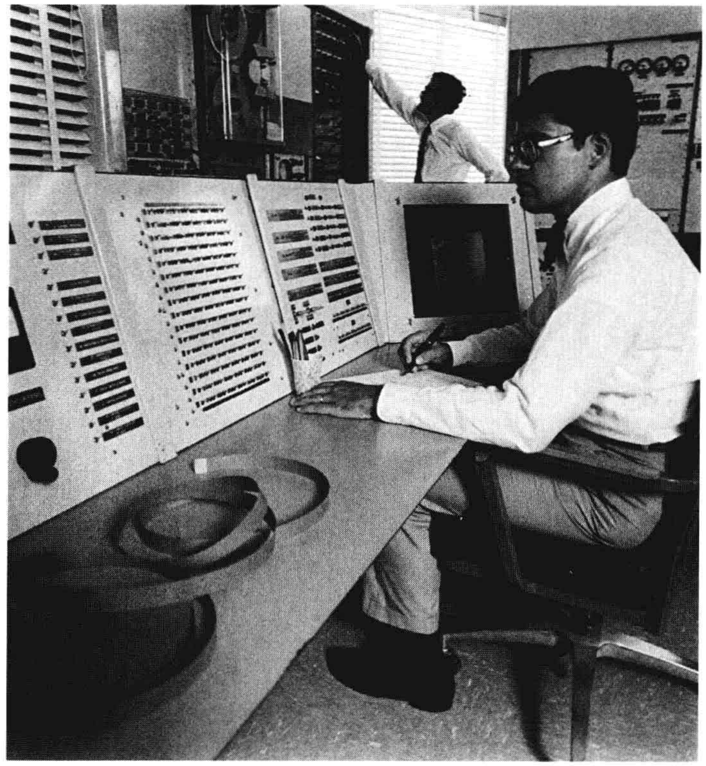
Size
200 square feet

Number Produced
1, originally installed at Lincoln Laboratory

Technology
3,500 Philco L-5122
surface-barrier transistors

Power
1,000 watts

History
An experimental digital computer
used to test advanced design techniques,
including very large core storage
and transistor circuitry



TX-0 operator's console

Whirlwind's Descendants

The TX-0 and the TX-2 computers were among the most advanced machines of their time. Developed at MIT's Lincoln Laboratory government-sponsored research center in Lexington, Massachusetts, by members of the Whirlwind team, the TX-0 was designed to verify the feasibility of building a 64K word core memory and to test a new type of transistor circuitry. Although the Philco SBT100 surface-barrier transistors were expensive at $80 each, they simplified transistor circuit design significantly.

The TX-0 was followed by the large-scale 36-bit TX-2 computer. The short word length, high-speed operation and interactive features of Whirlwind and both TX-0 computers greatly influenced early minicomputer design at Digital. When they joined Digital in the early 1960s, some of the engineers and programmers who had built these systems brought with them the lessons they learned.

TX-0 programmers with Gordon Bell (center)

Testing Memory

The Memory Test Computer, known as Ken Olsen's first computer, was designed to test Whirlwind's newly invented core memory.

> I was given the job of building the computer just as soon as my thesis was done. It cost a million dollars. I remember being impressed at how much work it took to spend a million dollars. Now I'm impressed at how little effort it takes to spend a million dollars. My way of showing off was to build it in a room in a straight row of racks with a console in front of it, with enough room for the photographer to stand back and take pictures of it. We naively showed off by saying, "Look how easy it is." That's kind of the young academic approach. The first night it ran, my wife was out of town. We stayed late in the lab. Everybody else went home. I stayed there and listened to it work. We put a loudspeaker on every computer we built because you always wanted to be able to play music or do other things. I had the computer on the loudspeaker, and as long as the tone was constant I knew it was working. So I went in the ladies lounge and lay down on the sofa with the door open and fell asleep with my ear tuned to that sound, so I knew it went all night long without a glitch. That was a significant test.
>
> — Ken Olsen

A Machine That Matched the Characteristics of a PC Today

When I was given the opportunity to work on a transistor computer, the idea was new and exciting. The rules were I could hire no one and have no space. I found all the loopholes. I somehow was able to get three or four people to work with me. We discovered that the hallway was not considered space, so we moved my office into the hall and put walls around it. We then traded that space for space in the basement which was less desirable but bigger. With that we were able to do our work. We asked for additional light, brightly colored walls, and a new floor. Then we set out to make a computer that would attract attention. Our experience with the Memory Test Computer told us that blah-looking computers never attract attention. So we set out to make as modern a design as we could. It had rakish lines, like race cars were supposed to have. We picked a color that was opposite the traditional black wrinkle finish from World War II. Brown and beige seemed like a dramatic change. It turned out to be the place where the laboratory brought visitors.

The cathode ray tube was automatically built into the computer. We used the light pen, which is the equivalent of today's mouse. We used Japanese model-railroad lamp bulbs, one for every flip flop. We joked that we probably confused the industry watchers there with that order! The circuitry in this computer was built around the Philco surface-barrier transistor, a magnificent piece of design. It was very expensive but very fast, very intolerant of power or spark or discharge.

The TX-0 was designed to be a demonstration of the reliability and the capability of transistor circuitry, and making a fast, inexpensive, low-powered computer. It really could do what a personal computer does today, limited only by the fact that the memory was small. You could draw pictures on the cathode ray tube, read your program in, take it home, play games—all the things you can do today.

— Ken Olsen
Smithsonian Interview
September 1988

General Doriot (left) with Ken Olsen

"Ken Olsen had a product that he could make the next day and that was important. But Ken also had a view of the future. He had a family of products in mind. Ken was taking a risk, but it was a thought-out risk, the kind of risk I favor. I was impressed Ken had the ability to sense the evolution of the market. He redeveloped or reinvented products in some cases, always following the market. Ken had the desire to do something useful, constructive, and imaginative."

— General Georges Doriot

"The Kind of Risk I Favor"

Georges Doriot (known as "General" since his tour of duty in the French army) headed one of the first venture capital firms in America, American Research and Development (AR&D), which helped launch 150 companies. In the course of 35 years on the Harvard Business School faculty, he taught his students as much about the value of ethics and integrity in business as about industrial management.

To Digital, he is best known as the man who, in 1957, loaned Digital President Ken Olsen $70,000 to launch a new company.

General Doriot often told a story about three men who were breaking stones. When asked what he was doing, one said he was breaking stones, the second said he was making a living. The third said he was building a cathedral. It was people like the third man, individuals with a dream, whose companies he prized.

The Manufacturing course General Doriot taught at Harvard was an inspiration to thousands of students who became successful business leaders. William McLean, Philip Caldwell, and Arnaud de Vitry, among them, were later to join Digital's Board of Directors.

AR&D advised on the selection of directors of the newly incorporated company. Seated left to right at an early board meeting are: Harry Hoagland, Jack Barnard, Jay Forrester, Bill Congleton, Harlan Anderson, Ken Olsen, Dorothy Rowe, Vernon Alden, Arnaud de Vitry, and Wayne Brobeck.

Digital's Board Members Pay Tribute

"Whatever a problem needed [General Doriot] would give day and night. He expected the same of his students. He brought the practical side of his life to the classroom, interpreted not just in terms of the individual company, but in how you live, how you work, how you serve your company. His was a commonsense message about the world, stressing many old-fashioned, simple virtues, such as frugality, willingness to stand up and be counted, courage and innovation."

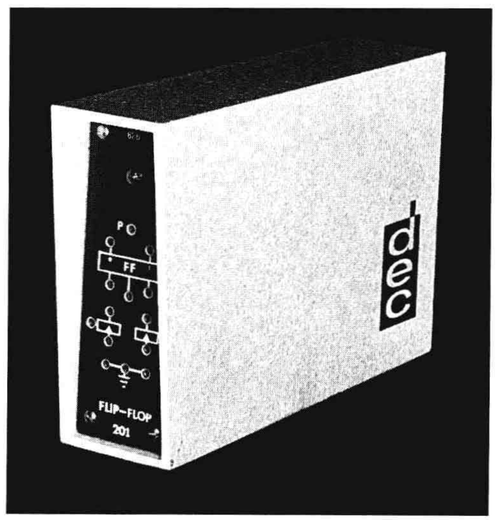
— William McLean

"Sometimes you wonder what lessons you learned from your professors. It would be fair to say that the course we took was manufacturing. What we learned was philosophy."

— Philip Caldwell

"General Doriot felt it was important for [the wives] to understand that their husbands should work very, very hard, but never take themselves too seriously. Even if they were to become wealthy it should be a by-product of doing good work. One should never be proud of earning money, but of doing good work."

— Arnaud de Vitry



First product: laboratory module

Kenneth H. Olsen
Resume of Experience

I am 31 years old and have a B.S. and M.S. from MIT in electrical engineering. For 12 months I attended the U.S. Navy radar school and had somewhat less than a year's experience in the fleet. Before that I studied machine shop practice and worked in a tool shop.

. . . for seven years I have worked at MIT Lincoln Lab. My M.S. thesis resulted in the first demonstration of a magnetic core memory. The circuits and techniques developed during this thesis are now commonly used in most large digital computers.

For 13 months I was in residence at IBM as the MIT representative and the Air Force quality-control engineer during the manufacture of the first SAGE computer. Here I had the opportunity to observe the production and organizational techniques of a large well-run company.

. . . in 1955 I organized a group to develop and build computers using the then-new Philco surface-barrier transistors. In just over two years, we developed a complete set of circuits and packaging techniques with which we have completed one computer and have well under way a computer that for some time will be the world's most capable computer.

Ken Olsen (left) with Harlan Anderson

A Proposal to American Research and Development from Digital Computer Corporation

On May 27, 1957, the objective of Digital Computer Corporation was to manufacture and sell electronic test equipment and high-speed electronic digital computers. Emphasis was placed on developing products that could be general purpose and would have a wide variety of applications.

American Research and Development directors cautioned that the "exceedingly active" field of digital computing would see "substantial competition develop in the future . . . successful survival will depend upon outstanding creative technological competence, an aggressive sales effort, high-quality precision manufacturing, and adequate financial support." AR&D's grant of a quarter-million dollars backed their confidence in the formation of a "speculative and daring" undertaking.

As outlined in Ken Olsen's and Harlan Anderson's proposal, the plans for starting Digital Computer Corporation were divided into two phases. The primary goal of Phase I was to design, produce, and sell transistorized digital test equipment. The secondary goal was to design on paper the general-purpose computer that would be built in Phase II and to obtain military study contracts that would lead to procurement of this type of equipment. Phase II would be entered after the test-equipment business was operating at a profit, or a firm purchase order for a general-purpose computer had been obtained.