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Fire in the Valley, Third Edition

The Birth and Death of the Personal Computer

The Pragmatic Bookshelf

Dallas, Texas • Raleigh, North Carolina

The Pragmatic Programmers

*"If you're going to read one history book this decade, **read this one**."*
— John Perry Barlow, co-founder, Electronic Frontier Foundation

Third Edition

Fire in the Valley

The Birth and Death of the Personal Computer

Michael Swaine and Paul Freiberger

Foreword by John Markoff, *The New York Times*

Edited by Brian P. Hogan

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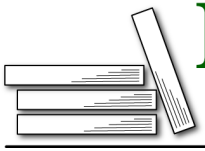

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Going for Broke

> *Why don't you call it Altair? That's where the Enterprise is going tonight.*
> –Lauren Solomon, daughter of *Popular Electronics* editor Les Solomon (like other Solomon stories, possibly apocryphal)

Ed Roberts made a decision of his own that spring—he was going to build a kit computer. He had been toying with the idea for some time only to find that by early 1974 the chips, so to speak, were down. MITS's calculator business had blown away like desert sand, leaving the company heavily in debt. Faced with the likelihood of going under, Roberts decided to go for broke. He would build a product that had essentially no precedent or defined market, a product most people considered fanciful at best. But the specter of bankruptcy only gave urgency to his decision. Roberts always cared more about technological challenges than about any business risks they presented. He would have gone ahead with the kit computer under any circumstances.

Les Solomon Flies to Albuquerque

Roberts studied Intel's chips—the early 4004, the 8008, and a third Intel product called the 4040—and rejected the 4004 and 4040 as too crude. He was considering building a machine around the 8008, until a programmer told him that he had tried to implement the BASIC programming language on the 8008 and had found it to be an excruciating process. The 8008 carried out the BASIC instructions far too slowly to be useful.

Then a new product caught Roberts's eye: the Intel 8080. By this time, Motorola also marketed a microprocessor, the 6800, and Texas Instruments and other companies had similar products. But Roberts had studied the chips carefully and concluded that the 8080 was technically superior to the 6800. It had another even more significant advantage.

Intel normally charged $360 for an 8080, but Roberts got the company to knock the price down to $75. It was unheard of: nobody else was getting that price, but for a very good reason. The Intel contract required him to buy in volume, and each computer needed only one processor. He'd be committing to a business model that would require him to sell a lot of computers.

That was fine with Roberts. After the calculator fiasco, which Roberts said was "something you don't want to go through twice in a lifetime," his operation was geared up to sell plenty of product—which he would need to do to salvage the company. He was going to have to think big or give it up entirely.

Meanwhile, *Popular Electronics* was narrowing its search for a computer project it could publicize. "We got in a bunch of computers," Art Salsberg recalled. "We wound up with two models and decided it was going to be a choice of one or the other. One amounted to no more than a promise. The promise was, I can get the chips at a lower price and make this whole thing feasible. That was from Ed Roberts. The other choice was a microcomputer trainer by Jerry Ogdin." The model from Ogdin was actually more a tool for learning about computers than an actual computer.

Roberts offered only a concept, whereas Ogdin's device actually existed and Salsberg and Solomon had seen it. They were both inclined to support a tangible machine over the mere promise of one, even though Ogdin's machine was built around the 8008 chip, which was about to be phased out. "It looked like it was a go with the microcomputer trainer," Salsberg said.

Then the July 1974 *Radio-Electronics* hit the newsstands with an article by Jonathan Titus on building an Intel 8008–based computer called the Mark-8. The article generated a lot of excitement among hobbyists, even if not a lot of orders. The editors at *Popular Electronics* realized immediately that this put a crimp in their plans. On reading the *Radio-Electronics* article, Salsberg announced, "That kills the trainer." Solomon agreed: Ogdin's trainer was just too similar to the Mark-8. *Popular Electronics* had to up the ante. An article on an 8080-based microcomputer would do just that.

Solomon promptly flew to Albuquerque to meet with Roberts and work out the details. Salsberg wanted the computer packaged like a serious commercial product. Roberts spent many late nights hashing out the exact components of a desktop computer that could sell for under $500.

This presented an enormous challenge. The Mark-8 sold for about twice that price, and when you added up the cost of the components that any computer needed, it was hard to get the price much lower. But Roberts did have the advantage of the volume pricing from Intel.

In the end, Roberts promised to meet the price and to deliver the first machine to *Popular Electronics* as soon as it was built, and *Popular Electronics* promised to publish a series of articles on it, including a cover story.

When Salsberg agreed to go with Roberts's machine, he was taking a risk. This was to be the cover story for the issue. If they promoted this computer and it turned out to be a bomb, the magazine would look bad. No one at MITS had ever built a computer before. Roberts had only two engineers on his staff, and one of them had his degree in aeronautical engineering. Roberts had no

prototype and no detailed proposal. But Uncle Sol kept assuring Salsberg that Roberts could deliver the goods. Salsberg hoped he was right.

Roberts was just as edgy about *Popular Electronics*'s promises. However much he liked and respected Les Solomon, he was wary of Solomon's cheerful assurances. And the more he realized how crucial a cover story in *Popular Electronics* was for MITS, the more nervous he became. His company's future was in the hands of a man who levitated tables.

The Mark-8 wasn't the first computer built around the Intel 8008, although Roberts had no way of knowing that. That distinction belongs to the Micral computer, built in 1973 by André Truong Trong Thi, a French Vietnamese entrepreneur. Thi sold 500 of the machines, all in France. Later that year, he demonstrated an 8080-based computer at a major computing conference in the United States. Whatever impact the demonstration had on the engineers and computer scientists who saw it apparently didn't extend much beyond that conference. The same fate could easily befall Roberts's machine.

Designing the Personal Computer

Over the summer of 1974, Roberts had sketched out the machine he wanted. As his ideas took shape, he passed them along to the two guys on his engineering team, Jim Bybe and Bill Yates. A quiet and serious man, Yates worked long hours on the layout of the main circuit board for the machine, planning how each electrical signal would get from one point to another in the computer.

Roberts wanted this computer to be expandable, like a minicomputer. He wanted the user to be able to install other circuit boards for particular functions, such as controlling an I/O device or providing extra memory. Roberts wanted the boards designed to plug easily into the computer, a capability that required not just a socket, but also specific, defined data paths. If different elements of the computer were to reside on physically distinct circuit boards, the boards had to be made to communicate with each other. This communication, in turn, required certain engineering conventions. For instance, one board needed to send information when and where it was expected by another board. Almost by default, a *bus structure* for the computer evolved.

A bus is a channel through which computer data or instructions travel. Typically, a bus is a parallel channel with several different signals passing simultaneously. The MITS computer had 100 separate channels, or paths, and each had to have a stated purpose. Added to that were the physical and electrical constraints that sometimes dictated the design of the layouts. For instance, electrical cross-talk—interference between wires—makes it unwise

to place channels for certain kinds of signals too close together. But Roberts allowed Yates no time to address such niceties of design, because the creditors had already begun to bay. Wherever the data channels fell, that's where they stayed. The bus design did the job, but it wasn't pretty.

While Yates laid out the boards, another MITS employee, technical writer David Bunnell, was casting about for a name for the computer. His favorite of all the candidates was "Little Brother," but he wasn't altogether comfortable with the name. Bunnell wasn't really comfortable with the whole notion of computers, Roberts recalled. But Bunnell kept his skepticism in check, given Roberts's lack of patience with dissent.

Bunnell had been with MITS since 1972. He and Roberts had coauthored articles for *Popular Electronics*, and they were writing a series of tutorials on digital electronics for the magazine at the same time they were toiling in the MITS workshop developing their computer.

Getting Financing

Despite their efforts, it was beginning to look as if the computer was destined to die in the workshop. MITS owed around $300,000 to its creditors. With Les Solomon's constant reminders that the article's deadline was imminent, Roberts made a grim trek to the bank. It was mid-September. He was out of money, needed another loan, and fully expected the bank to turn him down. Given his current credit rating and his depleted assets, he doubted anyone would lend him the $65,000 he needed to keep the company's doors open.

The officers of the bank listened patiently. He was going to build a kit computer? And what exactly was that? And who, did he think, would buy such a product? Electronics hobbyists, sight unseen, from ads in magazines? And how many of these kit computers did he think he could sell in the next year to these electronics hobbyists through advertisements in magazines?

With a straight face, Roberts told them 800. "You won't sell 800," they said, thinking he was being unrealistic. Roberts was indeed fantasizing. Still, the bank officers saw no advantage in bankrupting companies with outstanding loans. The loan officers figured that if Roberts could sell 200 of the things it would help MITS to repay the bank something. They agreed to advance him the $65,000.

Roberts did his best to hide his surprise. He was glad he hadn't mentioned the informal market survey that he had just conducted. Trying to get some sense of how the machine would be received, Roberts described it to some engineers he knew and asked if any of them would buy it. They all said no.

Although Roberts never considered himself a good businessman, he knew instinctively when to ignore market research. He took his $65,000 and, with Yates and Bybe, worked feverishly to complete the prototype to send to *Popular Electronics*. It was going to appear on the cover, so they made sure it looked especially attractive.

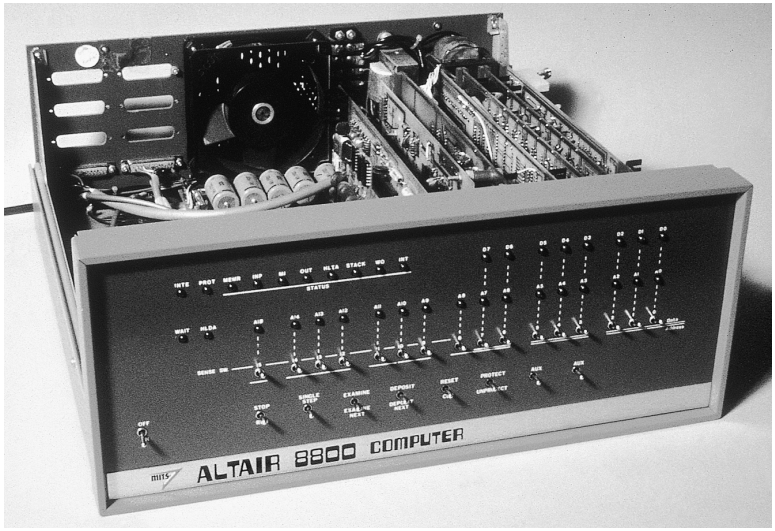
Because Bill Yates was doing most of the design, he worked with Roberts on the article. While Roberts and Yates were scrambling to finish both the computer and the article, they realized they still didn't have a name for their machine. They figured Solomon would put a *Popular Electronics* name on it if they didn't, so they beat him to the punch by calling it the PE-8. It was Roberts's last small hedge against *Popular Electronics*'s scuttling the project. But that wasn't the name by which the machine became famous.

According to Les Solomon, his 12-year-old daughter Lauren was the one who came up with the name that stuck. She was watching an episode of *Star Trek* when her father walked into the room and said, "I need a name for a computer. What's the name of the computer on the *Enterprise*?" Lauren thought for a moment and said, "Computer." Her father didn't think much of that name, so Lauren suggested, "Why don't you call it Altair? That's where the *Enterprise* is going tonight."

Some of Solomon's friends told a different story of the naming, but Altair it was. "I don't give a damn what you call it," Roberts told Solomon. "If we don't sell 200, we're finished." Solomon reassured him that things were going well and selling 200 was entirely possible. Solomon wasn't just being polite and trying to soothe the raw nerves of a man who'd been flayed in the calculator-market crash. He was confident that the Altair had the potential to far outstrip the Mark-8.

The Mark-8 was an experimenter's toy, a way for the engineering hobbyist to learn about computers firsthand. But the Altair was, for all its limitations, a real computer. Its bus structure would make it possible to expand the machine's capabilities by allowing the user to plug in new circuit boards. And the 8080 chip was a far better "brain" than the 8008. The Altair had the potential, at least in miniature, of doing everything a large mainframe computer could do.

Solomon was convinced of it and told Roberts as much. But he didn't voice his concern that the message might not get across to the *Popular Electronics* readers. Art Salsberg told him that *Popular Electronics* had to offer its readers more than just instructions for building the device. To prove that the Altair was a serious computer, *Popular Electronics* had to also offer one solid appli-



The MITS Altair 8800, assembled: *The default input and output for the Altair computer were the switches and lights on the front panel.* (Courtesy of Intel Corp.)

cation, a practical purpose for the Altair that could be demonstrated right away. What that application might be, Solomon had no idea.

Delivering the Goods

The deadline arrived for Roberts to deliver the prototype computer to Solomon. Roberts told him that it was coming by Railway Express, a troubled parcel-shipping service that would cease operations later that year, and to watch for it.

Solomon waited. No computer arrived.

Roberts reassured him that the computer was in the mail and should be arriving any day. Days later, the prototype was still a no-show. Solomon, in turn, tried to reassure Art Salsberg at *Popular Electronics* that the machine was on its way, but now everyone was getting nervous. Roberts flew to New York to demonstrate the prototype, confident that it would arrive by the time he did.

But it didn't. Railway Express had apparently lost their computer. This was a catastrophe, both for MITS and for *Popular Electronics*. The magazine had committed to a cover story, and now it had no computer to put on the cover. For weeks, Roberts had lain awake nights, static buzzing away in his brain. Now he felt that his worrying had been justified. His engineers couldn't pos-

sibly assemble another computer in time to meet the deadline. They were sunk.

Unless, of course, they faked it.

Yates could slap together a box, poke little lights through the holes in the front, and ship it to New York. Les Solomon didn't like the idea. Art Salsberg hated it. Ed Roberts was embarrassed. But when the January 1975 issue of *Popular Electronics* went to press, it featured a flashy cover photo of an empty metal box masquerading as a computer.

Between the time the issue was wrapped up and the time it hit the streets, Solomon finally got his hands on an Altair computer. He immediately set it up at his desk, but the noise from the Teletype machine he was using as an I/O device made him instantly unpopular in the *Popular Electronics* offices. So he took the system home and set it up in his basement. It was there that Roger Melen first saw it.

The day after Roberts and Yates's piece on the Altair appeared, an article came across Solomon's desk that caught his attention. Harry Garland and Roger Melen, the two Stanford graduate students Solomon had once hooked up with Ed Roberts, sent in a description of a digital camera they had designed. The Cyclops, as Garland and Melen called it, reduced an image to a rectangular grid of light and dark squares and provided a low-cost visual system for a digital computer.

In December 1974, coincidentally just before *Popular Electronics*'s Altair issue came out, Roger Melen decided to fly to New York. His trip ultimately led him to Les Solomon's basement.

Melen reminded Uncle Sol of Ed Roberts in a way. Both were well over six feet tall and heavyset, and both were inveterate engineers/hobbyists, but the Air Force–trained Roberts was older and tougher. Melen was quiet and soft-spoken, the product of one of the top engineering schools in the world. Nevertheless, the two would see eye-to-eye, Les thought, chuckling to himself at the unintentional joke. Trying to look nonchalant, he led Melen through his basement to a strange-looking apparatus. "What's that?" Melen asked. "That, sir," Solomon told him, "is a computer."

When Solomon told him what the Altair was and how much it cost, Melen politely demurred. There must have been some mistake. Melen knew for a fact that the microprocessor chip alone cost as much as he claimed this whole computer did. Solomon suppressed a smile and assured him that the price was correct. Roberts was actually going to sell this computer for $397.

Les Solomon's basement: Popular Electronics *technical editor Les Solomon showed the as-yet-unannounced Altair to an astonished Roger Melen in this basement. Here the basement features a Sol-20 and other historic personal computers.* (Courtesy of Les Solomon)

Delighted at Melen's reaction, Solomon picked up the phone, called Roberts in Albuquerque, and checked the price as Melen stood there. Yep, it was still $397.

Melen was stunned. As he and most hobbyists well knew, Intel was charging $360 for the 8080 chip alone. When Melen left New York that day, instead of flying directly back to San Francisco he took a side trip to New Mexico. Melen sensed that something big was happening, and he wanted to be a part of it.

Roberts greeted Melen enthusiastically at the Albuquerque airport that evening and drove him over to MITS. There Melen was in for another surprise: far from being the large company he had expected to see, the MITS office was in a strip mall, wedged in between a massage parlor and a laundromat. The MITS headquarters must have looked as odd to Melen as it did to the suburban shoppers who strolled past its doors that winter.

"It was obviously the skeleton of what used to be a company, because they had lots of equipment around," Melen later recalled. "But they only had, I think, 10 employees at that time. They had been very successful in producing calculators, but that was a fad that had passed. He [Roberts] saw this as his big chance for success—his second shot to pull him out of his predicament."

Melen recognized a mutual opportunity and proposed attaching his Cyclops camera to the Altair. Roberts was interested, and after a brief tour of MITS, the two men sat down to work. Melen studied the Altair schematics, gathering all the information he thought he would need to design an interface between the two devices. He and Roberts talked about computers in general and the Altair-Cyclops interface in particular until dawn, when Melen hurried back to the airport to catch an 8 A.M. flight to San Francisco.

Soon after the meeting between Melen and Roberts, Solomon wrote to Garland and Melen suggesting a television adapter for the Cyclops. They replied that it would be prohibitively expensive, and instead described their plan to link the Cyclops device to the Altair for use as a security camera. Solomon was gleeful. The security camera was the practical application that Art Salsberg had wanted. He incorporated the idea into Garland and Melen's article on the Cyclops.

The brainstorming session with Melen was not to be Ed Roberts's last sleepless night. His future, his company, everything hung on this article in *Popular Electronics* and on a positive response from the magazine's readers. He kept his enthusiasm in check, despite Les Solomon's cheery encouragement. Roberts felt that Solomon could scrap the project even on the eve of publication. If that happened, MITS was through. Already hundreds of thousands of dollars in debt, Roberts had borrowed heavily to finance this computer venture. He had purchased enough parts to build several hundred machines—and he still had to pay for advertising. At $397 for one machine, he would need to sell the 800 machines he'd glibly mentioned to the bank and a lot more just to break even. He began to suspect that he'd made a terrible mistake.