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Woz

STEVE Wozniak did not sit near the front of the SLAC auditorium along with Lee Felsenstein during Homebrew meetings. His participation in the mapping sessions were infrequent. He had no great social scheme, did not incubate plans for a Community Memory-style assault on the foundations of the batch-processed society. Meeting after meeting, Steve Wozniak would be at the back of the room, along with a loose contingent of followers of his digital exploits mostly high school-age computer nuts drawn by the sheer charisma of his hacking. He looked like a bum. His hair fell hap-hazardly on his shoulders, he had the kind of beard grown more to obviate the time-consuming act of shaving than to enhance appearance, and his clothes jeans and sports shirts, with little variation never seemed to fit quite right.

Still, it was Steve Wozniak, known to his friends as "Woz," who would best exemplify the spirit and the synergy of the Homebrew Computer Club. It was Wozniak and the computer he'd design that would take the Hacker Ethic, at least in terms of hardware hacking, to its apogee. It would be the legacy of the Homebrew.

Stephen Wozniak did not reach his views of hackerism through personal struggle and political rumination as Lee Felsenstein did. He was more like Richard Greenblatt and Stew Nelson: a born hacker. He grew up in Cupertino, California, amidst the curving streets lined with small single-family homes and the one-story, sparsely windowed buildings that sowed the crop of silicon which would be so central to his existence. Even in grammar school, Wozniak could get so engrossed in mathematical ponderings that his mother had to rap on his head to bring him back to the real world. He won a science contest at thirteen for building a computer-like machine which could add and subtract. His friend Alan Baum later remembered him at Homestead High School: "I saw a guy scribbling these neat diagrams on a piece of paper. I said, 'What's that?' He said, 'I'm designing a computer.' He had taught himself how to do it."

Baum was impressed enough to join this unusual classmate in a quest for computer access, and through contacts in the engineering-rich Silicon Valley they managed

to get on various time-sharing computers. Every Wednesday they would leave school and have a friend sneak them into a computer room at the Sylvania company. They'd program the machine to do things like printing out all the powers of two and finding the primes. The two followed the computer industry with the serious passion with which fanatic sports fans might follow favorite teams. Every time they heard of a new minicomputer being released, they would write to the manufacturer, be it Digital or Control Data or whoever, and request the manual, a request often routinely fulfilled. When the manual came, they would devour it. They would instantly turn to the part which described the computer's instruction set. They would note how many registers the machine had, how it added, how it did multiplication, division. They could discern from the instruction set the character of the machine, how easy it would be to use. Was this a machine to fantasize about? If it was, Woz later recalled, he would "spend hours in class writing code without ever being able to test it." Once, after receiving a manual for a Data General Nova computer, he and Baum took it upon themselves to redesign it, even sending their new design to the company, in case Data General wanted to implement the suggestions of two high school kids.

"It just seemed *neat* [to design computers]," Baum later recalled. "It seemed like an important thing to do. The glamour appealed to us. It was fun." As high school progressed, and Wozniak scrounged more time on computers to perfect his skills, Baum would often be astounded at the programming tricks Woz would come up with. "He seems to have invented all the tricks on his own," Baum later said. "Steve looks at things a different way. He says, 'Why don't I try this?' He's driven to use all the problem-solving techniques he can because ordinary design isn't good enough. He has to be the best. He'll do things no one's thought of, use every trick. Sometimes, using every trick, you find better ways to do things."

Woz graduated from high school before Baum did, and went off to college. But a few years later, both wound up working at the same company, the Hewlett-Packard computer firm. An extremely high-tech operation, devoted to high-performance computers which were like Mercedes cars compared to IBM's clunky Caddies, this was truly the big leagues, and Woz was very happy there. He was married, but computers still were his number one priority. Besides his work at HP designing arithmetic logic for calculator chips, he also did some extra design work for the Atari game company, where another high school friend, Steve Jobs, worked. This provided side benefits, like the time he went into a bowling alley and encountered a coin-operated videogame with a sign promising a pizza to anyone who scored over a certain level. After a number of pizzas, his amazed companion asked him how he had beaten the game so easily. "I designed it," said Wozniak between spasms of laughter.

A prankster with an unsettling, sometimes sophomoric sense of humor, Woz ran a

free "dial-a-joke" service from his home, dispensing a seemingly endless supply of Polish jokes. That was not the only amusement he derived from the phone. He and Jobs became inspired after reading a 1971 article in *Esquire* about a legendary fellow known as Captain Crunch who was a devoted builder of blue boxes these were devices which allowed one to make long distance calls for free. Jobs and Woz built their own, and not only used them to make free calls but at one point sold them door-to-door at the Berkeley dorms. Woz once used his box to see if he could phone the Pope; he pretended he was Henry Kissinger, and almost reached His Eminence before someone at the Vatican caught on.

It was a freewheeling life Woz lived, centered on hacking for HP, hacking on his own, and playing games. He loved to play games, especially electronic ones like Pong. He also played tennis; like Bill Gosper playing Ping-Pong, Wozniak got a kick out of putting spin on the ball. As he later told an interviewer, "The winning isn't as important as the running after the ball." A sentiment which applied to hacking computers as well as tennis.

He dreamed, always, of that computer he might design for himself. He had already homebrewed his own TV Typewriter, a good first step. His goal was, of course, a computer built to encourage more hacking a Tool to Make Tools, a system to create systems. It would be cleverer than any preceding it.

It was 1975, and most people, had they heard his dream, would have thought he was nuts.

Then Alan Baum saw the notice for the Homebrew meeting on a bulletin board and told Woz about it. They both went. Baum, admittedly too lazy to build a computer when he was surrounded with state-of-the-art machines at HP, wasn't terribly excited. But Woz was thrilled. Here were thirty people *like him* people quixot-ically fixated on building their own computers. When Marty Spergel passed out data sheets on the 8008 chip, Woz took one home and examined it until he realized that those minicomputers he was thinking of designing big machines like the ones Digital Equipment made were unnecessary. You could do it with microchips, like that Altair he had seen that night. He got hold of all the literature he could on microprocessors and wrote for more information, started files on all sorts of i/o devices and chips, and began designing circuits for this eventual computer. The second Homebrew Computer Club newsletter printed his report on current activities:

Have TVT my own design ... have my own version of Pong, a videogame called breakthrough, a NRZI reader for cassettes very simple! Working on a 17-chip TV chess display (includes 3 stored

boards); a 30-chip TV display. Skills: digital design, interfacing, I/O devices, short on time, have schematics.

The Homebrew atmosphere was perfect for Steve Wozniak; there was activity and energy focusing on the experimentation and electronic creativity which were as essential to him as the air he breathed or the junk food he ate. And even a person not normally taken to socializing could find himself making friends. Woz often used his home terminal to access the account that had been set up for Homebrew members on the Call Computer service. (Call Computer was a service that allowed people with home terminals to access a mainframe computer by phone.) There was a program on the computer much like the function on the MIT ITS system, where two people could "chat" to each other while on the computer, sharing information. Woz not only used this to communicate electronically with people, but he hacked into the depths of the system and discovered a way to break in on other people's electronic conversations. So when Gordon French, for instance, was naming about his new trick with the 8008 Chicken Hawk, his home terminal would inexplicably begin printing out these semi-obscene *Polish jokes,* and he never did figure out that somewhere miles away Steve Wozniak was doubled up in laughter.

Woz also met Randy Wigginton, an athletic, blond-haired fourteen-year-old computer kid who had managed to get a job at Call Computer. Wigginton lived just down the street from the cluttered garden apartment Wozniak shared with his wife, and Woz would drive the youngster to Homebrew meetings. Since before high school, Wigginton had been in love with computers. He came to almost idolize Woz for his profound understanding of computers, and deeply appreciated the fact that the twenty-five-year-old Woz "would talk to anybody about any technical thing," even to a fourteen-year-old like Wigginton. Though Randy's parents worried at the fact that computers were taking over their son's life, his obsession deepened, fueled by Woz's informal tutorials at Denny's restaurant on Foothill Drive on the way back from meetings. They would be driving in Woz's beat-up Malibu with its mounds of trash on the back seat dozens of McDonald's bags and technical journals, all soggy from Woz's strange reluctance to roll up the windows when it rained and stop for Cokes, fries, and onion rings. "I would ask Woz any dumb question just to get him talking 'How does a BASIC interpreter work?' and just listen to him as long as he talked," Wigginton later recalled.

Wozniak soon got to know another Homebrew member who worked at Call Computer John Draper. A semi-employed engineer, John Draper was better known as "Captain Crunch," the "phone phreak" hero of that *Esquire* article that excited Woz in 1971. Draper, whose unmodulated voice could drone like the last whines of a fire alarm, a scraggly dresser who never seemed to put a comb to his long dark hair, got that moniker after he discovered that when one blew the whistle that came

in the breakfast cereal by that name, the result would be the precise 2,600-cycle tone that the phone company used to shuttle long-distance traffic over the phone lines. John Draper, then an airman stationed overseas, used this knowledge to call friends at home.

But Draper's interest went beyond free calls as an engineer with a latent hacker tendency toward exploration which would soon prove overwhelming, he became fascinated with the phone company system. "I do [phreaking] for one reason and one reason only," he told the *Esquire* reporter who made him famous in 1971.

"I'm learning about a system. The phone company is a System. A computer is a System. Do you understand? If I do what I do, it is only to explore a System. That's my bag. The phone company is nothing but a computer." It was the same fascination shared by the Tech Model Railroad Club hackers, particularly Stew Nelson (the MIT hacker who had hacked phones since childhood); but, not having Nelson's access to sophisticated tools to explore it, Draper had to devise his own jerry-rigged means ofaccess. (The one time Nelson did meet Draper, the MIT hacker was unimpressed by Draper's technical ability.) Draper was helped by discovering a network of phone phreaks with similar interests, many of them blind men who could easily identify the tones which could whizz one through the system. Draper was astonished that there were alternate phone systems from which you could get into test boards, verification trunks for breaking into people's conversations (he once startled a woman he fancied by angrily interrupting her phone chat with another man), and overseas switching units. He soon figured out how to jump from one circuit to another, and mastered the secrets of "blue boxes," which like Stew Nelson's adjustment to the PDP-1 a decade earlier, could send tones over phone lines to get unlimited, free long-distance calls.

But John Draper, who sometimes acted so impulsively that he would seem an overgrown infant, wailing for his mother's milk of systems knowledge, did not have the focused resolve of the MIT hackers he could easily be cajoled into yielding the information about blue boxes to people who wanted to sell the boxes to people who wanted free calls as Wozniak and Jobs had done door-to-door in the Berkeley dorms.

Draper's own phone excursions were more benign. A typical caper would be to seek out and "map" various access codes for foreign countries, and he would use those codes to leapfrog from one trunk line to another, listening to a series of edifying clicks as his signal bounced from one communications satellite to the next. After the *Esquire* article, though, authorities targeted him, and in 1972 he was caught in the act of illegally calling a Sydney, Australia, number which gave callers the names of the top tunes Down Under. For this first offense, he was given a suspended sentence.

He turned to computer programming, and soon was a regular hacker. People would later recall him at People's Computer Company potlucks, filling his plate sky-high and stuffing himself. A virulent anti-smoker, he would also scream almost painfully when someone lit a cigarette. He was still interested in phone hacking, and among the subjects he'd talk about at the potlucks were things like getting ARPAnet access, something he considered eminently justifiable "I had some integrations I had to do analytically. The MIT computer [had a program to help me do it]. So I used it," he would later explain.

When the potlucks ended, he gravitated to Homebrew. He was a consultant to Call Computer, and had arranged for the Homebrew Club to get its account. He became a huge fan of Wozniak's hacking, and Wozniak was thrilled to meet the famous phone phreak who had inspired his own blue box escapades. It was not unusual to see them together at the back of the room, as they were one night in late 1975 when Dan Sokol approached them. Sokol was the long-haired, blond guy who would stand up at Homebrew, check that no one from Intel was around, and barter off 8080 chips to anyone with good equipment to trade.

Sokol at that time was going broke from using his home terminal to access the Call Computer account. Since Sokol lived in Santa Cruz, and Call Computer was in Palo Alto, his phone bill was outrageous; he was accessing the computer for forty to fifty hours a week. The solution came one day at the back of the SLAC auditorium when Sokol was introduced to Wozniak and John Draper.

Not Captain Crunch?

"Yeah, that's me!" Draper volunteered, and Sokol immediately peppered him with questions on building a blue box, which would enable him to make the Santa Cruz-Palo Alto phone calls for free. Though Draper's probation specified that he refuse to divulge his phone-hacking secrets, he was unable to resist when people asked; the hacker in his blood just let the information flow. "In the next fifteen minutes, he proceeded to tell me everything I needed to know [to build a blue box]," Sokol later said. But when Sokol put the blue box together it didn't work; he let Draper know and that next Saturday, Draper, accompanied by Steve Wozniak, came over. They looked over Sokol's box. "Looks OK," said Draper, and began adjusting the tones by ear. This time, when Sokol tried the blue box, it worked. Sokol would use the box only for connecting to the computer a practice which in the hacker mind justifies lawbreak-ing and not for personal gain in trivial matters like calling distant relatives.

Wozniak took a look at Sokol's "kluge," the computer he'd gotten from bartering

liberated parts, and they both lamented the high cost of hardware hacking. Woz complained that even though he worked for Hewlett-Packard the sales people wouldn't part with any chips for him. At the next Homebrew meeting, Dan Sokol presented Wozniak with a box full of parts that would work with a Motorola 6800 microprocessor. Woz got a 6800 manual and began designs for a computer that would interface with the TV Typewriter he'd built. When someone brought a computer to a Homebrew meeting that had video included, he knew that his computer would have to have video built in, too. He liked the idea of a computer you could play a videogame on. Around that time the Wescon computer show was being held, and Wozniak went by the MOS Technology booth and found that they were selling early models of their new microprocessor chip, the 6502, for only twenty dollars. Since the chip wasn't much different from the Motorola 6800, he bought a handful, and decided that the 6502 would be the heart of his new machine.

Wozniak was not thinking of building a computer to sell. He was building a computer to have fun with, to show to his friends. He would mention what he was doing to his friend Steve Jobs at Atari, who was interested in terminals and thinking about setting up a company that made them. Every two weeks Woz would go to Homebrew and see or hear what was new, never having any problem in following up on technical details because everyone was free with information. Some things he would incorporate into the computer; for instance, when he saw the Dazzler board, he knew he wanted color graphics. He knew, of course, that he wanted a BASIC, and since the only BASIC that ran on the 6502 then was Tom Pittman's Tiny BASIC, and Woz wanted a "big" BASIC, he wrote his own. He gave out the code to anyone who wanted it, and would even print some of his subroutines in *Dr. Dobbs Journal*.

By the time he was finished, he had a computer which was not really a kit or an assembled computer, but one board loaded with chips and circuitry. With just that board, you could do nothing, but when you attached a power supply and a keyboard and a video monitor and a cassette tape player to the board, you would have a working computer with video display, mass storage, and input/ output. You could then load in Steve Wozniak's "Integer BASIC" and write programs. There were several amazing things about his computer, not the least of which was that he had delivered the power and capabilities of an Altair and several boards on one much smaller board. What it took other people two chips to do, Woz did in one. This was not only fiscally prudent, but a sort of technical machismo reminiscent of the code-bumming of TMRC days, when Samson, Saunders, and Kotok would attempt to whittle a subroutine down to the fewest instructions.

Wozniak later explained why the board used so few chips: "I'm into it for esthetic purposes and I like to consider myself clever. That's my puzzle, and I do designs

that use one less chip than the last guy. I would think how could I do this faster or smaller or more cleverly. If [I work on something] considered a good job using six instructions, I try it in five or three, or two if I want to win [big]. I do tricky things that aren't normal. Every problem has a better solution when you start thinking it differently than the normal way. And I see them every single day I see several problems, I ask if it's a hardware problem, I start looking at a lot of techniques I've done before, counters and feedback or chip registers ... a bottom-line approach, looking for little specific end points from a hierarchy ... it creates basically a sort of different mathematics. The discoveries did increase my motivation because I would have something to show off and I hoped that other people would see them and say, 'Thank God, that's how I want to do it,' and that's what I got from the Homebrew Club."

Wozniak brought the board, along with the hardware to make it work, to Homebrew. He didn't have a cassette recorder, and while the meeting went on he sat outside, frantically typing in the hexadecimal code 3,000 bytes' worth of the 3K BASIC interpreter into the machine. He would run a test on part of the program, and the test might clobber it and he'd start over again. Finally it was running, though it was only a preliminary version which didn't have the full command set, and when people drifted over Wozniak would explain, in his breathless, high-speed drone, what the thing could do.

It was not long before Wozniak addressed the entire Homebrew Computer Club, holding his board in the air and fielding questions from the members, most of them asking how he did this or if he was going to put this feature or that into it. They were good ideas, and Wozniak brought his setup every two weeks, sitting in the back of the auditorium where the electrical outlet was, getting suggestions for improvements and incorporating those improvements.

Woz's friend Steve Jobs was very excited about the board; he thought that, like Processor Technology and Cromemco, they should make the boards in quantity and sell them. Jobs, at twenty-two, was a couple of years younger than Wozniak, and not much cleaner. He had what was described as a "Fidel Castro beard," often went shoeless, and had a Califomian interest in Oriental phi losophies and vegetarianism. He was a tireless promoter, silver-tongued, a deft persuader. Soon the pair was known as "the two Steves," and Wozniak's computer was known as the Apple, a name conceived by Jobs, who once worked in an orchard. Though the official address of the as yet unincorporated Apple company was a mail drop, Jobs and Wozniak really worked out of a garage. For capital, Jobs sold his Volkswagen bus and Woz sold his HP programmable calculator. Jobs placed ads in hobbyist publications and they began selling Apples for the price of $666.66. Anyone in Homebrew could take a look at the schematics for the design, Woz's BASIC was given away free with purchase of a piece of equipment that connected the

computer to a cassette recorder, and Woz published the routines for his 6502 "monitor," which enabled you to look into memory and see what instructions were stored, in magazines like *Dr. Dobbs*. The Apple ad even said, "our philosophy is to provide software for our machines free or at minimal cost."

While the selling was going on, Steve Wozniak began working on an expanded design of the board, something that would impress his Homebrew peers even more. Steve Jobs had plans to sell many computers based on this new design, and he started getting financing, support, and professional help for the day the product would be ready. The new version of Steve Wozniak's computer would be called the Apple II, and at the time no one suspected that it would become the most important computer in history.

It was the fertile atmosphere of Homebrew that guided Steve Wozniak through the incubation of the Apple II. The exchange of information, the access to esoteric technical hints, the swirling creative energy, and the chance to blow everybody's mind with a well-hacked design or program ... these were the incentives which only increased the intense desire Steve Wozniak already had: to build the kind of computer he wanted to play with. Computing was the boundary of his desires; he was not haunted by visions of riches and fame, nor was he obsessed by dreams of a world of end users exposed to computers. He liked his work at HP, and loved the heady atmosphere of being around the gentleman engineers atop the computer industry. At one point Wozniak asked his bosses at HP if they wanted him to design the Apple computer for them they thought it was unmarketable, and gave him a release to sell it on his own. When it looked like HP would be setting up a small computer division, Wozniak applied for a transfer; but, according to Alan Baum, "the head of the lab wasn't impressed. He had no degree." (Woz had left Berkeley before graduation.)

So he worked on the Apple II, often until 4 A.M. he would soon be one more Homebrew member divorced by a computer widow. Designing the Apple II was no picnic. There were hundreds of problems in making a ready-to-program, self-contained computer-and-terminal combination; Wozniak did not have even the moderate resources and cash flow that Bob Marsh and Lee Felsenstein had when they designed the Sol, the first computer-terminal combination and one of many inspirations for the Apple II. But he had a vision of what he wanted his computer to be, and could draw on help from Homebrew and other experts in the Valley. Finally he had a prototype working. He and Randy Wigginton carried it a loose but fully connected jumble of parts and boards over to a December 1976 Homebrew meeting in a couple of boxes, along with a klunky Scare color TV.

Years later, the people attending that Homebrew meeting would recall different versions of the reaction to Stephen Wozniak's presentation of the Apple II. Wozniak, and the other fans of the 6502 chip, came out with the impression that the computer had thrilled everyone. Others thought it was simply one more advance in the frantic climb toward an ultimate homebrewed computer. As Lee Felsenstein put it, "The people in Homebrew were not sitting around waiting for the Apple to happen: people were making stuff, talking about stuff, showing stuff off."

One thing that did not excite the members was the fact that the production models of the Apple would come only in fully assembled form why buy a computer, hardware hackers thought, if you could not build it yourself? The hard-core old-liners, who respected the solidity and predictability of the Processor Technology and Cromemco products, thought the Apple interesting, especially in its economical circuitry and its color capabilities, but not as good a machine as the Sol, which was based on the familiar Altair bus (newly named the S-100 bus by a consensus of manufacturers, notably Marsh and Garland, who were sick of referring to a part of their computers with the name of a competitor who in most un-hackerish spirit seemed to resent their existence). The Apple had an entirely new bus and a brand-new operating system, both designed by Woz; plus, there was the unfamiliar 6502 chip as its brain. Also, a proven company like Processor Technology seemed more likely to be able to support a machine in the field than did Apple, which apparently consisted only of two kids in a garage.

Basically, though, the disagreement came down to religious issues of design. The Sol reflected Lee Felsenstein's apocalyptic fears, shaped by post-holocaust science fiction, that the industrial infrastructure might be snatched away at any time, and people should be able to scrounge parts to keep his machine going in the rubble of this devastated society; ideally, the machine's design would be clear enough to allow users to figure out where to put those parts. "I've got to design so you can put it together out of garbage cans," Felsenstein once said. "In part because that's what I started from, but mostly because I don't trust the industrial structure they might decide to suppress us weirdos and try to deny us the parts we need." This philosophy was expressed in the VDM and the Sol itself, both of which were products which did their job cleanly, in a not overly flashy manner, and with a proletarian lack of sentimentality.

Steve Wozniak's Apple was another story. Growing up in a conventional family in the sheltered, suburban California world of single homes, science fairs, and McDonald's burgers, Wozniak had inbred security. He felt comfortable taking chances, letting the design go as far as his imagination could take him. He created an esthetic wonder by optimizing a limited number of off-the-shelf electronic parts

so that, very ingeniously laid out and wired, they delivered not only the power of a PDP-1, but color, motion, and sound.

If Woz had his way, he would add features forever. Just two days before the meeting, he had jimmied up the machine so that it could display special, high-resolution color graphics. He did this not by the usual way of adding special chips to do it, but by figuring out a way to wire the machine so that the central processing unit, the 6502, could do double duty.

Woz's genius for optimization sometimes had odd effects. For example, the way the Apple filled the screen with an image was much different than the Sol's method, which filled things in by a proper order; the Apple drew its screen in a seemingly haphazard, crazy-quilt manner. It did this not by chance, but because Woz figured out that doing it that way would save an instruction for each line put on the screen. A clever trick, disdained by some who thought it indicative of the Apple's unpredictability and "flaki-ness," but much admired by those who could appreciate the beauty of a maximized design. All in all, the design reflected a tour de force of hacking, and a very savvy engineer could see the clever twists of plot, the optimistic flights of fancy, and the eccentrically cosmic jokes embodied in the machine.

One person who thought that the Apple II was just super was Chris Espinosa, a young acquaintance of Randy Wigginton. Espi-nosa was a skinny, pale fourteen-year-old high school kid who loved computers and flunked math classes because he felt that doing homework was a non-optimal use of time. He was enthralled by this computer of Steve Wozniak's. From the explanation of the syntax of Woz's special BASIC commands which came out in the talk, and the explanation of sketches of the machine's innards distributed all around, Espinosa jotted down some BASIC programs, and during the random access period of the meeting, when people crowded around this new machine, he took over the keyboard and frantically hammered in some programs which created flashy color displays on the big old Sears television set Wozniak had dragged along. Wozniak was thrilled: "I didn't think somebody else could come up and show me 'Look!' and get excited and show other people and say, 'Look, this is easy, you just put this command in and you do this.'" Here was this high school kid, running programs on this little computer Wozniak had built. Steve Jobs' reaction was more pragmatic he hired Chris Espinosa as one of the company's first employees. Like the other teen-age software specialist, Randy Wigginton, he would earn three dollars an hour.

Steve Jobs was concentrating full-time on building up the Apple company to get ready to deliver the Apple II the following year and make a big splash in the marketplace. Jobs was a brilliant talker who, according to Alan Baum, "worked his tail off ... he told me about the prices he was getting for parts, and they were

favorable to the prices HP was paying." As an engineer, Jobs was mediocre; his strength was as a planner, someone with vision to see how computers could extend to a point of usefulness beyond that dreamed of by pure hackers like Steve Wozniak. He was also wise enough to realize that as a long-haired twenty-two-year-old whose customary garb was jeans and bare feet, he was not the person to head a major computer corporation; most of all, he lacked management and marketing experience. He decided that he would hire top-notch, high-priced management talent to run Apple Computer.

This was no easy conclusion in those days, when engineers like Ed Roberts and Bob Marsh thought that building a quality machine was the main ingredient for success, and management might take care of itself. Ed Roberts learned the folly of this, the hard way. By mid-1976, Roberts had tired of the "soap opera" (in his words) that MITS had become, with frustrated customers, a confusing line of several new and improved versions of the Altair, hundreds of employees, vicious internal politics, perpetually panicked dealers, hopelessly muddled finances, and not a decent night's sleep in over a year. He had been designing an exciting new Altair 2 computer a high-powered, compact machine which could fit in a briefcase but most of his energies were spent in management squabbles. So he decided to call it, he later said, "a page in my life it was time to move on to the next page," and he stunned the world of hardware hackers by selling the company to a big firm called Pertec. By the end of the year, Roberts, with his million-dollar-plus buy-out, left the business and became a farmer in southern Georgia.

The moral of the story was that engineers can't necessarily run companies. But finding people who can isn't easy, especially when your company, on the surface at least, looks like a small coven of hippies and high school kids. Chris Espinosa later noted that, in early 1977, Jobs looked so slovenly that "they wouldn't let him on to minibuses and airplanes, much less into the corridors of power of the semiconductor industry," yet he pulled off a major coup by getting Mike Markkula on the Apple team. Markkula was a former marketing whiz, now in his mid-thirties, who'd retired from Intel a few years back; he had been spending his time since then in various pursuits, some business-oriented, some as odd as inventing a wheel-chart to show different fingering positions for guitar chords. Jobs asked him to help draw a business plan for the Apple, and Markkula wound up helping to get venture capital for the company and signing up as its first chairman of the board. It was through Markkula that Jobs also got a nuts-and-bolts manager from Fairchild Semiconductor named Mike Scott to become president of the firm. So, while the most prominent company with a terminal-computer on the market. Processor Technology, was struggling with the inexperienced management of hardware hackers Bob Marsh and Gary Ingram, Apple was set for growth.

This real-world activity hadn't really sunk in as far as Steve Wozniak was

concerned. Chris Espinosa and Randy Wigginton would come over to his house from playing with Wigginton's half-built version of the Apple II, and there, on the living room floor of Woz's small place, they would debug programs and hardware, write tone generation programs, solder boards. It was fun. Meanwhile, in his own garage. Jobs was running the day-to-day operations. "He would come by every once in a while and see what we were doing, make recommendations, but he didn't do any designing," Espinosa later said. "He would pass judgment, which is his major talent: over the keyboards, the case design, the logo, what parts to buy, how to lay out the PC board to look nice, the arrangement of parts, the dealers we chose ... the method of assembly, the distribution method, everything."

He was guided in this by the experienced hand of Mike Mark-kula, who was taking the Apple venture very seriously. One thing he apparently recognized was that Steve Wozniak's commitment was to the computer rather than to the company. To Woz, the Apple was a brilliant hack, not an investment. It was his art, not his business. He got his payment by solving puzzles, saving chips, impressing people at Homebrew. This was fine for hacking, but Markkula wanted, at the least, Wozniak's full-time participation in the company. He told Jobs to tell his partner that if Woz wanted there to be an Apple Computer company, he must quit HP for all-out work on pre-production of the Apple II.

It was a tough decision for Wozniak. "This was different than the year we spent throwing the Apple I together in the garage," Wozniak later recalled. "This was a real *company*. I designed a computer because I like to design, to show off at the club. My motivation was not to have a company and make money. Mike was giving me three days to say yes or no, was I going to leave HP. I liked HP. They were a good company and I was secure and there was a lot of good work. I didn't want to leave, and I said no."

Steve Jobs heard the decision, and called Wozniak's friends and relatives, begging them to persuade Woz to quit HP and work for Apple full-time. Some of them did, and as Woz heard the arguments he reconsidered. Why not work to let the Apple II go out into the world? But even as he agreed to quit HP and work with Jobs full-time, he told himself that what he was doing was no longer pure hacking. The truth was that starting a company had nothing to do with hacking or creative design. It was about making money. It was "stepping over the boundary," as Wozniak later put it. Not in any kind of rip-off Wozniak believed in his computer and had confidence in the team that would produce and sell it but "there's no way I would associate Apple with doing good computer design in my head. It wasn't the reason for starting Apple. The reason for starting Apple after the computer design is there's something else that's to make money."

It was a crucial decision that would symbolize the shift taking place in small

computers. Now that hackers like Wozniak were building machines with terminals and keyboards, machines which might presumably be useful to people other than hobbyists, the direction of the budding industry was no longer in the hands of those hackers. It was almost twenty years after the TMRC hackers had been introduced to the TX-0. Now, going into business was The Right Thing.

In January of 1977, the half-dozen or so employees of this new firm, which would not incorporate until that March, moved into a cramped space on Stevens Creek Boulevard in Cupertino, within stone-throwing distance of a 7-Eleven and a Good Earth health food restaurant. Wozniak preferred to walk down the street to go to Bob's Big Boy. First thing in the morning, he and Wigginton would go there, order a cup of coffee, take a sip out of it, and talk about how bad the coffee was, leaving the almost full cup on the table. It was sort of a ritual. Woz had a fondness for taking packets of Fizine, a bubbling antacid, and emptying them into the sugar containers at Bob's, where he would wait until some unsuspecting customer put what he thought was sugar in his coffee. It would erupt like a small volcano, and Woz would get a big kick out of it. But often Woz would just talk, mostly technical stuff, and sometimes about Apple. Wigginton and Espinosa, both still in high school, had taken some of Jobs' planner-like hyperbole to heart they all had to some degree and believed that the Homebrew crusade was focused right there on Stevens Creek Boulevard. "Everybody was so much into it," Wigginton later said. "We were motivated more by a dream of what was going to happen than by what was actually happening. That we would be a successful company and were going to come out with the neatest product that had ever been produced."

They would often work around the clock, soldering, designing, and programming. One of Woz's friends hired as a hardware specialist would make bird calls as he worked. Woz would pull pranks, play games, and then do an incredible amount of work in a brief burst. Woz and his friends were preparing a different kind of computer than the previous bestsellers, the Altair, Sol, and IMSAI. Steve Jobs and Mike Markkula felt that the Apple's market went well beyond hobbyists, and to make the machine *look* friendlier, Jobs hired an industrial designer to construct a sleek, low-profile plastic case in a warm beige earth color. He made sure that Woz's layout would be appealing once the lid of the case was lifted. The Apple bus, like the S-100 bus, was capable of accepting extra circuit boards to make it do interesting things, but Woz had taken some advice from his friend Alan Baum and made it so that the eight "expansion slots" inside the Apple were especially easy for manufacturers to make compatible circuit boards for. They would be helped, of course, by the "open" architecture of the machine; true to the Hacker Ethic, Woz made sure the Apple had no secrets to prevent people from creating on it. Every twist and turn of his design, every coding trick in his BASIC interpreter (which would be included inside this machine, hard-wired into a custom circuit chip) would be documented and distributed to anyone who wanted to see.

At certain points, Woz and Jobs relied on their Homebrew connections for help. A good example was what happened with a potential problem in getting FCC approval of the computer. Rod Holt, an engineer from Atari who had been helping design the power supply, sadly declared that the machine's connector to a television set called the Radio Frequency (RF) Modulator gave off too much interference, and would never pass muster with the FCC. So Steve Jobs went to Marty Spergel, the Junk Man.

Spergel would often show up at Homebrew meetings, holding some esoteric part and giving it away. "I'd look through my junk box and say, 'Here's a box full of A through Z,' and people would run over at six hundred miles an hour and before I could even let go of the box it was gone." He had a nose for niches in the electronics market, and had recently made a killing by importing joystick controllers from Hong Kong so that people could play games like Steve Dompier's "Target" on Altairs and Sols. At one point, his company, M&R Electronics, even introduced a computer kit, but that product never really caught on. One day Marty visited the one-room Apple headquarters in Cupertino and talked to Woz, Jobs, and Rod Holt about the modulator situation. It was clear that Apple could not ship the computers with the current modulators, so it was decided that Holt would give Marty Spergel the specifications for the modulator, and *he* would build them. "My part was keeping the FCC away from Apple Computer," Spergel later said. "So what I did was ship modulators out of my door, Apple shipping Apples out of their door. But when they got to the dealers, the dealers would sell a modulator to the end user, and when the end user [went] home he could plug in the modulator. Consequently, it's now the end user's responsibility [to prevent RF interference]."

It was a classic case of Homebrew sharing, with everybody benefiting, to get around a bureaucratic obstacle. Spergel asked Jobs about how many modulators, which M&R would sell under the name "Sup'r Mod" for about thirty dollars each, would be required. Jobs promised it would be high volume. Perhaps even fifty units a month.

Several years later, Spergel estimated he had sold four hundred thousand Sup'r Mods.

In early 1977, Homebrew Computer Club member and editor of *Dr. Dobbs Journal* Jim Warren was hatching a rather large scheme himself. Warren was the short-haired, wide-faced, bearded fellow who collected "technogossip" as a hobby, and saw Homebrew as an outlet to spew all sorts of rumors about firms in the

"Silicon Gulch," as he called it. Often, his rumors were accurate. In addition to his editorial duties and his activities as a silicon *yenta,* Warren was in a self-described "dissertation mode" at Stanford. But the quantum growth rate of the personal computer interested him more than a doctorate. He was a fan, regarding the homebrew computer movement as a sort of post-Free University, take-your-clothes-off-and-get-dirty, humanistic lovefest.

His attendance at the PC '76 computer show in Atlantic City had reinforced that belief. He hadn't wanted to go at first, considering that faded resort as "the crotch of the nation," but the show's promoter had called him up and told him about all the exciting people who'd be there, adding how great it would be for the editor of *Dr. Dobbs* to be in attendance, and Jim Warren felt somewhat frustrated because, with Bob Albrecht paying him only $350 a month to edit the magazine, he had to beg for the money for the trip. He figured that the big show should be right there, in California. One night he was talking to Bob Reiling, an engineer at Phiico who had quietly taken over Fred Moore's duties as editor of the Homebrew newsletter. Warren asked why the hell all that stuff was happening on the wrong coast when the undisputed center of the microcomputer world was right here. Reiling agreed, and Warren decided that they should do it, put on a show which would also, in hacker spirit, be an exchange of information, equipment, technical knowledge, and good vibrations. It could have the idyllic atmosphere of the annual "Renaissance Faire" in Marin County a genuine "Computer *Faire*."

He was thinking about this show when he got to Atlantic City, which despite the horrid humidity and the dilapidated facilities was, he later said, "a complete turn-on. [You met] all the people you'd talked to on the phone or gotten a letter from who were doing things ... [you had] tremendous excitement over meeting the people who were doing the deeds." They were a powerful new interfacing feature, these face-to-face meetings, which provided much fresher information than you got in publications. "*Dr. Dobbs* had a six-week lead time and it was driving me crazy. Hell, six months was half a generation of machines. The opportunity to talk to people about what they were doing *that week* was a radical improvement. So it was in that kind of environment that I announced that we were going to do a Computer Faire on the West Coast."

With Reiling as his partner, Warren set out to organize the event. He was soon daunted by the fact that the ideal location, the Civic Auditorium in San Francisco, charged a considerable rental fee. Thousands of dollars a day! After hearing this, Warren and Reiling drove down to the peninsula, stopping at Pete's Harbor, an open-air cafe by the bayside marina, a favorite haunt of Albrecht and the PCC crowd. Warren recalls: "I remember saying, 'Boy, we're really getting in deep. Can we afford this?' And I pulled a napkin out of a big napkin holder and began scribbling. How many exhibits to expect. How many attendees. If they drew thirty-

five hundred in Atlantic City, we should double that ... maybe draw as many as seven thousand. How much to charge for exhibitors and attendees? Multiply it out. Add it up..." And Jim Warren was astonished to find out that not only could they afford it, but they could make a *profit* out of it. And certainly there was nothing wrong with that.

Jim Warren got on the phone and began calling the presidents of the biggest companies in the industry, most of whom he knew personally from Homebrew or his magazine work. "I phoned up Bob Marsh and said, 'Hey, we're going to do a Computer Faire, are you interested?' and he said, 'Hell yeah.' 'Okay, send some money and we'll get you exhibit space. Far out.' We phoned up Harry Garland from Cromemco. 'This is Jim Warren, we're doing a Computer Faire. Want in on it?' 'Sure, fine.' 'Yeah, well, we'll get a booth plan to you as soon as we get a chance. Send us the money because we need some.' I think it took us four days before we were in the black."

Warren turned out to have considerable talents as a promoter. He began a tabloid newspaper specifically to pump up excitement about the Faire, and, incidentally, to spread his brand of technogossip. It was called *Silicon Gulch Gazette,* and there were stories about what the Faire would be like and little profiles of some of the speakers, and also a profile of "chaircreature" Jim Warren. The paper boasted of the Faire's "co-sponsorship" arrangements with nonprofit groups like the Homebrew Computer Club, SCCS, PCC and its offshoot, Community Computer Center (CCC), and others. (Joanne Koltnow, who helped out the Faire from her job at CCC, later said that "everyone was shocked" when they later discovered that the Faire was a tor-profit organization.) With a staff of two secretaries, Warren and his partners worked almost around the clock as the Faire progressed.

Also working frantically before the Faire were the eight employees of Apple Computer. Apple had taken space for two of the $350 ten-foot-square booths and somehow managed to wangle the prime space near the entrance to the exhibit hall. The idea was to take advantage of that break to officially introduce the Apple II at the Faire. Though many around the Homebrew Club did not take Apple as a serious entry in the market (Gordon French came by one day and went away scoffing that the company was still basically two guys in a garage), there was now serious money behind Apple. One day the new president, Mike Scott, had told Chris Espinosa to copy the demo software that ran a "Breakout" game. It was a game Jobs had done for Atari and Woz had rewritten for Apple BASIC, and at the end of the game, the program rated your score with a comment. Scott said, by the way, could Chris also change the comments, making the screen say "Not Good" instead of "Pure Shit"? The reason was, some Bank of America people were coming to talk about a line of credit.

So the Apple people were prepared to spend for the show. They hired a decorator to design the booth, and they prepared professional-looking signs with their spiffy new logo, a rainbow-colored apple with a bite out of it. They worked frantically down to the last minute before they had to drive the machines up to San Francisco; they had planned to have four Apple IIs running, and those would be the only existing prototypes. On the night of April 15, the cases arrived, fresh from being made out of injection molds. As everyone worked to put the innards of the computers into those cases, it was clear how different the Apple II was from the competition (with the possible exception of the Sol). Everyone else's computer looked like the kind of thing that a combat radio operator might have strapped to his back. The Apple had no visible screws or bolts (the ten screws mainly hooked from underneath): just a sleek, warm, friendly variation of a typewriter, futuristic in its low slope, but not so harshly angled that it looked menacing. Inside the machine was the evidence of Woz's hackerish tinkering. He had gotten the number of chips down to an astonishing sixty-two, including the powerful 6502 central processing unit. In fact, when you opened the snap-on lid of the machine, what you saw was Woz's "motherboard" the chip-loaded green circuit card that was the Apple I, souped up a silvery power supply the size of a stack of Ritz crackers, and the eight expansion slots which indicated the infinite uses to which you might apply the machine. By the time the screws and rivet holes were inserted in the case, and the motherboards attached, and the base plates bolted, and everything was tested and the lids were snapped on, it was one in the morning of the Apple's official world debut.

On time that morning, the Apples were in the booth, near the entrance. Most every other company relied on the tried and true yellow-curtained backdrop with pasted-on cardboard signs spelling out the company name in block letters. But Apple's booth gleamed with its six-color Plexiglass logo.

Jim Warren was at the site very early that morning, of course, riding on adrenaline after his nonstop sixteen-hour days of preparation. Just two days before, he and Reiling had incorporated the Faire as a for-profit organization. Though he considered it a "load of bureaucratic bullshit legalistic crap," Reiling had pointed out that as a partnership they were individually liable for any damages, and Warren had gone along. There was really no doubt as to where Jim Warren was headed by then as a person who knew the Hacker Ethic well, he also could see what was happening in his own Silicon Gulch backyard. The Real World had arrived, and it was time for a merger between the two cultures, hacker and industrial, because if there was a clash there would be no question who would lose. The hardware hackers had let the microcomputer cat out of the bag, and the multimillion-dollar yearly grosses at MITS, Processor Technology, and IMSAI in 1976 were irrefutable proof that this was a growth industry, worthy of heavy money and the changes that implied. Jim Warren loved the hacker spirit, but he

was a survivor, too. If he lost money, or suffered some sort of disaster by sticking to his post-hippie, idealistic, antibureaucratic phobias, it would not help hackerism one bit. Whereas his making money would perhaps not be harmful at all to the Hacker Ethic. So even though, as he later put it, he "didn't care diddly shit about booths and power and contracts and all that stuff," he went with it.

The micro world was changing. He needed no further evidence of this than the scene at the ticket booths outside of the grand, Greek-columned edifice that was the San Francisco Civic Center.

On that sunny, bright April day in 1977, there were thousands of people standing in five long lines, snaking around both sides of the block-long auditorium and meeting in the back. A block-long beaded necklace of hackers, would-be hackers, people curious about hackers, or people wanting to know what was *going on* in this freaky new world where computers meant something different than a guy in a white shirt and black tie and fat billfold and dulled-out expression which all added up to IBM. True, the lines were there in large part because Jim Warren's inexperience had resulted in a total screw-up in preregistration and ticket sales. For instance, instead of one fixed price for day-of-sale entry, there were different rates eight dollars for general public, four dollars for students, five dollars for Homebrew Computer Club members, and so on. And because it cost ten dollars an hour for cashiers, Warren had decided not to hire too many extras. Now, with almost twice as many people arriving as anticipated, and everyone seeming to have arrived early, it was the kind of situation which could get out of hand.

But it did not get out of hand. Everyone was looking around in disbelief that *all these people were into computers,* that the secret hacker lust they'd had for machines, often as solipsistic little kids, tiny Greenblatts or Wozniaks, was not so aberrant after all. Loving computers was no longer a forbidden public practice. So it was no ordeal at all, standing with these people waiting to get into the First Annual West Coast Computer Faire. As Jim Warren later recalled: "We had these lines running all around the fucking building and nobody was irritated. Nobody was pushy. We didn't know what we were doing and the exhibitors didn't know what they were doing and the attendees didn't know what was going on, but everybody was excited and congenial and nondemanding and it was a tremendous turn-on. People just stood and talked 'Oh, you've got an Altair? Far out!' 'You solved this problem?' And nobody was irritated."

When people got inside the hall, it was wall-to-wall techno-freak, the sounds of voices mingling with the clatter of printers and the tinny tones of three or four different strains of computer-generated music. If you wanted to move from one place to another, you would have to gauge which part of the constant flow of people was moving in which direction, and you would shoulder your way into the

proper stream and go with it until you reached your destination. Almost every one of the nearly two hundred exhibitors had packed booths. Particularly Processor Technology, which was running Steve Dompier's "Target" game on Sol computers. People were also pushing into IMSAI's booth to get biorhythms charted. And right there at the entrance, the wave of the future, was Apple, running a kaleidoscopic video graphics program on a huge Advent display monitor. "It was crazy," Randy Wigginton, who was working in the booth with Woz and Chris Espinosa and the others, later recalled. "Everybody was coming by and asking for demonstrations, and it was fun because people were excited about it."

It wasn't only the Apple that people were excited about. It was the triumph of the hardware hackers in making their passion into an industry. You could see the excitement as people looked around disbelievingly at their sheer numbers all these people? and there was a huge roar when Jim Warren got on the public-address system and announced the attendance the weekend's total was almost thirteen thousand. He was immediately followed by *Computer Lib* author Ted Nelson, feeling no doubt like a once lonesome guru who in one fell swoop was united with a sea of disciples. "This is Captain Kirk," Nelson said. "Prepare for blastoff!"

Warren himself was long past lift-off. He shot around the Faire on a pair of roller skates, marveling at how far the movement had come. For him, as for the people at Apple, Processor Technology, and dozens of other places, this success had very welcome financial implications; soon after the Faire was over, after recovering from a period of what he would later call "ecstatic collapse," Warren would be considering whether to sink his profits into a Mercedes SL. He would finally decide to buy forty acres of land he was coveting in the hills overlooking Woodside, and within a few years he would have built a huge wooden structure with a redwood deck and hot tub overlooking the Pacific; it would be his home and computerized work quarters, from which a staff of over a dozen would prepare a small empire of publications and computer shows. Jim Warren understood the future.

The first Computer Faire was to the hardware hackers an event comparable to Woodstock in the movement of the sixties. Like the concert at Max Yasgur's farm, this was both a cultural vindication and a signal that the movement had gotten so big that it no longer belonged to its progenitors. The latter revelation was slow to sink in. Everyone was flying, moving from booth to booth, seeing all sorts of ground-breaking hardware and mind-blowing software, meeting people you could swap subroutines and wire-wrapping schemes with, and attending some of the nearly one hundred workshops, which included Lee Felsenstein on the Community Memory movement, Tom Pittman on computer languages, Bob Kahn on the Lawrence Hall of Science computing program, Marc LeBrun on computer music, and Ted Nelson on the triumphant future.

Nelson was one of the keynote speakers at a banquet held at the nearby St. Francis Hotel. The name of his talk was "Those Unforgettable Next Two Years," and looking over that mass of people drawn by micros, he opened by saying, "Here we are at the brink of a new world. Small computers are about to remake our society, and you know it." As far as Nelson was concerned, the battle was won the hackers had overthrown the evil Prophet. "IBM will be in disarray," Nelson crowed. It was truly a wonderful world about to unfold:

For now, though, the dinky computers are working magic enough. They will bring about changes in society as radical as those brought about by the telephone or the automobile. The little computers are here, you can buy them on your plastic charge card, and the available accessories include disc storage, graphic displays, interactive games, programmable turtles that draw pictures on butcher paper, and goodness knows what else. Here we have all the makings of a fad, it is fast blossoming into a cult, and soon it will mature into a full-blown consumer market.

FAD! CULT! CONSUMER MARKET! The rush will be on. The American manufacturing publicity machine will go ape. American society will go out of its gourd. And the next two years will be unforgettable.
