



U.S. Deputy Secretary of Defense, David Packard, 1969. (COURTESY OF HEWLETT-PACKARD COMPANY. REPRINTED BY PERMISSION.)

The HP-35 pocket scientific calculator,  
one of the great tech inventions.

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into a flat reader, and used it to detect the magnetic ink code on a passing check. This invention too sold in huge numbers.

But the biggest g-time invention, the one that changed modern civilization, would come later, in the mid-seventies, when a young HPer at the company's new Advanced Products Division in Cupertino, Steve Wozniak, would use HP time and tools to invent—the personal computer.

## HP's Greatest Product

In a very short time, Bill Hewlett had created a maverick innovative environment at Hewlett-Packard. Now it began to pay off. The middle-aged company suddenly felt young again—and ready to stir things up.

The opportunity came soon thereafter.

The four years since the introduction of the HP 9100 desktop computer had seen major changes in the calculator industry, and not just at Hewlett-Packard. At HP, the Loveland, Colorado, division (where the desktop computing operation had been transferred) had continued to evolve the original 9100 design into a new generation of much more sophisticated scientific desktop calculators.

This 9810/20/30 family was not only capable of much more powerful computing than the original 9100, but was also able—thanks to the HP-IB interfacing protocol—to operate multiple peripheral devices, or be plugged directly into laboratory or factory automation systems. This quickly made HP desktop computers the new workhorses of labs and assembly lines around the world—and, as originally planned, helped to further spur the sale of compatible HP test and measurement instruments.

But if HP owned the high-end desktop business, the low end—the descendants of the original four-function adding machines—was a near-chaos of dozens of competitors all scrapping for market share and facing oblivion in an inevitable shakeout. Among the players in this market were not only industry veterans such as Texas Instruments and Friden, and newcomers such as Bowmar, but a whole new generation of Japanese electronics companies—notably Sharp, Canon, and Sanyo—that saw these high-volume, low-priced devices as a way to break into the U.S. consumer electronics business.

The result was high tech's first consumer electronics bubble, with each competitor trying to capture customers with lower prices, smaller designs, and superior marketing. By the end of the 1960s, some of these companies even had secret design projects under way to build true handheld calculators. By 1969, TI was able to show a prototype four-function calculator, code-

named "Cal-Tech," that would even fit in one's pocket. At about the same time, Sharp announced a new "portable" calculator that would use the newest generation of large-scale integration (LSI) logic and memory chips. Moore's law had come to calculators—and, ironically, calculators were about to come to the home of Gordon Moore himself, Intel Corp.

It was an also-ran in the calculator wars, the Japanese company Busicom, which unconsciously sparked the creation of the so-called product of the century and changed the high-tech world forever. Busicom had struggled to keep up with its bigger competitors even during the good times. Now, as the downturn loomed, its executives concluded that the company's only hope of survival was to bet everything on one roll of the dice: convince a U.S. chip maker to come up with a custom calculator chip set with the smallest possible number of chips. If this could be done, Busicom might be able to leapfrog its competitors both in downsizing the product and cutting costs.

The company approached two U.S. semiconductor makers, Mostek and Intel; and while the former would eventually become Busicom's supplier, it was Intel that made the revolution. A team that included Ted Hoff, Stan Mazor, Federico Faggin, and Busicom's own Masatoshi Shima set out in October 1969 to build a four-chip package that would perform all of the functions of a basic calculator and more.

It took them a year, but the result, the 4004, proved to be more than just a chip set for a calculator. It was, in fact, the first microprocessor, the long-dreamed-of "computer on a chip," and, billions of units and a dozen generations later, the defining invention of the modern world. Within months after completing the 4004, Intel created the 8-bit 8008 and, in 1972, the epochal Intel 8080, the direct ancestor of the Pentium family and almost every other microprocessor on the planet. Luckily for history, Busicom didn't want the 4004 and reverted the rights to Intel—a decision that has proven to be worth (to date) more than \$100 billion to Intel.

None of these changes were lost on Hewlett-Packard. Tom Osborne had not forgotten the comment Hewlett had made that day they showed the 9100A to An Wang: that he wanted the next machine to be "a tenth the cost, a tenth the size, and be ten times faster than the HP 9100." Instead, the 9800 family had stayed the same size, and about the same price, and grown at least one hundred times more powerful.

But even if Osborne had forgotten Hewlett's challenge, Bill Hewlett had not. Osborne recalled, "I knew he was serious, but we were kept hostage by the lack of low-power integrated circuits."<sup>23</sup> Without those chips, it seemed impossible to build a multifunction, battery-powered, handheld scientific calculator. But that didn't keep Hewlett from regularly asking about the progress of the project: "I was visited regularly by Bill Hewlett who wanted to know

why we were not working on the calculator he had prescribed. The pressure cooker would have been hotter had Mr. Packard not been in Washington at the Department of Defense. Nonetheless, when he did visit the labs, he asked the same question.”<sup>24</sup> Luckily for the oppressed Osborne, in 1971, before Dave Packard came home to make his life even more miserable, he came across an article in a trade magazine. It described how Mostek was using a new fabrication process called ion implantation to create chips that required only a tiny fraction of the usual amount of current to operate. (Ironically, Mostek was building these chips for the next—and final—generation of Busicom calculators.) With these chips, Osborne knew he could build a handheld 9100. On the very day he read the article, he went to Bill Hewlett and told him that now, three years later, HP could finally build the calculator Hewlett wanted.

Then, as company legend has it, Osborne asked Bill what size he thought the new calculator should be. Hewlett pondered for a moment, then pointed at the chest pocket of his white, short-sleeved dress shirt. Small enough to fit in that pocket, he said.

Osborne had his marching orders. He quickly contacted the team he wanted to design the device, his old friend Paul Stoft and the HP Labs design team led by Tom Whitney.

I knew I would have a bit of trouble getting the project staffed because Paul Stoft, Tom Whitney, and Tom’s engineers were hard at work on a briefcase-sized something-or-other. This was one of a very few times that I used whatever power I had to pressure Paul and Tom to change their minds about what they wanted to be doing for the next couple of years. I told them that if they were sure we could not do a shirt pocket calculator, then they would have to explain their reasons to Bill Hewlett—because I had already told him that we could do it. During the next few days, they decided that it just might be possible.<sup>25</sup>

It was a remarkable moment. In less than a week, an outside contractor presents a radically new product, based on a largely unproven technology, to the CEO of a \$500 million firm with 20,000 employees, gets an immediate green light, and then redirects one of the company’s top design teams to take on the project. The phrase “agile corporation” wouldn’t be invented for another quarter century, but Hewlett-Packard during this era already personified it.

It was only after the team was assembled and under way that Osborne and his group made a wonderful discovery. Over at HP Associates, the company’s components division, another team had just spent two years working with a Phoenix company named Unidynamics to create the keyboard and display for

a radically new calculator design. This team had spent two years coming up with a number of innovations, including an inexpensive photoconductor keyboard of spectacular reliability, and a low-power LED display that would be magnified by an optical screen, all part of a larger effort to help Unidynamics come up with a four-function calculator (with some added functions hidden in memory for future use) the size of a pack of cigarettes for just \$200—half the price and size of the competition's best.

HPA gave the client everything it asked for—only to have Unidynamics suddenly and without warning cancel the project. The reason? Unidynamics never explained, but it is likely that its market research had estimated a total market for the new calculator of just 10,000 units. In fact, given that it would have been a year ahead of the market, Unidynamics likely would have sold as many as 100,000 of the planned calculator. Historian John Minck, who was part of that team, explained what happened next—and offers a glimpse of how the HP Way's philosophy of trustworthiness affected even the company's internal communications:

Once we confirmed that the project was clearly cancelled, we felt we were released from our self-imposed HPA rules about revealing any sales details to other HP entities. We always held such information strictly confidential during our contract periods. In the components business, such technical and business details were sacrosanct. If another HP entity should discover any such details about a competitor, we would lose all credibility.<sup>26</sup>

This is a very long way from the standard business practices of the rest of Silicon Valley during this period.

Now unleashed from any commitment to Unidynamics, Minck drafted a memo to HP Labs that laid out the nature of the planned calculator and the breakthroughs HPA had already accomplished to help realize it. Serendipitously, one of the scientists on the routing of that memo, dated January 27, 1970, was Paul Stoft. So, twenty months later, when Tom Osborne came calling with the idea for a pocket scientific calculator, Stoft already knew that half of the technical obstacles to such a device were already solved.

Looking back, Osborne would describe the creation of this new calculator as one of the happiest times of his working career:

The HP35 project was just plain fun. We knew it would work (the algorithms were similar to those in the HP 9100) so we spent a lot of time deciding whether the arithmetic keys should be on the right or the left, and whether the “+” key should follow the convention of adding machines

and be placed in the lower right corner, or whether it should be located where it is most convenient. As I recall, we did not seem to be the least bit worried about the fact that we were going to be the first people to have non-standard key spacing. After all, if the thing was to fit in a shirt pocket, the keys had to be crunched together.

. . . The [calculator's] design-to-production cycle was incredibly short for a product of that complexity. We got the official go ahead on Ground Hog's day (Feb. 2) and demonstrated working machines to the Board of Directors in August. I still do not know how it happened in such a short time. I remember being busy, but I do not recall having had any major hang-ups.<sup>27</sup>

Perhaps not for Tom Osborne, but over at HPA the calculator team had to break through one problem after another. One of the biggest came with the realization that Whitney's team would only be willing to pay \$1.05 for each digit on the LED display—and that it would cost HPA \$5 each to build them.

The only solution was to upgrade HPA's Gallium Arsenide Phosphide lab to produce cheaper chips. But that promised to be a \$500,000 investment—more than that team had ever asked for at one time. And that would need approval from Bill Hewlett himself.

What the HPA didn't know was at that moment their odds of getting approval just got infinitely lower. With initial estimates that the new scientific calculator might cost as much as \$350 to build, almost double the average price of standard calculators currently on the market, Hewlett had ordered a market research study on potential sales for a high-end calculator. The results weren't heartening—even at \$395, the proposed calculator was likely to generate sales of just 1,000 units per month as best. Bill Terry, who was now vice president of the HP Instrument Group, recalled:

One day the phone rang and Hewlett says, "We've got this calculator going on at HP labs." So I went up and talked to Bill and he gave me the market research report that suggested we shouldn't do it. [It's going to cost] twenty times more than a slide rule.

Then, Bill said, "I want one of these things."<sup>28</sup>

That was it. Looking at market research that offered an even worse prediction than the one that had scared off Unidynamics, his partner a continent away, at the head of a company dragging itself out of recession, Bill Hewlett had made the decision to spend HP's talent and fortune on a project that might, even if it proved possible to build, never find customers.

It was Hewlett's riskiest and bravest business decision. And it is likely that he was the only person at HP who could have made it. Even Dave Packard, with his preference for playing within his game, likely would have killed the project (though once he heard that Bill had made the decision, he stood behind his partner 100 percent).

But Hewlett during this period, like Steve Jobs at Apple a decade later, was so perfectly attuned to HP's market that their interests and desires were almost congruent: at that moment, Bill Hewlett knew that if he liked some new piece of technology, such as this calculator, hundreds of thousands of other scientists and engineers out there would too.\*

Did he make the right choice? History says it was a decision of genius. But in the context of the HP Way and the HP Corporate Objectives, it could also be deemed foolhardy and dangerous. But that's why Dave Packard was there: to keep Bill Hewlett from chasing new ideas for their own sake. Just as Bill was there to make sure that Dave remained open to new ideas.

Now that Hewlett had made up his mind to pursue the calculator project, there would be no stopping him. The goal now was to remove any obstacles in the path of Whitney's team getting the prototype built.

Meanwhile, the nervous HPA team held one last meeting before presenting its proposal for a new \$500,000 lab. Beyond the potential sales of the new, improved LEDs to the calculator group, the division's marketing people had convinced themselves that there might be another, outside, market for the stand-alone displays. How big? They had no idea. Finally, division manager Dave Weindorf announced abruptly, "What the hell, let's make it a proposal for a cool three-quarters of a million."<sup>29</sup>

The team quickly rejigged the numbers and, the next day, went to see Hewlett. Like the founders of the division had a dozen years before, they had prepared an elaborate presentation justifying both the project and its price tag. And like Packard had then, Hewlett now waved them off. According to Minck:

We had our arguments well-honed and practiced. . . . [But] after five minutes of preliminaries, presenting our executive summary, Bill stopped us, saying, "I've got another meeting, so is there anything else important that I should know? If not, let's go with it."

It was by far the easiest project I have ever sold.<sup>30</sup>

Now it was up to Tom Whitney and his crew, notably Dave Cochran, the unsung hero of the project, who was in charge of designing all of the "algorithms" (the simple mathematical steps that produced the complex functions)

for the calculator. As for Tom Osborne, unlike the 9100, his involvement in the actual circuit design of the new calculator was minimal. Rather, he focused on what functions the device should feature and making sure the final design would lend itself to what he saw as its natural follow-up: a programmable calculator.

Yet even choosing the functions for the calculator proved complicated, largely because of the endless meddling of both Hewlett and Barney Oliver. It continued right up until the moment Whitney had to send the final integrated circuit masks to the semiconductor fabricators. Finally, in exasperation, Whitney sent a memo to all concerned saying that he had reserved a meeting room for the entire day, and the group would meet to “freeze the keyboard functions to everyone’s satisfaction.”<sup>31</sup>

It did, in fact, take all day to reach an agreement; but at last everyone signed their signature to the document. Exhausted, Whitney walked back to his office to put the final touches on the paperwork in preparation for sending it off in the morning. He arrived to find the phone ringing. It was Barney Oliver: “I’ve got another idea.”

“Too late,” said Whitney and hung up.

Almost instantly, he had second thoughts. Oliver was, after all, not only the most brilliant person at HP, but also his *boss*. So he quickly put in a call to Bill Hewlett to explain what had just happened.

Go with the signed paper, Hewlett told him.<sup>32</sup>

That August, the prototype Osborne demonstrated to the HP board of directors, like the 9100 before it, was basically a finished but empty calculator case with a cable coming out of the top to a larger box containing the actual working components. But it was enough to amaze the board, and thrill Bill Hewlett.

Later, in a meeting with marketing, Hewlett went over possible names for the calculator. The brainstormed titles ranged from the mundane (The Math Marvel) to the silly (Captain Billy’s Whiz Bang Machine)—four pages of names in all, and not one of them a winner.<sup>33</sup> Finally, Osborne turned to Hewlett and asked, “Do you have any preference?”

Bill looked at the machine for a minute or so and said, “Let’s call it the HP 35.” It sounded OK to me, but why the 35? He smiled and said, “Well, it has 35 keys.”<sup>34</sup>

And that was it. The HP-35, according to *Forbes ASAP* magazine one of the twenty products that changed the modern world, had its name. To those involved in its creation, the calculator seemed like an almost mystical experi-

ence. Osborne recalled, “Looking back, it seems as if the HP-35 had a life of its own. It simply chose HP as its birthplace.”<sup>35</sup>

## Retailing a Revolution

Creating the HP-35 calculator was one thing; selling it was another. Within Hewlett-Packard there were serious doubts, even among the legions of HPers who quickly fell in love with the little marvel, whether there would be enough of a market for the device to escape serious losses, much less break even. Not only did the market research predict failure, but the very eccentricity of the HP-35, a product of all those internal battles over functionality, argued against public acceptance as well.

For example, the HP-35 featured tiny keys in a nonstandard pattern, as well as a computational language, called Reverse Polish Notation, that sounded like a joke. RPN was, in fact, an extremely efficient way to string together multiple operations without the need for traditional parentheses, equal signs, and other formatting. But it was also counterintuitive to anyone (that is, every one of HP’s engineer customers) who had grown up with traditional arithmetic. For example, in RPN,  $2 + 2 =$  became  $2\ 2\ +$ . It was as if Alexander Graham Bell had invented the telephone and then demanded that people only speak Hittite when they used it.

And yet none of that seemed to matter, because once they saw the HP-35, people simply *had to own it*. It was the first great example of digital consumer product hysteria, an augur of what was to come with video games, digital watches, the Macintosh, Windows, and iPod. Orders for the HP-35 poured in so fast that manufacturing at Hewlett-Packard was quickly overwhelmed—creating shortages that only fanned the flames of demand. A secondary market appeared of people who were lucky enough to have scored an HP-35 early, and were now reselling it at inflated prices. People sold their cars, fudged requisitions, and skipped meals to buy an HP-35. On college campuses around the world, a market HP had considered minor for such an expensive tool, ownership of an HP-35 was the zenith of cool in the engineering and science departments.

So great was demand for the HP-35 that even a black market formed for machines that had been stolen off lab tables and office desks—even ripped right out of the hands of astonished owners. The theft rate was so great at NASA and other big research laboratories that those organizations began putting the HP-35 into locking cradles fixed to tabletops—the 1970s

equivalent of the books chained to walls in medieval libraries. When the U.S. Army refused to honor purchase orders for such an expensive item, the scientists at the White Sands Proving Ground, seeing extra money still in the training budget, merely announced a new course in "Reverse Polish Notation Scientific Computers." The tuition fee: \$500, which included a new HP-35 "training tool."

But the HP-35 was more than just a precious novelty. It is hard to gauge just how great was the *cultural* impact of the calculator on both HP and, frankly, the modern world. For thousands of young people, the HP-35 was a glimpse of just how miraculous high technology had become. Here was an invention they could hold in their hands that had as much computing power as the million-dollar, room-sized computers they had seen in movies, such as had been used just a decade before to put a man in space.

Even Tom Osborne found himself overwhelmed. On a visit to Washington, he stopped by the Smithsonian to take a look at ENIAC, the first important American digital computer, built in the early 1940s to compute artillery trajectories. With 18,000 vacuum tubes, it was the size of a house—so big that technicians ran around in bathing suits inside its glowing racks replacing tubes that burned out on average every twelve minutes. As he read ENIAC's performance specifications, Osborne was staggered with the realization that the little HP-35 he had in his coat pocket was more powerful, and immensely more reliable, than the behemoth in front of him.

The HP-35 would eventually join ENIAC on display at the Smithsonian.

One young man in Silicon Valley who was especially affected by the HP-35 was a brilliant young computer programmer named Steve Wozniak. Woz had just dropped out of the University of Colorado at Boulder and was attending a local junior college just a few blocks from his old high school and trying to get his life back together. He had built a celebrated four-function calculator while still in junior high school, and now, seeing the HP-35—"I just drooled seeing that thing"<sup>36</sup>—he had an epiphany. Though it had long been assumed that he would follow his father in working at Lockheed, Wozniak decided that his future belonged with Hewlett-Packard, working on calculators and computers.

Though none of the others would go on to invent the personal computer, thousands of other young people were drawn into the sciences by the ease with which the HP-35 could cut through what had been laborious calculations. In the meantime, two of the most venerable of all technology businesses, with centuries of enduring success behind them—slide rules and books of scientific tables—died seemingly overnight. The HP-35, John Minck would write, was "not only a prestigious personal possession, but an amazing drudgery beater. It made better engineers, and it made them faster and more efficient."<sup>37</sup>

The prediction had been for, at most, 1,000 HP-35s sold per month. The reality was an order of magnitude greater: 10,000 per month, and the number would have been even higher had HP been able to build them. In the end, it would take eighteen months for Hewlett-Packard to finally catch up with demand—and by then, the company had the HP-35's nearly as famous successor already in the pipeline, ready to set off another rush. By the time the scientific calculator finally merged into the PC in the early 1990s, the HP-35 and its descendants would sell more than 20 million units for Hewlett-Packard, making them the most popular products in the company's history. Said Bill Terry, "Bill was willing to take a risk—and boy was he right."<sup>38</sup>

## Selling Uncertainty

For good and bad, the HP-35 also taught Hewlett-Packard something about consumer marketing and retailing. Thanks to the efforts over the course of thirty years by Noel Eldred, Russ Berg, and Dave Kirby, as well as the company's veteran PR, advertising, and marketing professionals, HP knew how to sell technology to technologists about as well as anybody.

But the breakout of the HP-35 changed everything. Before that, the height of clever marketing at the company had been Barney Oliver's inspired decision to send, preintroduction, HP-35s to fifty Nobel Prize winners. A few months later, the company looked up to find itself selling calculators to college kids, even teenagers. And HP had little idea of even how to *talk* to these consumers.

On the sales side, salesmen, marketing types, even group VP Bill Terry fanned out to talk to retailers and learn something about selling to consumers. They got an earful. Remembered Packard:

Bill Terry vividly recall[ed] going to Macy's department store in San Francisco. Macy's, at that time, was interested in building an electronics department. Bill remembers showing the calculator, eliciting interest, striking a deal on the price, then starting to talk about order and delivery schedules.

At that point the Macy's manager placed both hands squarely on the table in front of him, looked Bill in the eye, and said, "You young boys don't understand. I don't sell anything unless I have it in the store." That was our initiation into the consumer market.<sup>39</sup>

HP had always been either a contract supplier of equipment or a one-off catalog seller. Now it had to learn how to build for inventory, to keep retailers' shelves replenished, and to budget for returns. It was training that would

serve the company well in another twenty years with inkjet printers and personal computers.

Meanwhile, HP advertising also found itself in a brave new world of consumer promotion: student discounts, back-to-school promotions, expensive consumer media print advertising, packaging, point-of-sale promotion, four-color brochures—all of the standard tools for promoting to mass audiences. It was not something HP took to easily, and it would be many years before the company's advertising looked like more than tweaked-up trade press marketing.

HP corporate PR faced its own challenges. The good news was that the HP-35 didn't need much promoting: the world's media came to Hewlett-Packard for stories on the little miracle. But for the first time, the company found itself barraged with requests for review models, donations, sponsorships of everything from America's Cup yachts to dirt-bike racers, and free gifts for the rich and famous. For thirty years, the only people who had requested free HP instruments were trade magazine reporters who were often as technically astute as HP's own engineers. Now, HP public relations found itself dealing with reporters who took review machines and never returned them, or, in one case, plugged it into the power cord of his electric shaver, blew up the calculator, taped it into a standard envelope, and mailed it back to HP demanding another one.

Public relations learned to be patient and as accommodating as possible to all of these requests. Still, it did draw the line at sponsorships—mostly because Kirby and his team were fearful of an image on the nightly news of the sole surviving remnant of a burning land speed record contender or the floating shard of an exploded hydroplane bearing the HP logo.

It was only after the HP-35 had been on the market for a few months that HP public relations began to hear some extraordinary stories about the little calculator—and quickly began to turn those tales into a series of popular press releases. It seemed that, thanks to the overengineering of almost every part of the HP-35, especially the keyboard and the high-impact plastic case, the calculator was astonishingly durable. Stories began to come in about HP-35s being bounced off the backs of motorcycles at seventy miles per hour, dropped into a bucket of molten lead, frozen in a pond over the winter—and when finally retrieved, even as a twisted lump of plastic, having an uncanny ability to still work.

This only added to the HP-35 legend, especially when HP PR began to distribute these survival stories to the media. The success of these releases led Kirby and his team to embark a series of “application” stories about how the HP-35, and later, other HP products, were being used in unusual real-life applications from determining medication dosages in emergency rooms to

calculating flight paths of bush pilots to directing the operations of giant earthmoving equipment.

These features, which would eventually number in the hundreds (and would be Hewlett-Packard's most enduring contribution to the PR profession), enabled HP to be the first high-tech company to reach beyond the electronics trade press into the mainstream media. Before long, stories of the HP-35 and its descendants were appearing in everything from *Time* magazine to the *National Enquirer*.\*

Meanwhile, over at HP Labs, the HP-35's creators were also learning some important lessons from their little machine—mostly about duplicity. Dave Cochran, the algorithm expert, found himself at gatherings with potential future competitors from Bowmar and Texas Instruments, equally clever and competitive mathematicians, whose reputations rose and fell in their profession with whoever came up with the most elegant and powerful equations. But at the same time, all were also scouting competitive information for their employers. Minck recounts:

It became a kind of chess game. They might tell about a new algorithm idea, but might salt-in traps and false leads to put the other company on the wrong track. Naturally, there were advantages to be gained in talking together since, often, it established industry standards and processes, and it was an arcane art. Yet, all information had to be taken with huge caution. Did we gain more than we lost? Knowing Cochran, I suspect we gained a lot more.<sup>40</sup>

Tom Osborne, as the best-known name connected with the HP-35 project, found himself in an even brighter spotlight. As the HP-35 was being finalized, heedful of his promise to Bill Hewlett to put the power of an HP desktop computer in one's pocket, Osborne took it upon himself to fight for certain specifications in the calculator that would lend itself to a more powerful follow-up machine. In particular, he intended for this next calculator, unlike the HP-35, to be fully programmable.

## Calculating Opportunities

The astounding success of the HP-35 not only immediately green-lighted Osborne's follow-up plan, but also drew a host of competitors hungry for a piece of the huge new market. In the end, three different calculator models would enter the design phase. Two of them, the HP-45, a more powerful version of

the original, and the HP-55, a programmable calculator, were already anticipated by the analysts, customers, and competitors.

But it was the third, the HP-65, that Osborne knew would be the company's next great product, and the linchpin of HP's future dominance in the calculator business. What made the HP-65 revolutionary was that it was not only programmable, but it featured a tiny magnetic card reader. Users could simply feed a narrow strip of plastic, containing a complex application program (that is, a series of mathematical equations, rather than a computer's programming code), into a slot in the side of the HP-65 behind the display, and the calculator would then be programmed to perform the operation. Even better, users could write their own programs, run a blank strip through the HP-65, and preserve their application for future use.

There was simply nothing in the world like the HP-65, and Osborne knew it. He decided to protect the crown jewels, even if it meant violating the HP Way: "By that time, everyone in the calculator business was aiming at HP. I knew they would be second guessing what we were doing, so at a convention at which I was a speaker, I somewhat intentionally misled the competition by telling them that to just have a programmable calculator was inadequate. The programs had to be easily loaded into the machine."<sup>41</sup>

So far, so honest—but then Osborne decided to send the competition on a wild goose chase. To the assembled, he dissembled: "Keying them in once is OK, but successive loadings should come from a magnetic media, like an external tape reader (at the time we were designing an internal card reader into the HP 65). When we introduced the HP 65 with its tiny internal mag reader, I could hear the competitor's projects fall by the wayside."<sup>42</sup>

If anyone at HP knew beforehand about Osborne's planned misrepresentation, they didn't stop him. It wasn't in the spirit of the HP Way, but it worked. If anything, the HP-65 made an even bigger explosion on the market than the HP-35. Consumers were now prepared for something new, and the HP-65 delivered. Even the \$695 retail price didn't scare them away—on the contrary, demand had now become so inelastic for HP calculators that the higher price merely made the calculator more exclusive and desirable.\*

The HP-65 was destined for the Smithsonian too. And with good reason. It was not only a masterpiece of compact, reliable design, but it radically enhanced the productivity of professionals from scientists and engineers to doctors and educators. It also brought, for the first time, the power of programming into the everyday working world—thus setting the stage for the personal computer. So influential, in fact, was the HP-65 that it became emblematic of the entire electronics industry in the early 1970s. And, if anything, the hysteria surrounding it—thefts, cooked books, students selling their possessions to own one, reporters scamming "review" copies—was even greater.

And HP's PR, advertising, and marketing operations, now with some experience, had a field day getting the story out.

As was standard practice at HP, as the HP-35 had rolled out of HP Labs and into manufacturing, the company had created a new division to manage it. HP's Advanced Products Division was located a few miles from headquarters in Cupertino, in an anonymous leased building across the street from HP's new computer division campus.

If the computer operation was classic HP, from the cubicles to the standardized building and grounds, APD was anything but. In retrospect, it was the prototype of the next generation of Valley entrepreneurs, and one that still survives at places such as Google and eBay: offices filled with toys and tchotchkes, endless practical jokes, all-night work sessions, active rebellion against company dress codes and management hierarchies—all of the Triumph of the Nerds corporate culture that would soon capture the world's imagination a few blocks away at the newly founded Apple Computer.

This wasn't a coincidence. One of the new young hires at APD was Steve Wozniak, who quickly used his salary and employee discount to buy an HP-65—the calculator he would sell (along with Steve Jobs's VW van) to finance the founding of Apple. And Apple itself was a company that Wozniak and Jobs self-consciously modeled after those things—the HP Way, the spirit of innovation, and the culture of APD—they most admired at Hewlett-Packard. (Jobs, in fact, was so much in thrall of HP that he presented Woz's credentials as his own—including a fabricated claim that he worked on the HP-35 project—to get a job at Atari.) Wozniak recalled, "It was just something magic. Designing the products, laying them out, doing the software work—and we were all part of the same thing, working together. And we knew while we were working together that we would take care of each other—and boy that sure influenced my thinking."<sup>43</sup>

Wozniak worked for HP for less than four years. Yet the experience never left him—and years later, for all of his fame from his time at Apple, he seemed to gravitate back to Hewlett-Packard as representing one of the happiest times of his life. This is somewhat surprising, given that his tenure there was marked first by sleep deprivation and distraction, and then by the most disappointing experience of his early career.

One reason Wozniak was so happy at APD was that he was able to work with a childhood friend, Bill Fernandez, the now all but forgotten third player in the creation of Apple Computer. The other was the HP-65, a machine that instantly captured his heart:

Woz, who was naturally inclined toward finding the most economic and compact solution to any electronics design problem, found the HP-65 a

revelation. "It's got this little chip and serial registers and an instruction set," he would later recall thinking. "Except for its I/O [input/output] it's a computer, the love of my life." Studying the HP-65's design, he got his first clue that it might now be possible to enter that middle ground of computation from the other direction as well.<sup>44</sup>

Happy with his work and life, Wozniak rented an apartment and settled into what he hoped to be a long and rewarding career as a Hewlett-Packard technician—and in time, with luck, an engineer. As a hobby, he set up at home a Dial-a-Joke phone line, and through it met a woman and soon thereafter married her. In every way, Steve Wozniak looked to be an up-and-coming member of the new, third generation of HPers.

But it wasn't to be—and though what happened next was certainly unique, it still offers a glimpse into the changing nature of the electronics industry, entrepreneurship, and Hewlett-Packard's growing struggle to remain relevant in this new business world.

In Wozniak's case, as everyone knows, he ran into a Pied Piper, another childhood friend named Steve Jobs. Jobs was manipulative, brilliant, obnoxious, and a born entrepreneur. And he too had had his brush with Hewlett-Packard. While still in high school, Jobs had taken some Stanford courses taught at HP and open to the public. There he had made his name as a fearless (and tireless) questioner of instructors after class.

At age sixteen, not long after he had met Wozniak and began helping him build an early (failed) computer, Jobs gave the first glimpse of his future self when, the team being short of components, he got on the phone and called Bill Hewlett to hustle free parts:

Hewlett, a great engineer and an even greater entrepreneur, was at this point one of the most powerful businessmen in America and on the way to becoming a multi-billionaire. Forty thousand people reported to him from HP divisions and sales offices in nearly one hundred countries.

It speaks volumes that, even as a teenager, Steven Jobs could detect a soft touch in Hewlett and then contact him directly (and even more volumes that Hewlett would answer the call). Once he had Hewlett on the line, Jobs made his pitch. Remarkably, though also characteristically, Hewlett agreed. [He] was never one to turn down a student.

But once Steve Jobs scored, he wasn't about to stop there. He also pitched Hewlett for a summer job at HP. He got that too, ending up on the assembly line at HP's plant in Cupertino, building computers. The experience was so compelling that Steven even tried to design a computer of his own—a notion he quickly abandoned as too difficult.<sup>45</sup>

Now, after a sojourn at an ashram in India, Jobs was working at the hot new video game company, Atari. Moreover, he had talked its flamboyant founder, Nolan Bushnell, into letting him design a computer game. Bushnell didn't think the odd young man could pull it off, but sensing a kindred entrepreneur, he decided to give him a chance.

But Jobs had an ace in the hole: Steve Wozniak, who was already spending many evenings after work in the Atari game room trying out new products. Jobs had just four days to create the game, to be called "Breakout," and having no real ability to actually create such a product, he prevailed upon his friend to help him. As Woz already had a day job at HP, he agreed to work in shifts: Jobs would work all day, and Woz all night.

In the end, to Bushnell's astonishment, Jobs delivered the game. No mention was made of Wozniak's role; nor did Jobs honestly split the money he was paid for the project. Nevertheless, a partnership was born.

Two threads—his work at HP on programmable calculators, and, beginning with Atari, a growing interest in programming for consumer applications—were beginning to knit together in Wozniak's life. Within months the third, and most crucial, thread would appear. Around the San Francisco Bay Area, a growing number of young people, obsessed with computers thanks to university data processing centers, time-share terminals, and not least, HP desktop computers, were beginning to talk with each other about the prospect of building their own computers.

In due time, the most committed of these computer fanatics formed an organization called the Homebrew Computer Club. It met each month, first in yet another Silicon Valley garage, this one also a few blocks from Stanford, then eventually in a lecture hall at the Stanford Linear Accelerator offices. There they swapped notes, helped each other through design bottlenecks—and ultimately showed off their newly built computers to one another in an ongoing game of intellectual one-upmanship.

Wozniak was drawn to this crowd (Jobs had moved to Oregon) and soon became a mainstay of Homebrew, the go-to guy for the really tough design problems. He seemed to have a genius, no doubt enhanced by his work on calculators, for being able to find the cheapest, simplest, and smallest design solutions, solutions that awed even his peers.

It was inevitable that Wozniak would once again (he'd tried once before in high school) build his own computer, and that he would show it to Homebrew. He spent much of his spare time in the second half of 1975 preparing to do just that. Jobs, now back in the Valley, saw Woz's work and, sensing a business opportunity, spurred him on.

Thanks in no small part to his HP "g-time," Woz finished what would be the Apple I prototype that December. But before he took it to Homebrew, he

decided to first show it to his bosses at Hewlett-Packard in hopes that HP might decide to build it.

As it turned out, he wasn't the only Homebrewer at APD: his workmate Myron Tuttle was also working on a personal computer prototype—one that even contained the same second-rate microprocessor that Woz had bought on the cheap. When Tuttle saw Wozniak's design he instantly recognized that it was far superior to his own, and offered to help Woz present it to their supervisor.

In January 1976, the two young men, along with a third technician, made the presentation to their boss. This is how Wozniak remembered that meeting thirty years later:

As soon as Steve Jobs suggested, "Why don't we sell a PC board of this computer?" I said, "I think I signed something, an employment contract, that said what I designed belongs to Hewlett-Packard." And I loved that company. That was my company for life.

So I approached Hewlett-Packard first. Boy, did I make a pitch. I wanted them to do it. I had the Apple I, and I had a description of what the Apple II could do. I spoke of color. I described an \$800 machine that ran BASIC (an early computer language), came out of the box fully built and talked to your home TV. And Hewlett-Packard found some reasons it couldn't be a Hewlett-Packard product.<sup>46</sup>

Tuttle would remember the meeting slightly differently: "It was one of those informal meetings. It wasn't a big deal. We just sort of asked for five minutes and showed Woz's board. We were told, 'HP doesn't want to be in that kind of market.'"<sup>47</sup>

From this has come the Silicon Valley's legend of HP's Great Lost Opportunity. The young hippie genius in its midst came up with the most valuable invention of the age—and hidebound old Hewlett-Packard, with its white shirts and skinny black ties, had looked at this bearded freak with his hand-built motherboard and dismissed him out of hand.

The truth is much more complicated, as anyone who walked the halls of the Advanced Products Division in 1976 would have known.

The fact was that the entire building was full of mavericks, many of them far more unusual than Wozniak—and their new product plans always got a hearing. Indeed, at that moment the division was a hotbed of new ideas, thanks to the announcement that APD would be leaving Cupertino and moving to Corvallis, Oregon. With the next generation of calculator designs already under way, and the division distracted with an imminent move (with all

that it entailed regarding selling and buying homes, transferring equipment, finishing the new Oregon facility), operations at APD had slowed considerably from the mad rush of the year before, and employees spent their empty hours coming up with new inventions.

In fact, it can be said that Silicon Valley would not see anything like HP's Advanced Products Division until—Apple Computer itself.

Thus, by the time Wozniak made their presentation, it is very likely that APD management had already seen similar proposals, and already come to some conclusions. It is also probable that both the computer division across the street in Cupertino and the desktop computer division in Loveland, Colorado, were also contemplating the same idea.

That this was indeed the case is suggested by the supervisor's remark: the decision that HP "doesn't want to be in that kind of market" was not likely made by a divisional department supervisor, but had been made earlier by senior management after extensive consideration. Wozniak and Tuttle, unknowingly, had walked in late to the conversation.

In fact, there were very good reasons why HP wasn't prepared to take on a brand-new consumer market in personal computing, the biggest being that the company was still learning how to sell calculators to that same market, how to set up a viable distribution system to retailers, and how to deal with millions of technically inexperienced customers. HP simply couldn't afford at that moment to throw another new product category into the mix.

But the decisive arguments against the claim that Hewlett-Packard was too out of touch to recognize a brilliant new idea like the Apple I, are other HP products of the era, especially those coming out of APD. Both the HP-35 and HP-65 were revolutionary products, in many ways much more innovative than the Apple I, which was essentially a budget minicomputer featuring some inspired design work. On top of that, even as Wozniak was making his pitch, APD had another product in the works, a calculator-watch, code-named Cricket, that was even more radical in its ambitions than Woz's prototype.

Finally, there is one last factor to be remembered. As brilliant as Steve Wozniak's design was, there were other, nearly as brilliant, personal computer designs coming out of places like the Homebrew Computer Club. And most used better processors, such as the Intel 8080, and were thus far more powerful. In the end, what made Apple unique was not Wozniak, though his contributions were considerable, but the marketing savvy and charisma of Steve Jobs. And Jobs was not in that January meeting; on the contrary, he was trying to pull Wozniak the other way.

All of that having been said, the ultimate truth about that historic meeting

was that, however lackadaisical the supervisor may have seemed, word of young Steve Wozniak's invention reached the top of the company, indeed to Bill Hewlett himself.

At the end of April Wozniak gave up and filed a formal memo to HP's legal department requesting a release of his technology (followed a few days later by a schematic of this "Microprocessor System," with the footnote, "Apple Computer Co. is a partnership of myself and Steve Jobs founded to market PC boards"). Over the next two weeks HP's general counsel, J. C. Chognard, ran Wozniak's request past every HP division. There were no takers. Wozniak got his release. It was Hewlett himself who signed it.

To the last moment, Steve Wozniak still believed that he would find a way to work with his friend Steve Jobs and continue to be an HPer for the rest of his career. But in the end, he couldn't do both, and the new company offered him a chance to be his own person and follow his computer dreams. In a symbolic moment, he sold his most cherished possession, his HP-65, and invested it as his share in the founding of Apple Computer.

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Did HP make a mistake in passing on the Apple I prototype? A decade later, when Apple had captured the world's imagination with the Macintosh computer and one of the most successful IPOs in business history—and Woz's design was properly acknowledged as one of the great technology inventions—it certainly seemed so. HP was still struggling to find an attractive PC design and a workable business strategy, and was looking to become a perennial also-ran in the business.

But three decades on, when the myth of the Lost Opportunity is fixed in the public's mind (if they remember the beginnings of the PC industry at all), the answer is very different. HP at last found its footing in personal computers and had passed Apple in industry market share by the mid-1990s. By the thirtieth anniversary of that fateful meeting, HP was now the world's second largest personal computer maker, its market share four times that of Apple, and its total revenues and profits over those intervening years far outstripping that of its more notorious competitor.

## Lost in the Woods

If Hewlett-Packard made a major mistake with its Advanced Products Division in the mid-1970s, it wasn't with Steve Wozniak, but rather in moving the operation to Corvallis, Oregon.