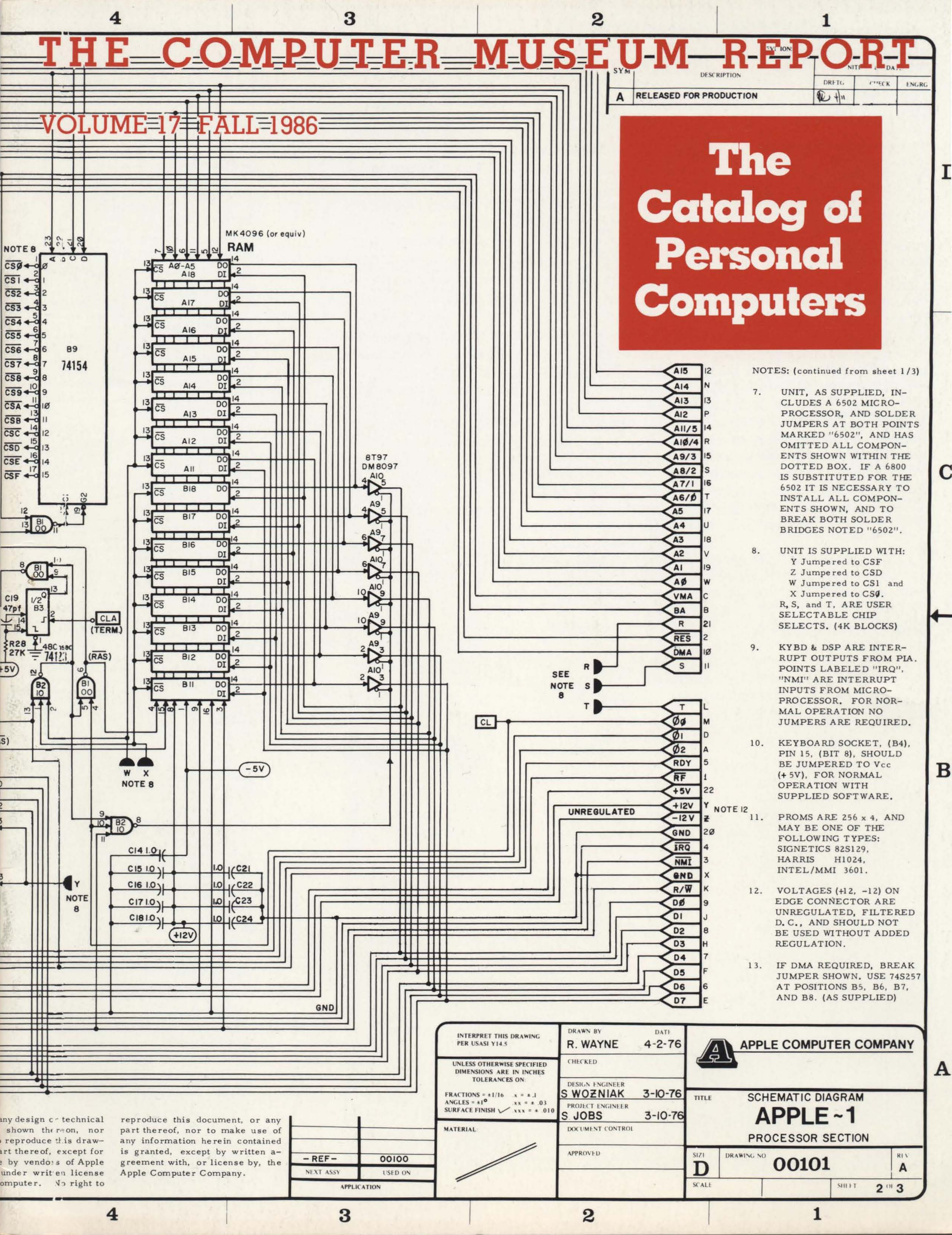
THE COMPUTER MUSEUM REPORT

VOLUME 17 FALL 1986

The Catalog of Personal Computers



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The Early Model Personal Computer Contest

Oliver Strimpel

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Cover

Schematic of the processor section of the Apple 1 computer.
See article on page **3** and photograph of the Apple 1 board on page **6**.
Reproduced from Apple 1 Operation Manual, Courtesy of Apple Computer.
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The Computer Museum

The Computer Museum is a non-profit 501(c)3 foundation that chronicles the evolution of information processing through exhibitions, archives, publications, research, and programs.

Museum Hours: The Museum hours are 10 AM-6PM, Tuesday-Thursday, Saturday, and Sunday, and 10 AM-9 PM Friday. It is Closed Mondays, Christmas, New Years, and Thanksgiving.

Membership: All members receive a membership card, free subscription to The Computer Museum Report, a 10% discount on merchandise from The Computer Museum Store, free admission and invitations to Museum previews. For more information, contact Membership Coordinator at The Computer Museum, 300 Congress Street, Boston, MA 02210. (617) 426-2800.

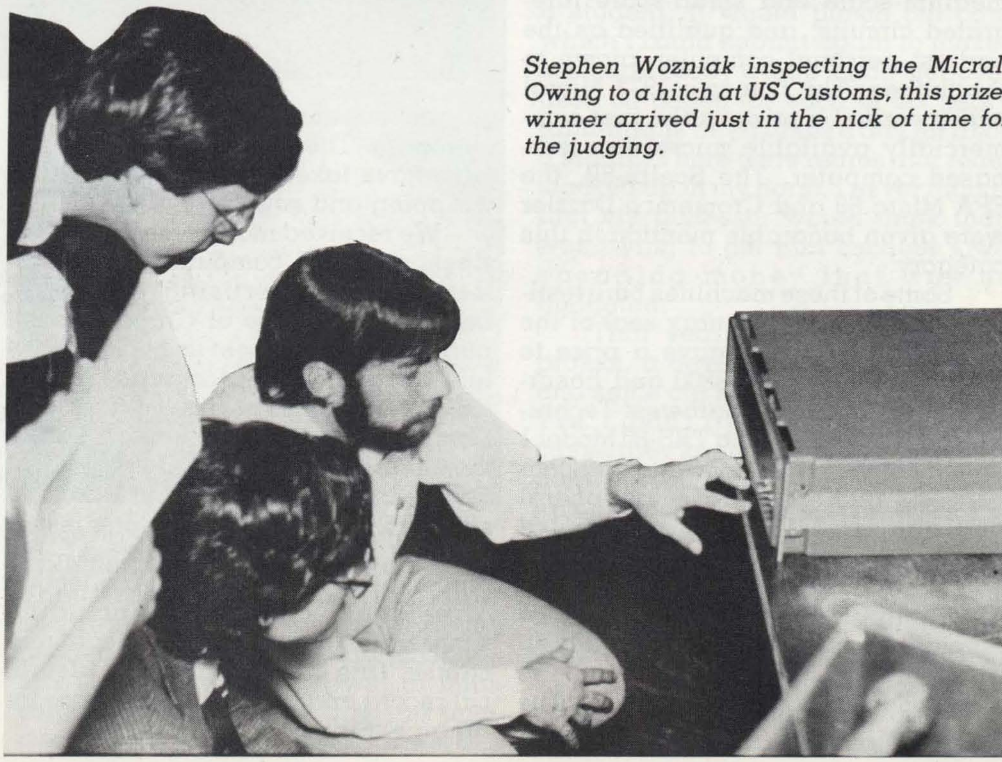
Every year the Fall issue of The Computer Museum Report features the Museum's collections. This issue constitutes a complete catalog of the Museum's collection of personal computer hardware as of July 1986. Collected artifacts not relating to personal computers will be listed next year. It follows a somewhat unusual collecting event—the Early Model Personal Computer Contest.

In the Spring of 1985, William Millard, then chairman of ComputerLand, toured the Museum with Pat McGovern, chairman of CW Communications, the world's largest publisher of computer trade magazines, and Gwen Bell, Museum President. Millard noticed gaps in our collection of personal computers and asked how the Museum could remedy the situation before the early machines disappeared. Bell, half in jest, suggested a contest to find the earliest personal computers. Millard took up the idea enthusiastically and offered ComputerLand's support for the collection. McGovern offered to publicize the event and the contest was born.

From October 1985 to March 1986 advertisements appeared in CW Communications' magazines all over the world. The heading ran—"Wanted: Old Thinker-toys". Phil Lemmons, editor-in-chief of *Byte* magazine also put out the call in *Byte's* tenth anniversary issue.

Offers flooded in—320 in all from 13 countries. The early US commercial machines, topped by the Altair 8800's (13 offers) were well represented. There were also many offers of one-of-a-kind homebrew machines and single-board computers, mostly still in full working order. Perhaps the most bizarre offer came from Argentina—a manuscript dating from around 1800 containing a card punched with holes. Said to be from Marie Antoinette imprisoned in the Bastille, it contained a coded message to her supporters outside the prison. Overall the response from abroad was disappointing; the collection still needs foreign enrichment.

A total of 137 items were accepted. The remainder were declined to avoid excessive duplication, or because they did not really fall into the categories collected by the Museum. The donors shipped their items to us for the final judging by Stephen Wozniak, designer of the Apple II and co-founder of Apple Computer, David Bunnell, an early MITS employee and current publisher



Stephen Wozniak inspecting the Micral. Owing to a hitch at US Customs, this prize-winner arrived just in the nick of time for the judging.

of *PC World*, and myself. It was on this occasion that Wozniak announced his intention to donate his personal collection of hardware and notebooks to the Museum. He also gave a public lecture to a packed house after the judging. We include his talk in this issue as the story behind the machine that epitomized the spectacular growth of personal computing—the Apple II.

In defining the personal computer, we excluded plastic or cardboard educational and toy kit 'computers' (such as CARDIAC, BRANIAC and GENIAC), as well as programmable calculators. We were impressed by machines in several categories. First, there were the highly original designs that had significant impact on the development of the technology. Don Lancaster's TV Typewriter and Lee Felsenstein's Visual Display Module paved the way to the keyboard and screen interface now universal on personal computers. They were each awarded a prize.

Next there were the early commercial products, bold design and packaging efforts. We awarded the first prize to the 1971 Kenbak-1, submitted by its creator John Blankenbaker. This small machine contained an eight-bit processor built up from medium-scale and small-scale integrated circuits, and qualified as the earliest personal computer known to the judges. Thi Truong's 1973 Micral was awarded a prize as the first commercially available microprocessor-based computer. The Scelbi-8B, the EPA Micro 68 and Cromemco Dazzler were given honorable mention in this category.

Some of these machines bore testimony to the extraordinary zeal of the early hobbyists. We gave a prize to Robert Pond's Altair 8800 and honorable mentions to a Southwest Technical Products 6800 and a TRS-80 Model 1 which came complete with every conceivable add-on board or peripheral and with extensive, well documented software collections. One Altair had even been time-shared!

Lastly there were the homebrew machines, some indicating that builders had gone to enormous lengths to make useful machines at low cost. The computer based on an RGS-008 kit gained honorable mention for completeness. There were machines that must have taken solid weeks of wire-wrapping and soldering to assemble.

We received many offers of magazines, personal computer club newsletters and advertising literature. David Ahl, founder of *Creative Computing* magazine, sent us his large collection of personal computer periodicals. Volunteers from the Boston Computer Society are piecing together the offers to create complete periodical runs. The collections of literature and software will be listed in a later issue.

The contest was a success—the Museum now has a very fine collection of personal computers, including some little known, but significant machines. This provides a unique historical record and a valuable resource for future exhibits.

The winners were flown to the Museum for "Personal Computer Pioneers Day" and presented with engraved silicon wafer medals. From left to right: John V. Blankenbaker (Kenbak-1), Robert Pond (Altair 8800 hobbyist), Lee Felsenstein (prototype VDM-1) and Thi T. Truong (Micral). Don Lancaster (prototype TVT-1) was unable to attend the prize-giving.

Stephen Wozniak

The Making of an Engineer and a Computer

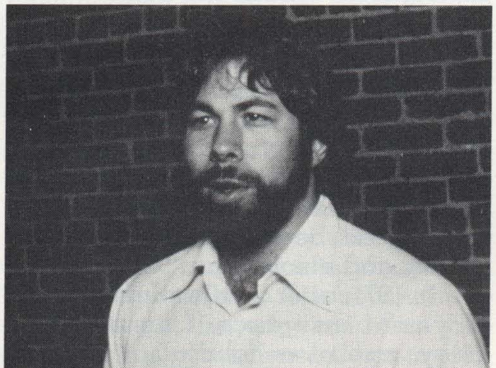
I was lucky as a kid because my Mom and Dad got me to do science fair projects, tell jokes, and have fun. I knew I'd get an electronics project for Christmas. I'd sneak down the night before and open up the packages (then close them up again). It was sort of like exploring a computer system without getting caught. In sixth grade my hero was Tom Swift who used his resourcefulness with technology to do good. The kids on my block wired house-to-house intercoms, helped by the local electronics store where we hung out. We got someone to give us a ton of telephone wire and we just walked down the block hammering it to the fences and jumping into people's yards and burying it in the ground. When you're kids you don't understand that things are owned by others.

Mom gave me 35 cents a day for lunch. I didn't eat; I saved the money for a walky-talky. But I got nailed. The school had a lottery and I spent all the money on tickets. And I lost.

My father, an engineer, taught me how transistors work and got me interested in computers by giving me IEEE reports to read. This way I learned the basics of Boolean logic and built some adders/subtracters for science fair projects. By eighth grade I talked a company into giving me a few hundred transistors and diodes. I built some gates and figured out why they weren't working. It was a good head start.

By the time I got to high school, I was real fast on the slide rule and that helped me become the top math student. But when you're in math you don't take electronics, because you're in the college curriculum. Electronics was a shop course. Somehow a few people covered both. Neither the students nor the teachers in high school knew what a computer was and vacuum tube technology was still being taught. When I was a junior, a teacher said "we now have a computer and you can use it." I said, "Great- . . . what an opportunity." It was a little board that could be wired to create a relay. The teachers thought this was a computer!

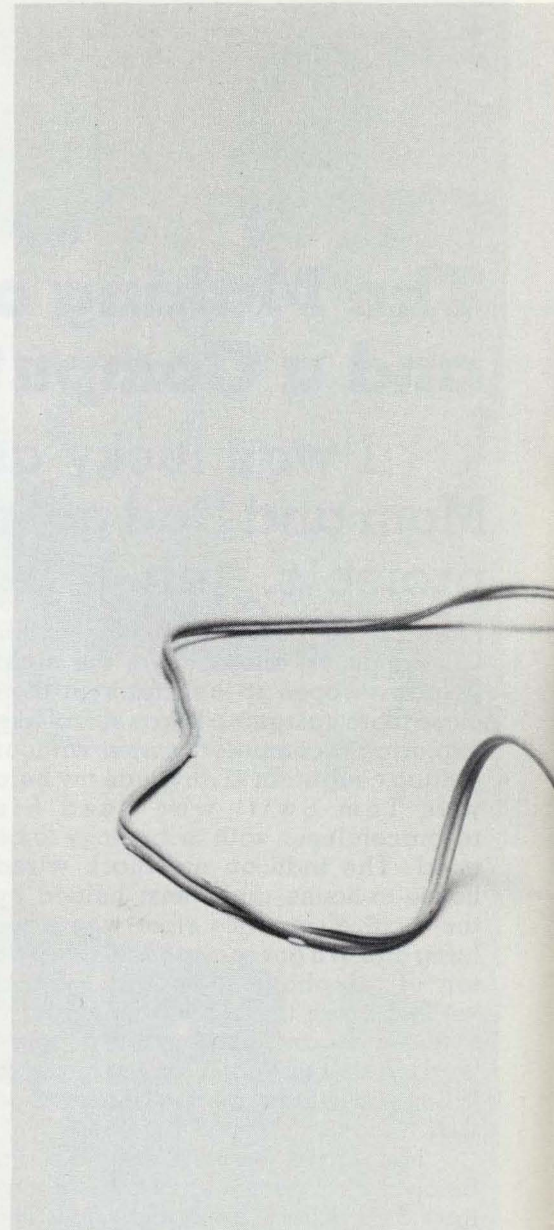
Then, I had a teacher who recognized that I needed something beyond what the school could provide. He had a couple of friends at Sylvania and arranged for me to go down once a week to program computers. They gave me a FORTRAN manual and I thought it was the neatest thing in the world. Then one day, I saw *The Small Computer Handbook* on someone's desk. It described DEC's PDP-8. I read it from



cover to cover learning about binary arithmetic, how ands and ors work, about registers, instruction sets, sequencing, and everything you needed to know to build a minicomputer. Later, when the growth of minicomputers started exploding, my favorite machine was Data General's NOVA. I started to design my own versions of it. Sometimes it would take 20 pages to design a floating point add. Then I tried to make the design smaller and smaller. Every time a company, like Fairchild, would come out with a new chip, I'd go back and re-design the NOVA using that chip. I'd make the design better and better using fewer chips. If I could have afforded building any of these machines, I would have stopped designing and learning. The reward was in improving a design.

In 1968, I headed off to the University of Colorado where I signed up for a computer class. This gave me the opportunity to sign up for computer time by using my student number. I didn't understand that computer time was charged for. As a kid I really didn't know about accounting principles—and I was still a kid. I was put on probation for computer abuse. I ran some programs that just printed scrap paper as fast as they could; others that ran every mathematical table that I could find—powers of two, inverse powers of two, and so on. Eventually my factorials would take more than a page and it would run 60 pages worth; that was what the CDC machine could do in under the minute that I was allowed as a student. It would punch out cards which I could submit again to make it start up exactly where it had stopped. I used 60 pages for each of six sets of tabulations three times a day for about a month. There were reams and reams stacked up in my dorm. I never thought that my professor would think that I was trying to get him because I was spending money that was unbudgeted.

That year I built my first video project, a device out of one transistor and some old radio parts that jammed TVs. I didn't try it out in my dorm because they knew me. I went to another dorm, sat in the TV room and started to jam the picture. A friend, in on the gag, went up to the TV, hit it, and I unjammed the picture. Each time I'd jam it, my friend would have to hit it harder and harder. Everyone understands that when an inanimate object doesn't work you just hit it. I discovered in that age of peace-loving anti-war college students that you could turn any group



Blue Box, 1972

Inspired by the "phone phreak" hero Captain Crunch, Steve Jobs and Stephen Wozniak built their own tone generators to make free calls. Known as blue boxes, they were sold in the dormitories of the University of California at Berkeley where Wozniak was an undergraduate. The particular box shown here was demonstrated to a packed roomful of students performing the legendary experiment of calling around the world to a phone in the next room. The signals had to travel over such a great distance that there was sufficient delay for a person to walk over to the receiving phone to hear his own voice. Following this demonstration, Richard Prelinger bought the box for $120.

The box used a crystal oscillator and was switched on or off simply by inserting or removing the plug leading to the earpiece. The early boxes were equipped with a safety feature—a reed switch inside the housing operated by a magnet taped onto the outside of the box. Should the phone phreak be apprehended, the magnet could be removed quickly, whereupon the blue box would generate distorted off-frequency tones rendering it inoperable. "You tell them it's just a music box", said Wozniak. The taped-on magnet is visible on the bottom right side of the box.

Gift of Richard Prelinger

into animals just by jamming the TV set. One time I jammed it and someone said the TV repairman had been in and had said it was the antenna. So he held the antenna up in the air, and the set was perfect, but only for a couple of minutes, then it went bad again. The guy held it up higher. Same scenario. When it went bad, he stood up on a chair, and it worked, for a while. Up on his tiptoes it worked; down on his heels it didn't work. On another occasion they discovered if you touched the set in a weird position —hand on set and leg on the chair—it worked. He said, "It's a grounding effect." And they watched the last half hour of Mission Impossible with a hand on the middle of the TV.

The computer class was very large. The professor would lecture to a quarter of the students and the rest would watch on TV monitors in another room. I built the TV jammer into a magic marker pen and took it to class. The class started and I jammed the TV. Three teaching assistants stood up, looked us over and I was scared. Then, before I paniced, someone picked up his books and started to leave early. He was near the worst jammed TV. As he got up the TV started to go in and out, until as he walked out the door it was perfect. I learned that whatever prank you do, make someone else get the credit.

My second year of college was in Cupertino. They had an IBM 360. I took some computer courses that gave me no credit at all, but they were what I wanted to take. I met a computer operator and I found that as an insider he had keys and passwords. We would go in late at night and run programs. By sliding a piece of paper over the official record on the console printer, we prevented our jobs from being recorded. One night the manager of the center came in at about 2 AM and found me alone in the computer room. I was scared because he didn't even know me. I said, "Larry went out for the pizza."

To pay for my third year of college, I went to work for a mini-computer company. It had a great machine with 64 terminals that could run FORTRAN and other programs. But the company was hit by the recession and went under. It was surprising for me to learn that people could invest two million dollars in a company and it couldn't make it.

In my spare time a friend and I built "The Cream Soda Computer", because we drank cream soda while we put it together from spare parts given to us by another company. The friend that helped me build it, introduced me to another friend, Steve Jobs. We were introduced because we both liked pranks and electronics.

In 1971, after a little stint on unemployment insurance, I went to Berkeley, one of a handful of colleges offering computer science, for my third year of college. I took a course on writing assemblers and wanted to learn computing, read every manual, try every code, and learn every language. Getting grades or going to classes was of secondary importance. One time I signed up for ten courses and only went to five. Steve Jobs, a freer spirit, went off to Reed College in Oregon, where he only attended the courses that he wanted to, not the ones that he was registered for. Reed was also free and let him hang around for two years.

One day at my parents house, I read an article characterized as "fiction" about these weird phone phreaks who drove around the country in vans with racks of equipment in their buses, plugging into communications networks. The author, Captain Crunch, philosophized that exploring the phone system would improve it for Ma Bell. I fell in love with this philosophy. I wanted to explore a system and a computer and I didn't care about free calls. Half way through the article, I called Steve Jobs up and started to read it to him. Suddenly I realized there were too many details in the article—frequencies of 700 hertz and 900 hertz. They gave too much information. It's too real. These are not things that a fiction writer can make up. My source for material at the time was the Stanford Linear Accelerator; I knew I could always get in there on the weekend. With those high end research types, the door was never locked. Steve and I went to the library and

started to research the phone system. We discovered that the frequencies mentioned in the article were correct. Now we knew that we could build a box and make free phone calls all over the world. We even managed to meet the author of the article, Captain Crunch. I was so pure about the philosophy of the phone company as a system, that I paid for my phone calls home. Then, late at night, I'd call every country in the world. I showed it off. I told phone jokes. I sold blue boxes on the campus. I just wondered how far I could get. But I was still pure, I paid for everything I should pay for—I was just using unused wires. It was disappointing when I found out that the phone phreaks were not pure.

After that year at Berkeley I had to take another year off to work and earn enough money to go back to college. I got a job as an engineer at Hewlett Packard designing scientific calculators, an incredibly good product that bypassed slide rules. My career kept going up. While it's widely reported that I'm a college dropout, that's not true. It just took ten years until I had enough money to finish.

I started to get away from computers. The blue boxes had been fun. Then I heard about "Dial-a-Joke" and I started the first one in the San Francisco area. In those days you could not own your own answering machine, you had to rent it from the phone company. Two thousand calls a day came into my machine to hear a Polish joke. Then the Polish/American Congress Incorporated in Chicago twice threatened me with law suits. I said, "How about Italian jokes?" They said, "Fine with us." Twelve years later the organization gave me their national heritage award.

One night after work, I walked into a bowling alley and I saw the first Pong game. It blew me away. I wanted one and since I knew TV sets and digital logic, I designed my own. Around that time, Steve Jobs got a temporary job at Atari. He introduced me to some of those people, but I wouldn't leave such a good company as HP for Atari. HP really cared about its employees and I just didn't feel like leaving, for any reason. On the side, Steve and I got a job to design the game Breakout for Nolan Bushnell at Atari.

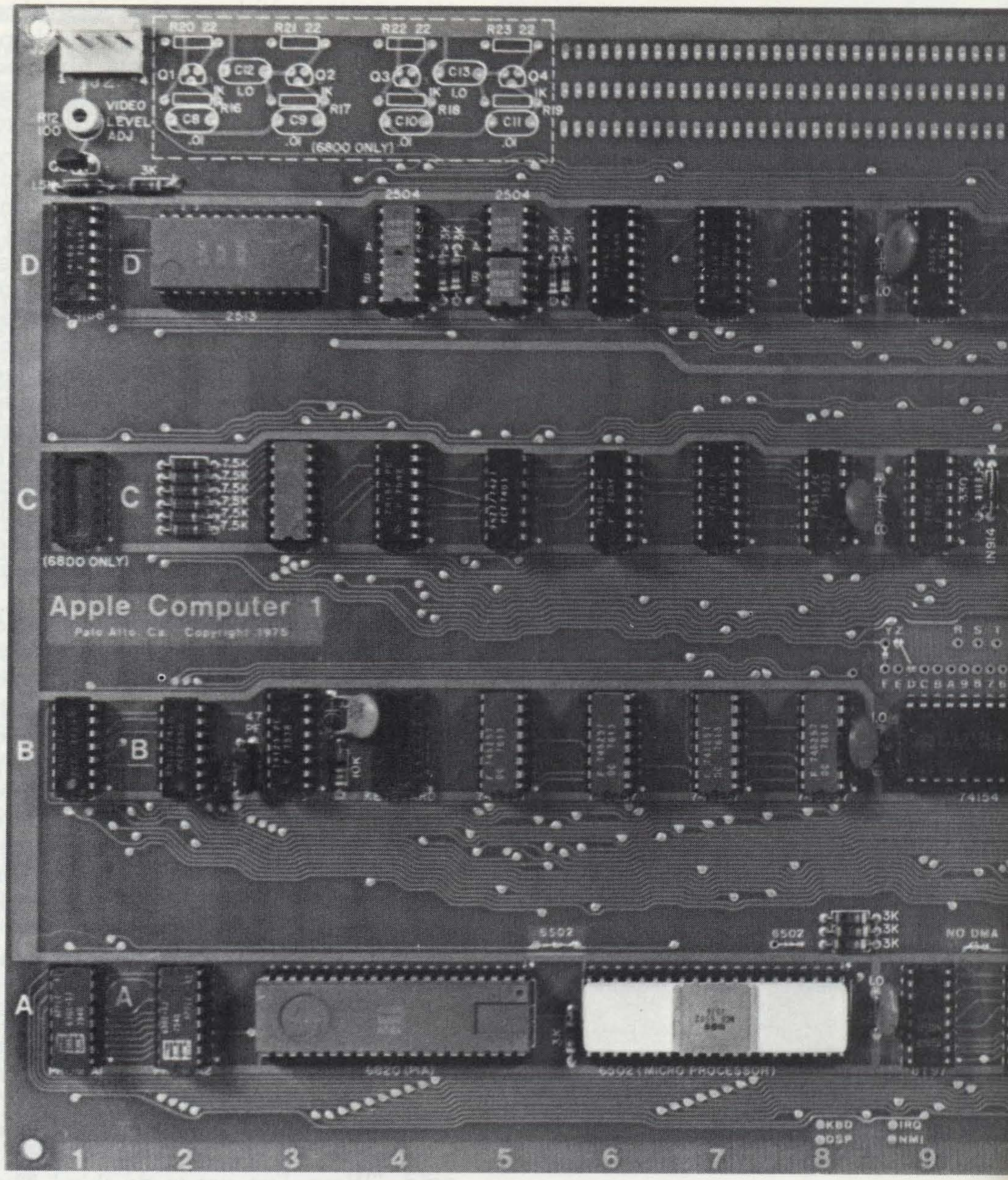
Then, one day, I went to see my old friend Captain Crunch who was in his basement on a teletype. He said, "I'm playing chess with someone at MIT." Then said, "Look I can log into all these computers." He was on the ARPANET. I said, "Wow, I've got to do this." The only way that I could afford it was to build a terminal. I designed a video terminal because the cheapest input output device was your own tv set. Later Captain Crunch was to go to prison for phone phreaking. The second time he got caught the judge said that if he ever did this again he would go to prison. He got the same judge the third time.

I had been out of the computer area for a while and I wasn't aware that the microprocessor had been introduced. A friend of mine, who had gone to MIT, called me up and said there was club starting up for people who had built terminals and things. Since I had just built a terminal and since I like to show off, I said, "Great, I've got to go to this meeting and show off my terminal." He didn't tell me it was a microcomputer club because if he had, I would have said, "I don't know anything." And I wouldn't have gone. I met a lot of interesting people there who were all talking about the new Altair Computer. Somehow everybody knew that some day they were going to own there own computer. I had decided back in high school in the sixties that I was going to own a personal computer—a 4K NOVA was what I really wanted. At the time, it was the cost of two Pintos and almost the cost of a home. This was a big thing to think: to have a computer instead of a home or a car. Now I discovered that there were people around who knew how to build affordable computers. And, I got back into the field by studying a microprocessor instruction set, the inner workings of the chip. I discovered a microprocessor was just like a minicomputer.

Over the next year, the club grew to five hundred members who met twice a week. We all worked for companies with mainframes—and submitted our decks of cards through the window and the computer priests would run the program. We'd try to crash the system because it wasn't ours. We were a group that had a purpose: the revolution of home computers. Byte Magazine started. In the beginning most home computers were sold as kits and you had to be a hobbyist who knew how to use a soldering iron and not be afraid to put one together. The members of our club were not high level managers; we ran around with holes in our jeans, and were a technical community who wanted their own computers. The club was based on sharing. Lee Felsenstein conducted our meetings. The first segment was called the mapping period. People offered information, material or discussed problems. For example, one of the members would ask, "Is there anyone here from AMI?" If no hands went up, he'd say, "I've got some chips to raffle off for the club." He gave the first Pong chip for your home Pong game to members of the club before Atari got it. Then, in the random access groups, people matched offers and problems.

I still could not afford a computer so I started to think about building one for myself. A new company called MOS Technology introduced a new microprocessor, the 8-bit 6502 costing $400. It was the finest microprocessor yet and they sold it over-the-counter at a show in San Francisco for $20—a very unique marketing step. A lot of folks from the club bought one and that night at the Homebrew Computer Club meeting it was a big topic.

A company called Sphere stopped



Apple 1, 1975

In designing the Apple 1, Wozniak squeezed as many functions as he could onto a single PC board. The upper two rows of integrated circuits constitute the video terminal he designed in 1974 to access mainframes remotely; it contains its own memory consisting of 7 1K dynamic shift registers and displays characters in a 5 by 7 matrix, with 40 characters per line, 24 lines per page and automatic scrolling. It interfaces to an ASCII encoded keyboard which is plugged into the empty socket at location B4. The video output and low voltage AC power sockets are at the top left corner. The lower two rows are the computer, shown in schematic form on the cover. The 6502 microprocessor is in the white package on the bottom row towards the left; the 16 chips on the right (A,B11-18) are 4K dynamic RAM's; 2 PROM's, containing the 256 byte resident system monitor program, are at the bottom left corner. The memory could be expanded to 65K via the edge connector on the right.
Gift of Dysan Corporation

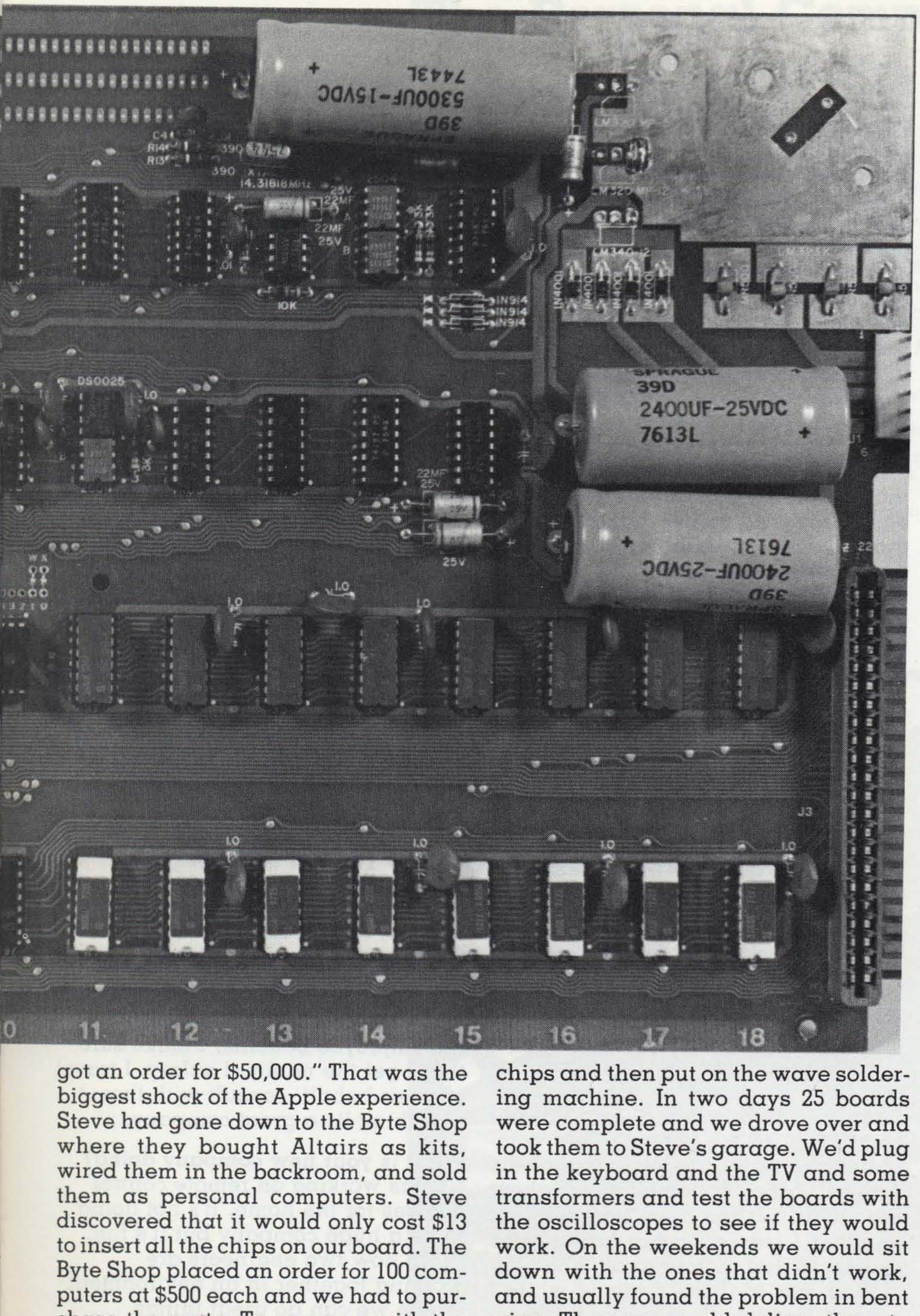
by our club meeting with a 16-bit minicomputer hooked up to a color monitor that spun a color clock around. To see a computer doing color on a video screen was beyond our imaginations. It was shocking. This was at the time that Microsoft BASIC was only available on paper tape for input via Teletype terminals. The first two attempts at color for personal computing came from the club: the Dazzler, built by Cromemco, and the Apple II computer.

Although I had a FORTRAN and ALGOL background, I saw that BASIC was going to be the language for personal computers. Within two months I wrote a BASIC that would run on the 6502. I wrote a simulator in ALGOL to see that it would work. I had to assemble the code by hand, because I didn't have a computer to work on. Once it was done, I put together what became known as the Apple 1. I worked hard and late to get it done before January when I was getting married. In late November 1975, I demonstrated the Apple 1 computer running BASIC. All it could do was a tab and a print.

I went to Hewlett Packard with the design and the costs and suggested that they manufacture and sell it for $800. My manager was intrigued with a machine that could run BASIC and have 4K of RAM that would sell for about the same price as HP's top-end calculators. He was especially interested since HP's desk-top machine sold for $5-8,000. He said no to the project in the end. But this took weeks.

One time when I was showing off the computer at the club, Steve Jobs came along and said, "Why don't we sell it?" I was passing out a lot of schematics and literature because a lot of people wanted to build one. Steve said, "Let's just make the PC board for $20 each and sell them at the club for $40." We figured we'd have to sell 50 to get our money back and we didn't think we could sell that many. Steve said, "We might not sell 50, but at least we'll have a company." Steve's motivation was to be like Nolan Bushnell. I was telling Steve about everything that microprocessors would do one day, which was everything that minis did. I bought a microprocessor for $20, a keyboard for $60, a few transformers for about $10 each, and picked up the integrated circuits from the lab stock at HP. The company has a written rule that any engineer can take chips from lab stock without cost for a project of their own design if their supervisor approves. The company feels that one learns by doing, and that the lowest level of management can decide.

One day Steve called me up at HP and said, "Guess what." "What?" "I



got an order for $50,000." That was the biggest shock of the Apple experience. Steve had gone down to the Byte Shop where they bought Altairs as kits, wired them in the backroom, and sold them as personal computers. Steve discovered that it would only cost $13 to insert all the chips on our board. The Byte Shop placed an order for 100 computers at $500 each and we had to purchase the parts. To come up with the money, I sold my HP-65 calculator for $500. However I knew we were coming out with the HP-67 the next month and my employee price would be $37, so I didn't take much risk. I still had my HP job as well. Steve went to the component suppliers and by showing the order asked for 30 days net credit. The chips were stocked in a closet at the company making the board. When the chips came out of the closet the 30 days started. When the pc boards came off the line, they would be stuffed with the chips and then put on the wave soldering machine. In two days 25 boards were complete and we drove over and took them to Steve's garage. We'd plug in the keyboard and the TV and some transformers and test the boards with the oscilloscopes to see if they would work. On the weekends we would sit down with the ones that didn't work, and usually found the problem in bent pins. Then we would deliver them to the local store and get paid. It was a ten day cycle. It's amazing what you can do when you have one level of management.

The Apple 1 design had few chips and was optimized for one board. The biggest decision was memory; the first 4K dynamic RAMS were about to come out. One principle that I had was "the fewer chips the better". After a discussion about chip size and number of pins, I decided that I would go for optimizing board size. When the 4K dynamic RAMS came out I could do in 4 chips what I used to do in 32. In 1975 several styles of 4K dynamic RAMS came out; the first set were from AMI and the second from Intel. The Apple 1 had the right RAM, a 16 pin Intel chip that led to a 16K RAM.

After I had my legal release for the machine and was selling Apple 1s, HP had a project called Capricorn—doing everything that I had just done. I went to the new lab manager and I said I'd do anything to work on the personal computer and he turned me down.

Steve and I went to Atari and asked if they would like it. They said, "No, the home video market is going to be very large." They were so friendly to us, that they let us buy chips for the Apple 1 right out of their warehouse. We went down to Commodore and talked to Chuck Peddle who was about to do the Pet Computer. Steve thought we might get a few hundred thousand dollars but they only offered us employment. All in all about 200 Apple 1's were sold out of the garage.

A few months later, I started to think about color. I made sure that the Apple 1 worked at the right speed so that color could be added. Things began to coalesce. I realized that I could combine video screen memory and processor memory and save chips. The Apple II design started to emerge. It would be twice as fast, do twice as many things, and have tons of memory. In the first days, I designed the Apple II to work with both 4 and 16K RAMS (because the 16K chips were still very expensive). There was an issue of slots for extra cards. How much do they matter? The only argument over the Apple II design was that Steve Jobs wanted two slots and I wanted eight because I was a little leery about locking into too little. So I sat down with Steve and said, "OK, I don't want the company." And we had eight slots. That was the end of it.

I decided to write the Atari game Breakout on a microprocessor, in BASIC not in hardware. So I wrote some commands in BASIC to put color dots on the screen and to make sounds come over a little speaker. It was shocking to me how much you could do in software and still run so much faster than hardware.

Originally Apple had three partners: Steve and I each had 45% and Ron Wayne, who helped with the manual, had 10%. Ron sold his 10% to us for $800. The Apple II looked like an outstanding product that could sell 1,000 a month. We thought we had hit the big one. The problem was that we didn't know how to build a thousand of something that cost $250 each. Where would we get $250,000 worth of credit? We had to look for money. People would come by the garage and ask, "What's the market?" I'd say, "A million." They'd say, "What makes you say that?" And I'd have too rational an answer: "There's a million ham radio operators and more people are getting into computers." There's no way that answer could be wrong but they weren't the right words. We got directed to Mike Markkula, who had wanted to build computers in the home for quite a while. He had left Intel with a lot of stock options and he was still young. He started developing a business plan and joined us as a third and equal partner. For a while I didn't want to leave Hewlett Packard. Then a friend said to me, "Steve, you can start this company, manage it and get rich. Or, Steve, you can start this company, stay an engineer all your life and get rich." I realized that I could still sit down and write code and build things, and that the company was just a way to make money. We hired a President who could get things done. Steve had a friend at Atari who could design switching power supplies which required less cooling than the regular type. Our phony reason for needing this was our belief that no computer should have a fan.

We started producing Apple II's. This was the first computer that you could take out of the box, plug in, read only a little bit and start typing, "playing" BASIC. It was the first computer to be in a plastic case; it was the first computer to come with video as standard; it was the first to build BASIC in ROM; it was the first low cost computer to come fully assembled; it was the first to have paddles and sound. Fortunately it had a lot of memory slots. While the world only wanted 4K bytes that year for anything, they thought maybe 8 sometime, but 48K bytes would never be needed. In the beginning, The Commodore, Radio Shack and Apple machines all sold in about equal numbers. Then, 8K programs started to come out and, in 1978, the first spreadsheet and floppy discs came out. Both needed more than 8K of RAM. The Apple was the one of the three that had expandable memory and could support spreadsheet or floppy control software. With Visicalc computers had a different flavor: now you could walk into a store and buy a computer with a solution. Our dreams of people controlling garage doors and keeping recipes were of much less importance.

A lot of things happened at Apple because one of the top managers had a pet project. One of Mike Markkula's pet ideas was that recipes and keeping track of the check-book were going to be principle uses. So he had Randy Wigginton (who was to write MacWrite in the future) write a check-book program in BASIC. Two things came out of that: a floating point BASIC to make it easier to write money handling programs, and the addition of a floppy disc to make the machine fast. The current practice had been to use cassette tapes that took three minutes to load a program after which you could add the data for two checks, and then download, which took another several minutes. We started to work on both projects. The floppy disc controllers at the time used about 50 chips. I had figured out a design with five chips and thought that I must be leaving important things out. But after a lot of analysis of other designs, I found that mine did even more. So I knew that I was onto a good winner: real fast, real small (based on the new 5 and a half inch disc from Shugart), and real cheap. From that time, Apple took off. We were backlogged for four months of orders and the path had been set.

We premiered the floppy disc at the first National Computer Conference in Dallas that allowed microcomputers to be shown. This completed the initial development of the Apple II. I don't remember much about the show, but the hotel was the first one that I stayed in that had movies you could dial in your room. I had designed one of these systems while I was at Hewlett Packard and I knew that it has to send your room number down to a computer. Travelling with our tools, we opened up the box and saw a bunch of switches. I just toggled in a different code on the switches and didn't get billed for the movies. Randy Wigginton and I looked at the touch-tone phone with different numbers for room service and so on. We took it apart and rewired the keypad to go vertically instead of horizontally.

QUESTIONS

There are some things that are inevitable in history and other things that depend on a unique individual. How do you feel about your role?
Almost everything would have happened about the same time. It turns out that my whole life was directed to one kind of computer design and when the window occurred, I was there. It was great luck for me.

What is it like to have to use an assumed name to go to college and to be a hero?
I used an assumed name and went back to Berkeley in 1981-2 for a full year. And I got away with it, because I wasn't known quite that well then. It was strange to read about myself. I couldn't understand why people would want to come up and shake my hand. Then I met Ted Turner who was my hero for challenging the networks and I asked him for his autograph. I now understand that we all want to have heros.

How do you feel about the Macintosh?
I love my Macintosh. I brought it on the trip. I dropped it in the San Francisco airport but it lived.

What's your relationship with Apple?
Since the computer keeps track of the employee benefits, I make sure that I get the minimal salary. I travel on their behalf, consult with them, and think its a great company.

What is your new company doing?
CL 9 is working on remote control devices for the home. It's not going to be a huge company but it's fun. Right now two engineers are working together in an environment where we can do great things.

The Personal Computer Collection

Complete Hardware Listing as of July 1986.

x-numbered artifacts constitute the permanent collection.

s-numbered artifacts are duplicates, retained for exhibits and loans.

Acorn Computers, Ltd.,
Acorn Atom,
Gift of Acorn Computers, Ltd. (X667.86)
Gift of Nigel H. Searle (S26)

Acorn Computers, Ltd.,
Acorn Electron, (X666.86)
Gift of Acorn Computers, Ltd.

Acorn Computers, Ltd.,
BBC Model B Microcomputer, with 6502 Second Processor, Z80 Second Processor, Acorn Data Recorder, Music 500 Synthesiser and Teletext Adapter, (X665.86)
Gift of Acorn Computers, Ltd.

APF Electronics, Inc.,
PeCos I, (X710.86)
Gift of Carl D. Hess

Apple Computer Company,
Apple 1, (X210.83)
Gift of Dysan Corporation

Apple Computer, Inc.,
Apple II Plus, (X539.84)
Gift of Katherine Schwartz

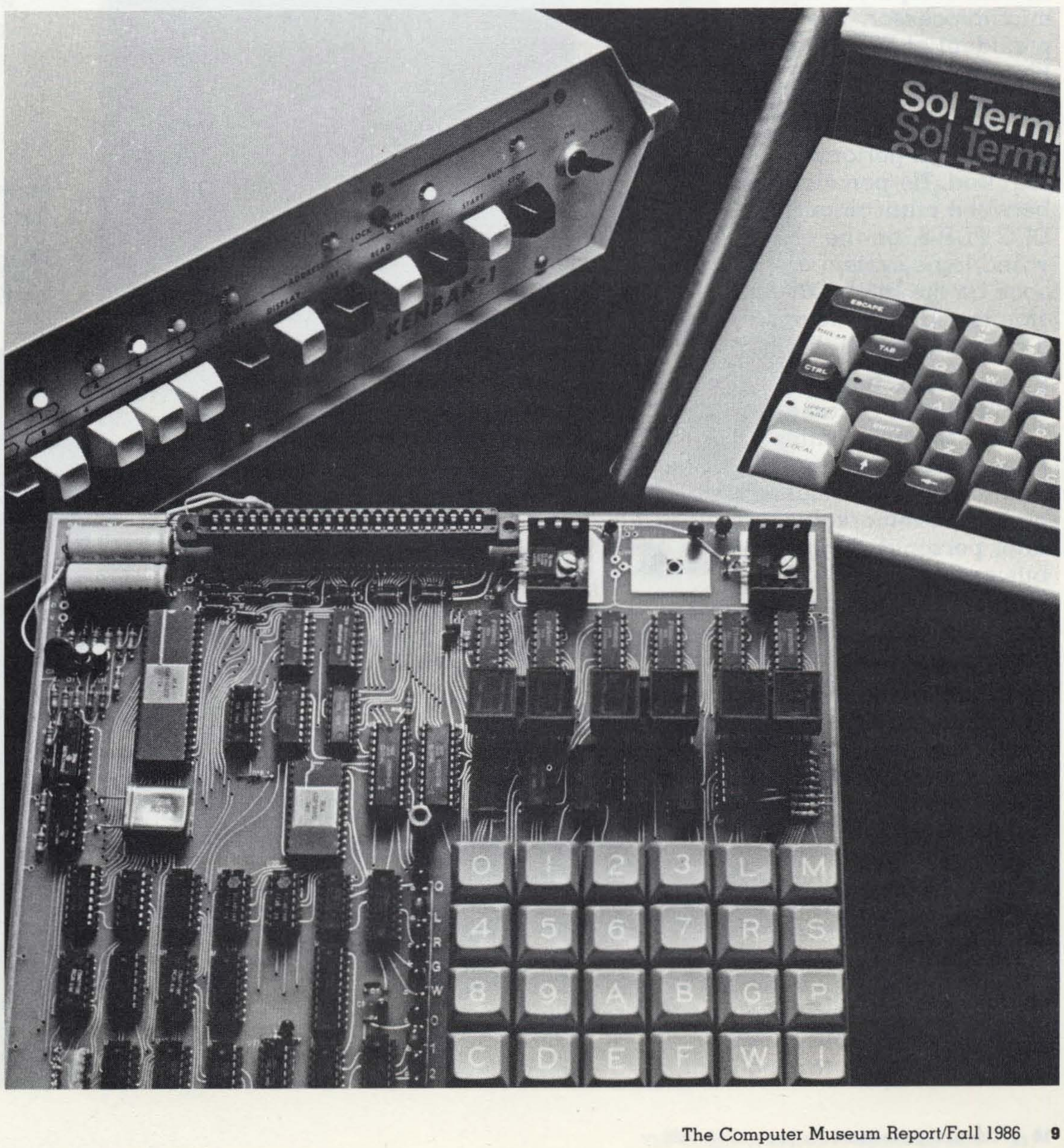
Apple Computer, Inc.,
Apple II, (X683.86)
Gift of Dr. and Mrs. Fred O. Smith and family

Apple Computer, Inc.,
Apple III, (X684.86)
Gift of Kenneth Dockser

Apple Computer, Inc.,
Apple Lisa, (X496.84, S48, S49)
Gift of Apple Computer, Inc.

Apple Computer, Inc.,
Apple Macintosh,
(X499.84, S50, S51)
Gift of Apple Computer, Inc.

AT&T Information Systems,
AT&T Personal Computer 6300,
(X639.85, S52, S53, S54)
Gift of AT&T



Bull Micral of America (formerly R2E of America), Micral, model XP/2, (X747.86)
Gift of Bull Corporation of America

Commodore Business Machines, Inc., Amiga, (X675.86)
Gift of Commodore Business Machines, Inc.

Commodore Business Machines, Inc., Commodore 64, (X366.84 A-E)
Gift of Commodore Business Machines, Inc.

Commodore Business Machines, Inc., Commodore PET 2001,
Gift of Commodore Business Machines, Inc. (X364.84)
Gift of Microsoft Corporation (S55)

Commodore Business Machines, Inc., VIC 1001 with Japanese keyboard, (X723.86)
Gift of Kenneth C. Barroll

Commodore Business Machines, Inc., Commodore VIC-20,
Gift of Commodore Business Machines, Inc. (X367.84)
Gift of Kenneth C. Barroll (S44)

Compaq Computer Corporation, Compaq DeskPro, (X481.84, S56, S57)
Gift of Compaq Computer Corporation

Compaq Computer Corporation, Compaq Portable, (X484.84, S58, S59)
Gift of Compaq Computer Corporation

Cromemco, Inc., Cromemco Dazzler boards (2), (X687.86)
Gift of Michael K. Lomax

Data General Corporation, Data General Desktop Model 10, (X479.84, S60)
Gift of Data General Corporation

Digital Equipment Corporation, Digital Professional 350, (X435.84)
Gift of Digital Equipment Corporation

Digital Equipment Corporation, Rainbow, (X476.84, S61, S62)
Gift of Digital Equipment Corporation

Digital Group, The, Digital Group System 2, (X555.85)
Gift of St. George's School, Newport, RI

Micral, by R2E, 1973

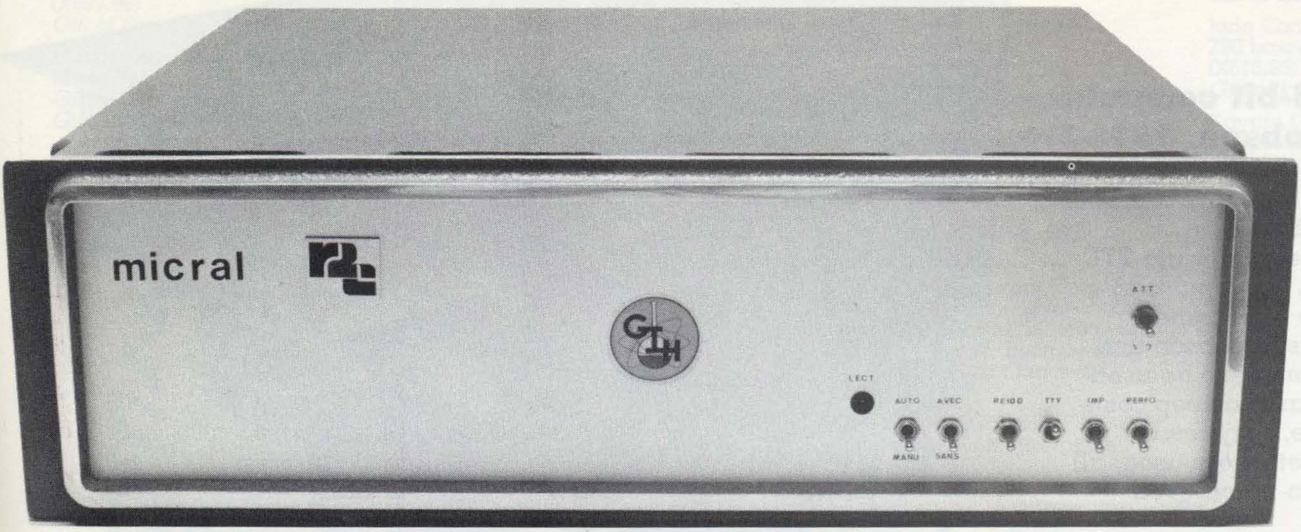
The **Micral** is the earliest commercial non-kit computer based on a microprocessor. The founder and president of R2E (Realisations Etudes Electroniques), Thi T. Truong, created the Micral as a replacement for minicomputers in applications where high performance was not required. He perceived a big gap between minicomputers, such as the DEC PDP-8, on the one hand, and a wired logic system on the other. As soon as the Intel 8008 microprocessor was introduced, he decided to build a computer to fill this gap.

Thi T. Truong, speaking at the Museum after receiving his prize.

By May 1973, barely six months after the Intel 8008 became available, Truong together with engineers Francois Gernelle and Ben Chetrite, had the Micral designed and built. It had some remarkable similarities to later personal computers such as a bus system and slots for expansion. The basic original model had 256 bytes of RAM, and could be expanded to 2K with ROMS and PROMS. It was capable of directly addressing 16K, and boards to expand the memory beyond 2K soon became available. The Micral had a real-time clock, eight levels of interrupt priority and automatic enabling and disabling. The CPU, memory, input/output interfaces and fast peripheral controllers all plugged into the Pluribus - a 60-bit single data bus. There were 52 instructions, oriented towards process-control and data transmission applications. Instruction times ranged from 7.5 to 27.5 microseconds. The Micral had an assembler and an operating system which supported a teletype and cassette recorder connected to the Pluribus. The machine evolved rapidly, with later models offering more RAM, floppy discs, hard discs and a range of standard software.

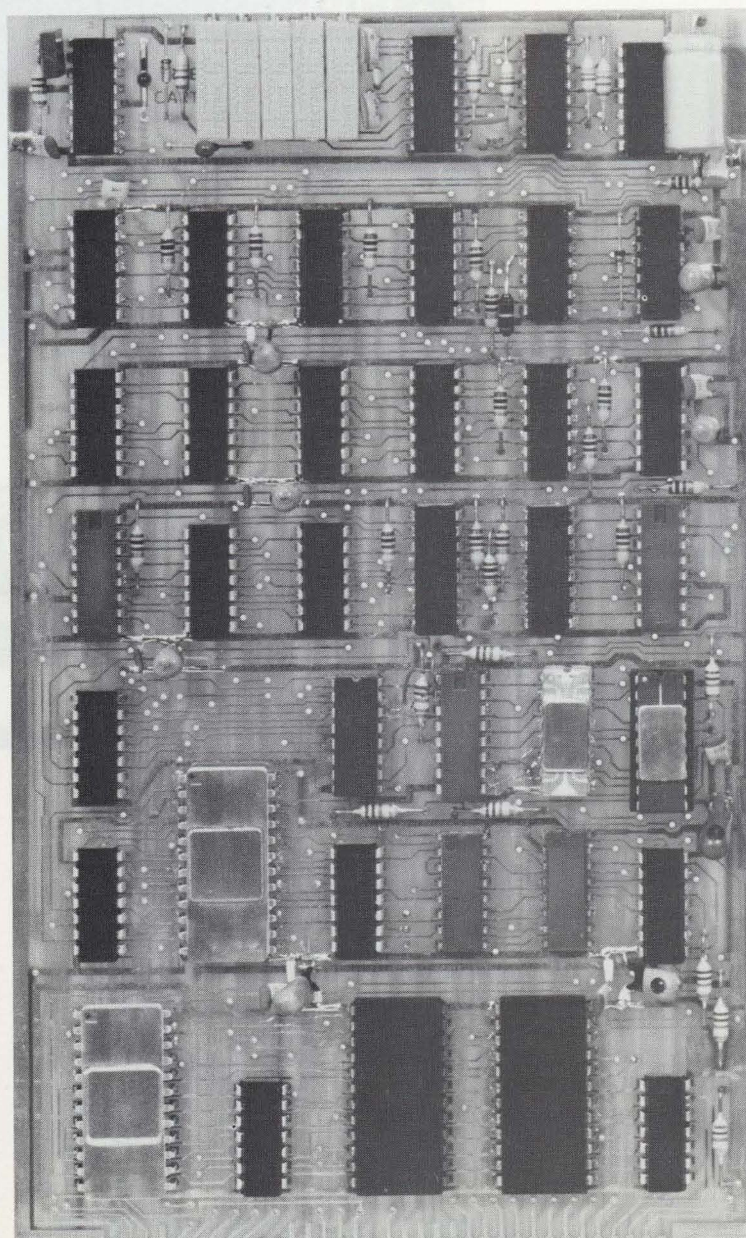
The Micral's low cost of $1950 and bus architecture attracted great interest. By 1974, only six months after the Micral's debut, 500 had been sold; 2000 were sold over the next two years. However, following an unsuccessful attempt to penetrate the US market, Truong could no longer finance the growth of his business. In 1979 he sold Micral to the major French computer maker Bull who currently produce IBM PC-compatible Bull-Micrals.

Micral advertising for the National Computer Conference Exhibition, Chicago May 1974.

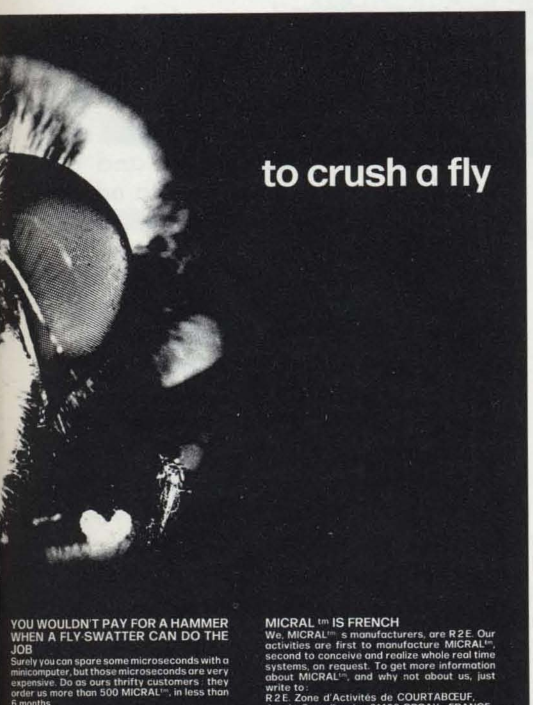


The first Micrals were sold to industry for process control and to the French government to help collect demographic information in France's African colonies. It was therefore supplied with a strong protective metal cabinet.

Gift of Thi T. Truong



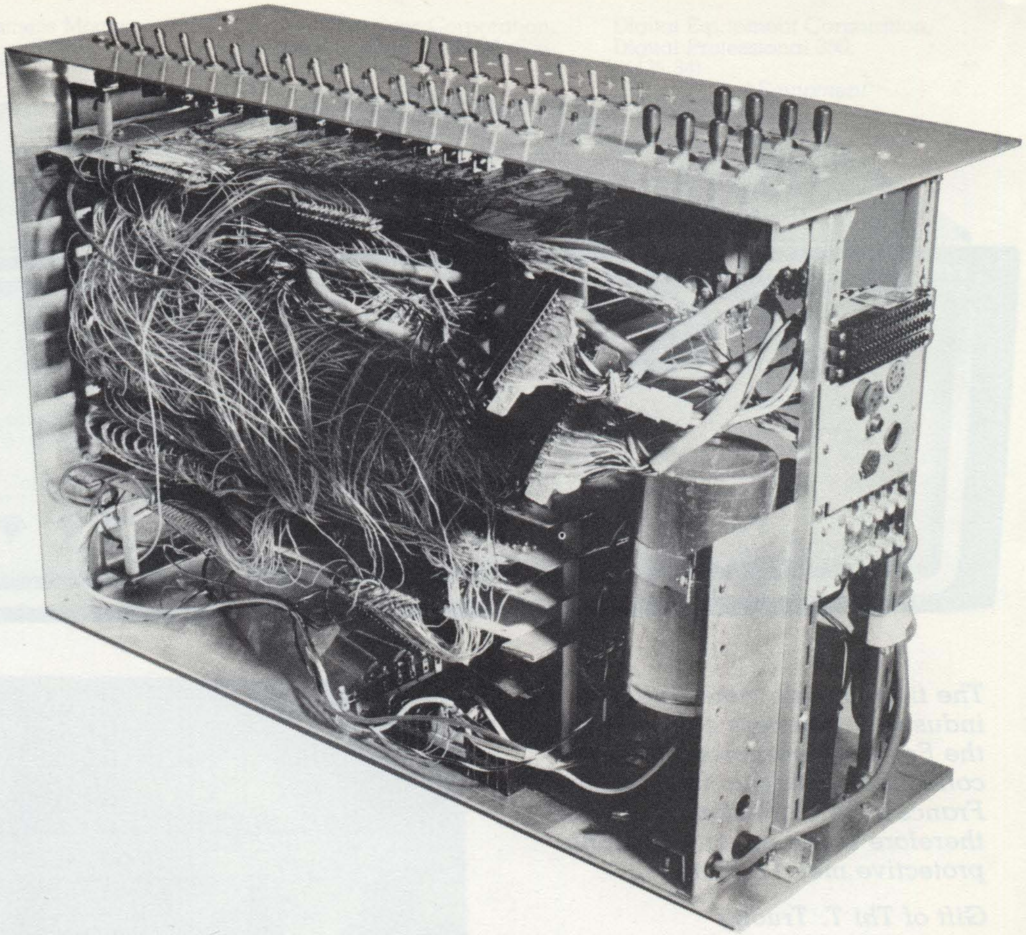
The Micral's CPU board. The use of a microprocessor earned the Micral the name 'microcomputer', used for the first time in print in the June 21 1973 issue of Electronics *magazine.*



Homebrew 16-bit computer, by Loren Jacobson, 1974-5

This one-of-a-kind machine contains a 16-bit processor based on small-scale and medium-scale TTL integrated circuits. All input and output was via the front panel switches and lights. Jacobson had more time than money, so he used every possible means to keep costs down. For example, very few connectors or sockets were used; all wiring was point-to-point, even between boards.

Gift of Loren Jacobson



Micro-68, by Electronic Product Associates Inc.,1975

The **Micro-68** was a microcomputer trainer based on the Motorola 6800 microprocessor. Priced at $430, it came with integral numeric keypad input and LED output in a slim hardwood cabinet that could fit inside a briefcase. It had an on-board maximum of 1K words of ROM and 768 words of RAM and could be expanded to 64K via edge connectors. The system was controlled by the John Bug monitor program, contained in a 512-word PROM. This allowed users to load, inspect and edit programs, insert break points for debugging purposes, and execute.

Victor Wintriss, president of EPA Associates, developed the Micro-68 as a low-cost tool for training engineers in the use of microprocessors. It could also be used to prototype applications for the Motorola 6800. 1500 Micro-68's were sold between 1975 and 1978 when EPA went out of business, due, in part, to competition from the identical Heath ET3400, introduced in 1976.

Gift of G. Victor Wintriss

Eckert, Scott B.,
Homebrew system based on the MOS Technology 6502 CPU, (X699.86)
Gift of Scott B. Eckert

Electronic Product Associates, Inc.,
Micro-68,
Gift of G. Victor Wintriss (X694.86)
Gift of Sanford Shapiro, MD (S31)

Felsenstein, Lee,
VDM-1 Video Display Module prototype, (X711.86)
Gift of Lee Felsenstein

Franklin Computer Corporation,
Franklin Ace 100, (X340.84)
Gift of Franklin Computer Corporation

Godbout, Thinkertoys, SD Sales, et. al.,
Various boards for personal computer kits, (S36)
Gift of Robert Pond

Heath Company,
Heathkit H-8, (X696.86)
Gift of Terry Brandon

Heath Company,
Heathkit H-11, (X695.86)
Gift of Errol Brick

Hewlett-Packard Company,
HP 150 Personal Computer, (X432.84, S63, S64)
Gift of Hewlett-Packard Company

Home assembled as per Aug. and Sept. 1976 Popular Electronics magazine design,
Cosmac ELF, (X692.86)
Gift of Klaus Ernst

Home assembled as per July 1974 Radio Electronics magazine design,
Mark-8, (X704.86)
Gift of Myron A. Cahoun

IBM,
IBM 5100,
Gift of Silenus Wines, Inc. (X629.85)
Gift of United Fruit Company (S17)
Gift of Neil Karl (S18)
Gift of Arthur D. Little, Inc. (S22)

IBM,
IBM PC XT, (X430.84, S65)
Loan from IBM

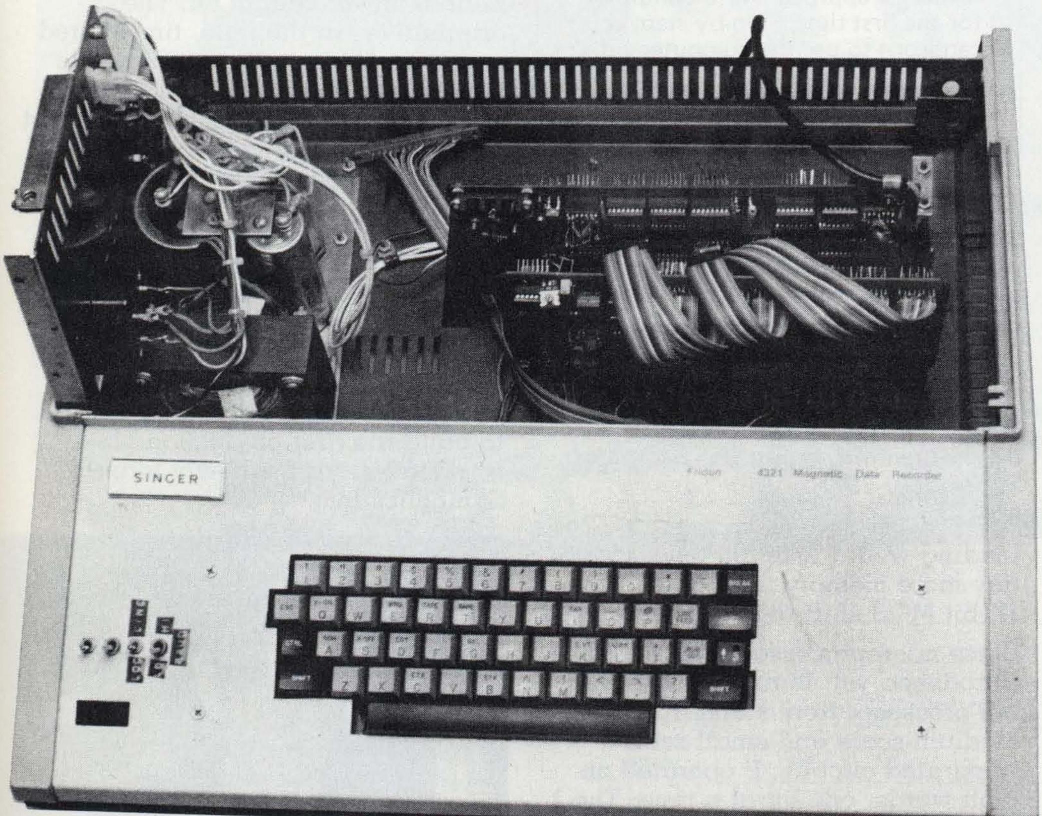
IMSAI Manufacturing Corporation,
IMSAI 8080 Microcomputer System,
Loan from Mike Miller (X589.85)
Gift of Robert W. Beatrice (S32)
Gift of R. Donald Carter (S33)

Intersil, Inc.,
Intercept Jr., (X700.86)
Gift of Stephen S. Mangione

Jacobson, Loren,
Homebrew 16-bit Computer, (X698.86)
Gift of Loren Jacobson

Jade Computer Products,
Z80 based S-100 Computer System, (X616.85)
Gift of Joel Goldstick

Kaypro Corporation,
Kaypro 10, (X487.84)
Gift of Kaypro Corporation



Lee Felsenstein and the VDM-1.

Visual Display Module Prototype, by Lee Felsenstein, 1975

Gift of Lee Felsenstein

This unit is the first implementation of a memory-mapped alphanumeric video display for personal computers. The key design innovation was making the RAM directly accessible from the computer's data and address busses, rather than in a character sequential fashion through an I/O port. As Lee Felsenstein put it, he made it possible to view the video display as a "window on memory rather than a glass teletype [such as in the TV Typewriter]". This made it possible for the first time to use personal computers for highly interactive uses such as real-time games.

The unit in the collection is adapted for stand-alone operation. The chassis was salvaged from a Singer-Friden 4321 key-to-tape converter bought at a junkyard. The keyboard was bought at a hobby shop. The unit was used for several months as a terminal in the development of software for The Community Memory Project.

The **VDM-1** prototype was demonstrated at the World Altair Convention in Albuquerque in March 1976. Variants of the VDM board were immediately incorporated into many personal computers; the design had a great influence on the development of personal computer video displays. Felsenstein himself used the design in the Sol terminal computer and the Osborne-1.

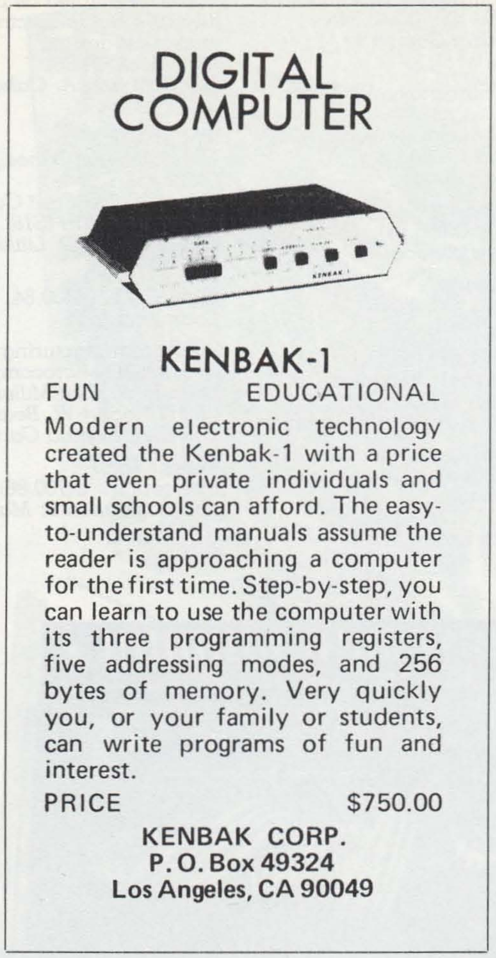
Kenbak-1, by Kenbak Corp., 1971

The **Kenbak-1** was awarded first prize in the Museum's Early Model Personal Computer Contest as the earliest personal computer. It was presented to the Museum by its designer and builder, John V. Blankenbaker.

Blankenbaker became interested in computing while at college. In 1951, during his junior year, he got a job at the National Bureau of Standards where he came into contact with the SEAC (Standards Eastern Automatic Computer) project. The following year Hughes Aircraft charged him with the considerable task of building, from scratch, an arithmetic unit based on binary-coded decimal numbers. At that time, flip-flops cost $500 each. He struggled to design the machine with the absolute minimum number of flip-flops and even came up with a design that would use only one. Though such a machine would take a long time to get through even one clock cycle, it could emulate any other computer. Blankenbaker was so taken by this single flip-flop design that in 1955 he tried to patent it. Though he was unsuccessful, the idea of a $500 computer had been firmly planted in his mind.

In 1970 Blankenbaker actually set out to build a small computer. His fixation upon a selling price of $500 meant that he had to keep the cost of parts down to about $150. He decided that speed was not important and that the only input/output within the price constraint were lights and switches. However he did cut a slot in the front panel in the hope that one day punched card input could be added.

He could only afford the tooling costs for the printed circuit board. Everything else, including the cabinet, lights, switches and logic circuits had to be made from standard parts. He decided that the machine would be byte-oriented, and that 256 bytes would be a good choice of memory size. This allowed a single byte to store a complete address. In any case, manual



Kenbak's most successful advertisement, Scientific American, *September 1971*

loading would take too long with any more memory than that. Two 1K-bit MOS shift registers were used.

Since microprocessors had not been introduced yet, Blankenbaker built his processor from standard medium-scale and small-scale integrated circuits. It operated on 8-bit words, one bit at a time. The 1 MHz clock coupled with a serial memory organization gave the Kenbak an effective speed of 1000 instructions per second. Altogether the machine used 130 integrated circuits, all mounted on a single board.

In Spring 1971, a working prototype was shown to a convention of mathematics teachers. Blankenbaker even managed to demonstrate a three-dimensional tic-tac-toe program that just squeezed into the 256 bytes. Complete documentation, programming manual and exercises suitable for school laboratories were published.

The Kenbak Corporation was formed, and the computer was marketed through advertisements and direct mail. From the start, the machine was billed more as an educational tool rather than as a full-blown machine for executing applications programs. The marketing was accordingly focused on schools as a low cost way of introducing hands-on computing to students.

Although small computers eventually found their way into the classroom in large numbers, the Kenbak never caught on. The alternatives at the time, timeshared minicomputers and programmable calculators, were beyond the reach of school budgets. Teachers were not yet attuned to the idea that an electronic computer might be affordable, and those that wanted one often took a long time to secure the funds. Only 40 machines were sold to schools and a dozen to individuals over two years. In 1973, the Kenbak Corporation closed its doors. Blankenbaker moved on to use his creative engineering talents to build the first production LISP workstation for the newly formed Symbolics Inc.

John V. Blankenbaker

Kenbak Corporation,
Kenbak-1, (X703.86)
Gift of John V. Blankenbaker

Lancaster, Donald,
ASCII Keyboard and Encoder prototype, (X691.86)
Gift of Don Lancaster

Lancaster, Donald,
Cheap Video prototype board, (X688.86)
Gift of Don Lancaster

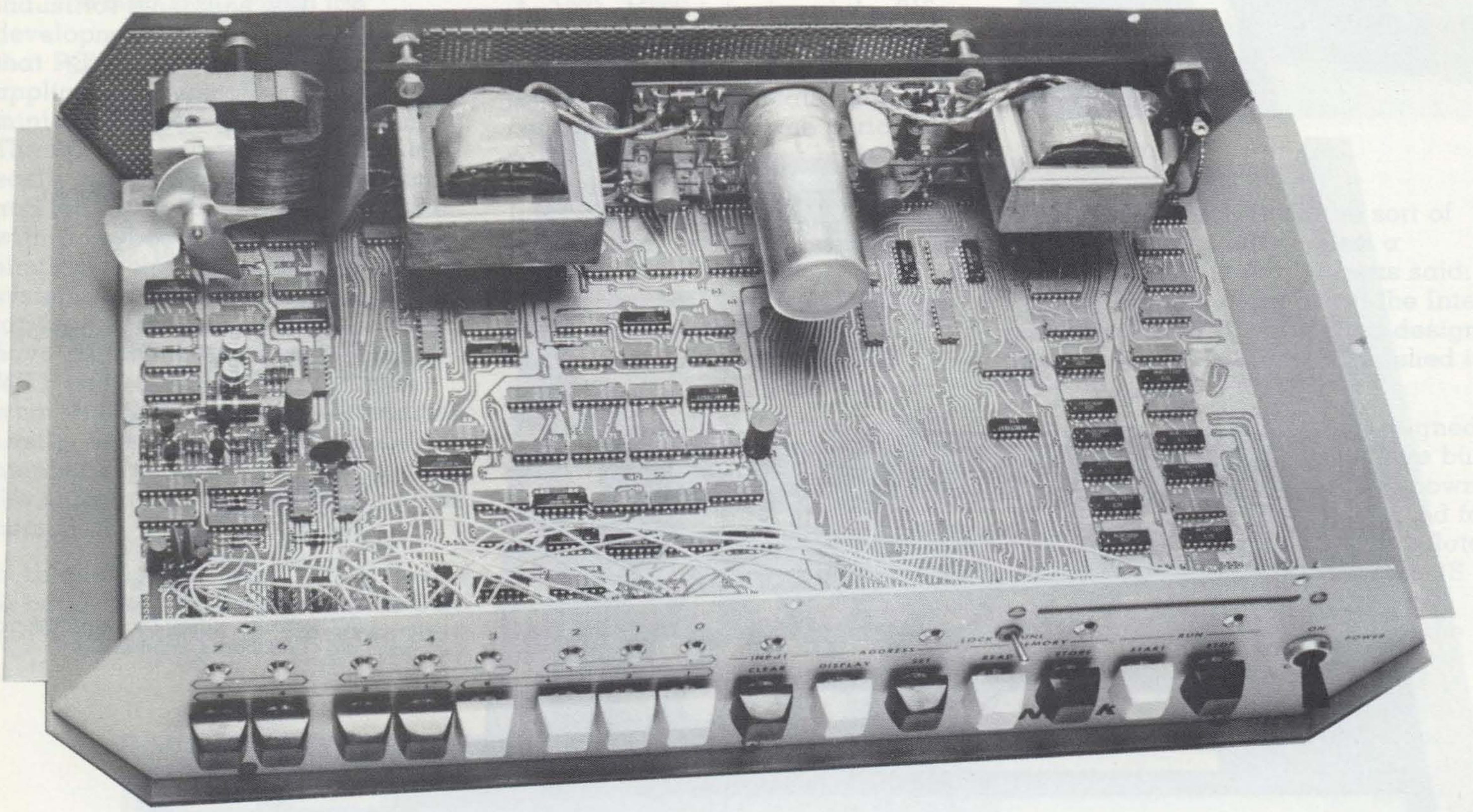
Lancaster, Donald,
TVT-1 TV Typewriter prototype, (X689.86)
Gift of Don Lancaster

Lancaster, Donald,
TVT-3 TV Typewriter prototype, (X690.86)
Gift of Don Lancaster

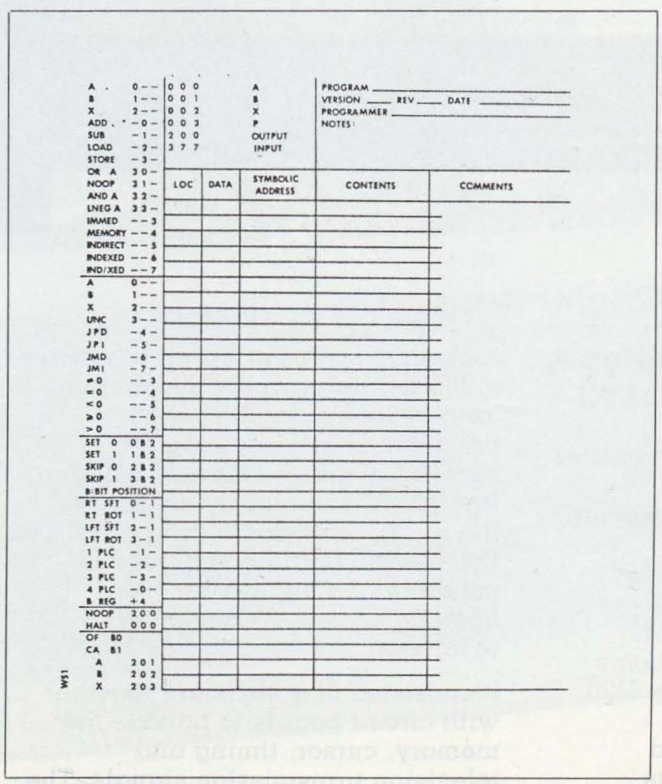
Martin Research,
Mike 2, (X706.86)
Gift of Robert F. Casey

Microcomputer Associates, Inc.,
JOLT microcomputer, (X701.86)
Gift of Brian Yee

MITS, Inc.,
Altair 680b, (X679.86)
Gift of James Post



Gift of John V. Blankenbaker



A . 0-- | 000 A
B 1-- | 001 B
X 2-- | 002 X
ADD . -0- | 003 P
SUB -1- | 200 OUTPUT
LOAD -2- | 377 INPUT
STORE -3-
OR A 30-
NOOP 31-
AND A 32-
LNEG A 33-
IMMED --3
MEMORY --4
INDIRECT --5
INDEXED --6
IND/XED --7
A 0--
B 1--
X 2--
UNC 3--
JPD -4-
JPI -5-
JMD -6-
JMI -7-
≠0 --3
=0 --4
<0 --5
≥0 --6
>0 --7
SET 0 0B2
SET 1 1B2
SKIP 0 2B2
SKIP 1 3B2
B:BIT POSITION
RT SFT 0-1
RT ROT 1-1
LFT SFT 2-1
LFT ROT 3-1
1 PLC -1-
2 PLC -2-
3 PLC -3-
4 PLC -0-
B REG +4
NOOP 200
HALT 000
OF B0
CA B1
A 201
B 202
X 203

PROGRAM ____
VERSION ____ REV ____ DATE ____
PROGRAMMER ____
NOTES:

LOC	DATA	SYMBOLIC ADDRESS	CONTENTS	COMMENTS

WS1

Programming sheet, showing the Kenbak's instruction set.

MITS, Inc.,
Altair 8800,
Anonymous Gift (X58.82)Gift of Robert L. Froemke (X680.86)
Gift of Robert L. Leffert (S28)
Gift of Robert Pond (S29)
Gift of Wallace B. Riley (S30)

MITS, Inc.,
Altair 8800A with two disk drives, adapted for time-sharing, (X681.86)
Loan from The State of Colorado

MITS, Inc.,
Altair 8800b, (X682.86)
Gift of Jerry Soden

MOS Technology, Inc.,
KIM-1 Microcomputer,
Gift of Commodore Business Machines, Inc. (X365.84)
Gift of Robert F. Casey (S34)

Motorola, Inc.,
Micro Chroma 68, (X707.86)
Gift of Robert Pond

NEC Corporation,
NEC APC III, (X494.84, S19, S20)
Gift of NEC Systems Laboratory

NEC Corporation,
NEC PC-8000, (X446.84)
Gift of Microsoft Corporation

NEC Corporation,
NEC TK-80 (X447.84)
Gift of Microsoft Corporation

Netronics, R&D Ltd.,
Cosmac ELF II, (X693.86)
Gift of S. Scott Kostka

North Star Computers, Inc., North Star Horizon,*Gift of James B. Straus (X708.86)*
Gift of William Romaine (S35)

Ohio Scientific, Inc.,
Ohio Scientific, model 600, (X709.86)
Gift of Bill Leehan

Osborne Computer Corporation,
Osborne 1,
Gift of Osborne Computer Corporation (X362.84, S66)
Gift of Ben Rosen (S3)
Anonymous Gift (S9)

Osborne Computer Corporation,
Osborne Executive, (X615.85)
Gift of Joel Goldstick
Polymorphic Systems,
Polymorphic System 8813, (X614.85)Gift of Robert and Margaret Wesley

Powertran Computers,
Psi 80, (X724.86)
Gift of Livnat Yehiel

Processor Technology, Inc.,
Sol Terminal Computer,
Gift of Richard S. Russell (X715.86)Gift of Ray Duncan (S39)
Gift of Michael Cuchna (S40)

TV Typewriter Prototype, by Don Lancaster, 1973

The **TV Typewriter** made it possible for the first time to display personally generated alphanumeric information on an ordinary unmodified television set. The design was published in the September 1973 issue of *Radio Electronics* magazine as a home assembly project using only $120 worth of components. Don Lancaster's design attracted considerable attention as its extremely low cost proved that home video terminals and video displays for personal computers were practical. High resolution bit mapped displays followed within a few years, enormously enhancing the utility of personal computers. Lee Felsenstein (featured on page 13) called the TV Typewriter "the opening shot of the computer revolution".

It consisted of a keyboard together with circuit boards to provide the memory, cursor, timing and television transmission signals. The on-board memory consisted of 512-bit serial registers. The memory boards had character generators which displayed each character as an array of 5 by 7 dots. The original design had two memory boards and could generate and store 512 characters arranged as 16 lines of 32 characters. The device could also use a cassette recorder to provide additional storage; a 90 minute cassette could hold about 100 pages.

Gift of Don Lancaster

Altair 8800 by MITS 1975

The **Altair** is widely thought of as the first personal computer. Indeed, the Altair's creator, Ed Roberts, founder and president of MITS (Micro Instrumentation and Telemetry Systems), coined the term. Distinguishing PC's from hobby machines, demonstration machines, industrial machines and development systems, his view was that PC's had to be used for applications typically run on a minicomputer or larger computer. The PC also had to be affordable, easily interfaced with other devices and feature a conventional console with a keyboard, CRT or something similar. It should have an operating system and mass storage; paper tape was acceptable. A PC should have a reasonably large memory. MITS used 64K because that was what the 8080 could directly address. Lastly, he stipulated that a good number of people had actually used the machine as a computer that was personal!

In thinking about what sort of device to build, Roberts considered the DEC PDP-8 as a prototype. However, the machine that had the greatest impact on him was the Hewlett Packard 9100, introduced in 1968. It had a CRT, keyboard, magnetic storage for programs and data, and a printer. It could even drive a plotter. But it was not a personal computer by Roberts' definition—it was expensive ($6000), did not have a real programming language and only had a small memory.

In 1971, MITS introduced the 816, a kind of programmable calculator. Several thousand were sold, mainly for accounting applications and as controllers. In the same period, a company called Prolog built industrial processors based on the Intel 4004, 4040 and 8008. Intel built the Intellect series of machines between 1971 and 1973. The TV Typewriter was also noticed by MITS, as were several logic demonstration devices and an 8008-based machine, the Mark-8, introduced in Radio Electronics in 1974.

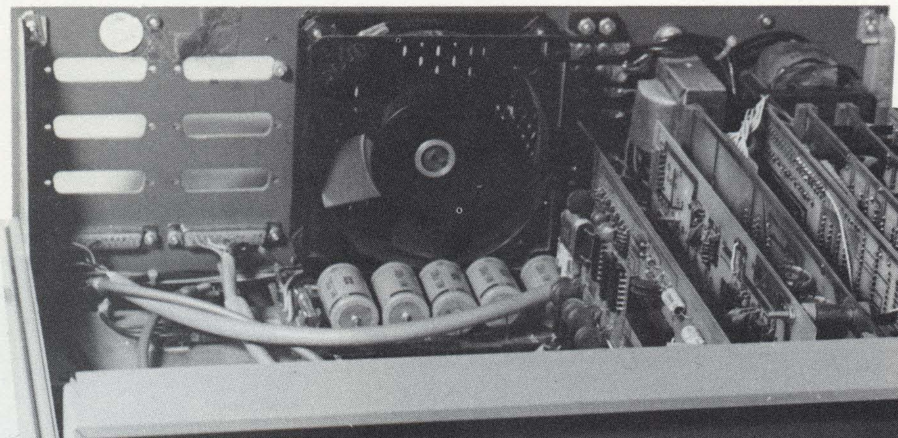
In 1972 MITS made a terminal system that could be interfaced to time-shared computers. "In 1973 and 1974 we started design work at MITS with 4004, 4040 and 8008 processors and didn't feel that they were

Ed Roberts.

powerful enough to do the sort of things you normally expect a minicomputer to do", Roberts said. "When we found out about the Intel 8080 in late 1973, we started design on the Altair, which was finished in the summer of 1974."

Ed Roberts and Bill Yates designed the Altair with an open 100-line bus structure. Though originally known as the Altair bus, it was adopted for so many other machines that it later came to be called the S-100 bus (S for Standard). The first machines were shipped with only two of the 18

Gift of Robert Pond



available slots filled with the CPU board and the 256 byte memory board. Programs had to be entered in machine code via the switches on the front panel. During the next few months, MITS as well as many third parties, came out with expansion boards to provide more memory (up to a maximum of 64K) and interfaces for input-output devices and storage media. One of the first boards was a 4K memory board, big enough to hold a 4K BASIC interpreter specially written for the Altair by Bill Gates and Paul Allen.

The original Altair sold without the case for $297, $395 with the case—an order of magnitude less than the cost of the PDP-8. Though initially offered as a kit, the first units were sold as assembly units since the kit manuals were not completed.

The demand for the machine exceeded even MITS's wildest expectations. More machines were sold in the first day than the company expected to sell during the entire lifetime of the product. Roberts likes to point out how MITS increased the installed base of general computers by 1% each month for a period between 1975 and 1976. There was a huge pent-up demand for a computer with the kind of power offered by the Altair. Most of the machines were purchased by electronics hobbyists who simply wanted to have a machine of their own. They tinkered with and modified their computers. However the machine was not really powerful enough or equipped with enough software to enable it do useful work conveniently. It was used to control various processes—some industrial, some recreational. One of the first customers used his Altair to control his model railway.

The company was sold to Pertec in 1977 for 6 million dollars. Faced with stiff emerging competition from companies such as Processor Technology, IMSAI, Commodore and Apple, Pertec was unable to retain market share, and the Altair went out of production in 1978.

MITS and the Altair played a central role in the development of the US personal computer market. They pioneered a whole marketing style—computer shows, computer retailing, computer company magazines, user groups and numerous add-on hardware and software options.

Quest, Inc.,
Super ELF, (X717.86)
Gift of Willits High School/ROP

RCA,
Cosmac VIP, (X686.86)
Gift of Robert F. Casey

R2E,
Micral, (X705.86)
Gift of Thi T. Truong

RGS Electronics,
RGS-008, Intel 8008 based microcomputer built from kit, (X712.86)
Gift of Brian Yee

Rockwell International,
AIM 65,
Gift of David Martz (X678.86)
Gift of Neil Doughty (S27)

Saga Systems,
Saga, model PPS-800S, (X713.86)
Gift of Computer Maintenance Corporation

Scelbi Computer Consulting, Inc.,
SCELBI-8B, (X714.86)
Gift of Michael Rossman

Scelbi Computer Consulting, Inc.,
SCELBI-8H , (X574.85)
Gift of Carlton B. Hensley

Sinclair Research Ltd.,
Sinclair ZX80,
Gift of Sinclair Research Ltd. (X513.84)
Gift of Lea Vanderboom (S37)

Sinclair Research Ltd.,
Sinclair ZX81,
Gift of Sinclair Research Ltd. (X514.84)
Gift of Arnold J. Savitt (S38)

Solid State Music, California Computer Systems, Heathkit, et. al.,Various boards for personal computer kits, (X658.86)
Gift of Alan Frisbie

Southwest Technical Products Company,SwTPC 6800,
Gift of Steven B. Leeland (X718.86)
Gift of Fred Laskowski (S41)
Gift of Dr. Gordon Wolfe (S42)

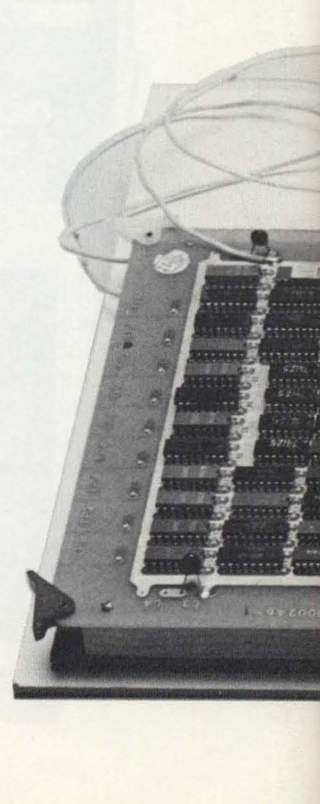
Southwest Technical Products Company,TVT-2 TV Typewriter, (X719.86)
Gift of Robert Pond

Sphere Corporation,
Sphere System 330,
Gift of Dr. Roger J. Spott (X295.83)
Gift of John Rible (S14)

Sphere Corporation,
Sphere System 320, (X297.83)
Gift of Dr. Roger J. Spott

SSM Microcomputer Products (formerly: Solid State Music), SSM CB1 8080 CPU Board, (X716.86)
Gift of Dana Smith

The January 1975 issue of Popular Electronics *ran a cover story on the Altair which propelled the machine to instant success.*

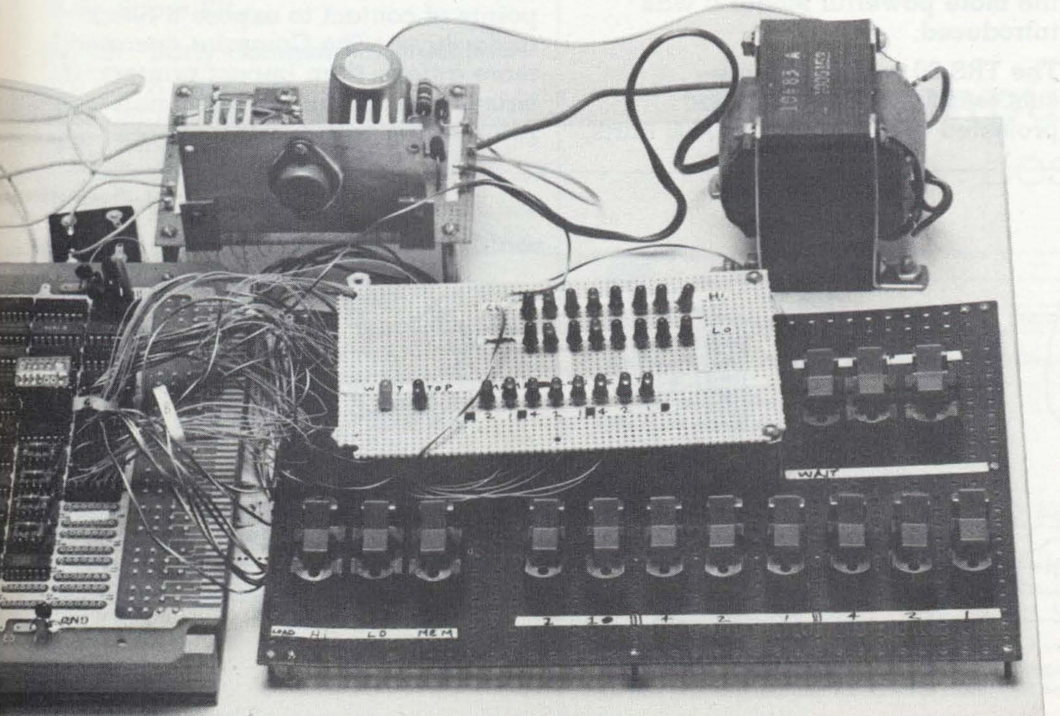


6800 Computer System, by Southwest Technical Products Corp., 1975

The **SWTPC 6800** was one of the first computers to be based on the Motorola 6800 microprocessor. The 6800 was thought by some engineers to be more powerful and versatile than its competitor, the Intel 8080. The computer was sold as a kit, costing $395 for the basic system which included 2K bytes of RAM and a serial teletype interface. It could be expanded to 16K. It had a mini-operating system in ROM enabling it to boot up automatically without throwing switches on a front panel.

Southwest also offered a video terminal, the $275 CT-1024, based on Don Lancaster's TV Typewriter, shown on the left in the picture. Above the computer on the right, are the $79.50 AC-30 cassette interface and the $250 PR-40 matrix printer kit. In front of the keyboard is a home-made switch box, a useful input device, especially for games. With its complete set of peripherals, the SWTPC 6800 was one of the first low-cost systems on which software could be developed and run in a reasonably convenient fashion.

Gift of Steven B. Leeland



008A Microcomputer Kit, by RGS Electronics, 1974

The **008A** was sold for $375 as a kit based on the Intel 8008. The system had 1K of static RAM, expandable to 16K, and an RC (not crystal) clock. It featured an input/output bus which could handle up to 256 perihperal devices instead of the arrangement of input/output ports more usual with the 8008. The programs were entered into memory using toggle switches. The version received was built on a 60-socket wire-wrap board. The printed circuit board version of the RGS-008 was described in September 1975 in the first issue of *Byte* magazine.

Gift of Brian Yee

Sutherland, James,
ECHO IV Home Computer,
(X509.84)
Gift of James Sutherland

Tandy Corporation,
TRS-80, Model 1,
Gift of Melvin O. Duke (X722.86)
Gift of Nigel H. Searle (S43)
Gift of Samuel M. Gerber (S67)

Terak Corporation,
Terak Model 8510, (X351.84, S68, S69)
Gift of Douglas Ross

Terak Corporation,
Terak Model 8512, (X354.84)
Gift of Douglas Ross

Texas Instruments, Inc.,
TI-99/4 prototype (Dimension 4), (X720.86)
Gift of Robert Childress

Timex -Sinclair, Inc.,
Timex-Sinclair TS-1000,
Gift of Dennis Knollenberg (X721.86)
Gift of Ruth Leyden (S47)

Van Cleve, Robert,
Homebrew system based on the Motorola 6808 TV Bug CPU, (X697.86)
Gift of Robert Van Cleve

Wang Laboratories,
Wang PIC (Professional Image Computer), (X566.85)
Gift of Wang Laboratories

Wave Mate, Inc.,
Jupiter Computer system, (X702.86)
Gift of Dennis Painter

Xerox Corporation,
Notetaker 1, (X748.86)
Gift of Xerox Corporation

Gift of Melvin O. Duke

TRS-80, Model 1 by Radio Shack, 1977

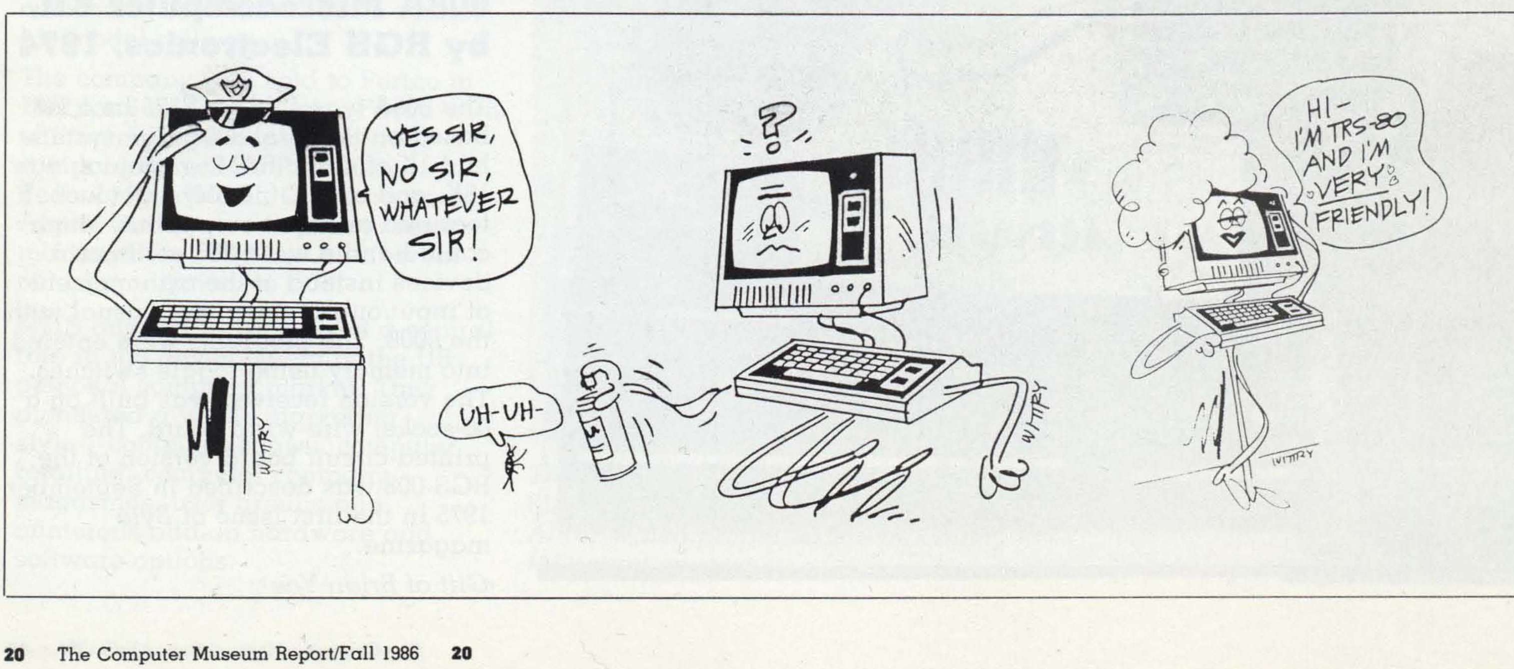
The **TRS-80** was Radio Shack's first entry into the computer market. Their wide network of retail outlets greatly increased the accessibility of microcomputers. The TRS-80 was based on a Z80 microprocessor and came with a video display, 4K of memory, BASIC and cassette storage, at a price of $599.95. It was aimed at the novice—the manuals assumed no prior computer knowledge. The original machine was slow as Radio Shack had kept the price down to an absolute minimum. New software and extended memory were released to improve performance, and in 1979 the more powerful Model II was introduced.

The TRS-80 was extremely successful; the company had projected annual sales of 3000 units, but over 10,000 were sold within a month of the TRS-80's introduction.

To the left of the TRS-80 is an Exatron Stringy Floppy, a miniature tape-drive which holds a small, continuous, removable tape. Called a wafer, the tapes could be up to 75 feet long and stored 4K bytes on five feet of tape in 6 seconds. It was significantly faster and more reliable than the standard cassette tape drive originally supplied with the TRS-80.

To the right of the TRS-80 is the Comprint Model 912 thermal printer. This could print 225 12 by 9 dot matrix characters per second. It used special silvery-looking aluminum-coated paper. Characters were printed by styli which vaporized the metal surface at the points of contact to expose a black under-layer. The Comprint operated more quietly than impact printers. It was one of the first matrix printers to print letters with true decenders.

Illustrations from the friendly manual "Getting Started with TRS-80 BASIC". Courtesy of Radio Shack



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- 13.2 Micral (1973)
- 13.3 Scelbi (1974)
- 13.4 Altair (1975)

Set 14: The Hobbyist Milestones
- 14.1 Apple 1 Board
- 14.2 Visual Display Module, Lee Felsenstein's VDM-1
- 14.3 Don Lancaster's TV Typewriter
- 14.4 Cromemco Dazzler boards

Set 15: Homebrew and Single Board Computers
- 15.1 Homebrew 16-bit computer by Loren Jacobson
- 15.2 RGS Electronics 008A Microcomputer Kit
- 15.3 Kim 1
- 15.4 Super Elf

Set 16: Early Commercial Machines
- 16.1 EPA Micro 68
- 16.2 IMSAI 8080
- 16.3 SWTPC 6800 (Southwest Technical Products)
- 16.4 Sol Terminal Computer

Set 17: Classic Commercial Machines
- 17.1 Apple II
- 17.2 TRS 80 Model I
- 17.3 Commodore Pet
- 17.4 Sinclair ZX80

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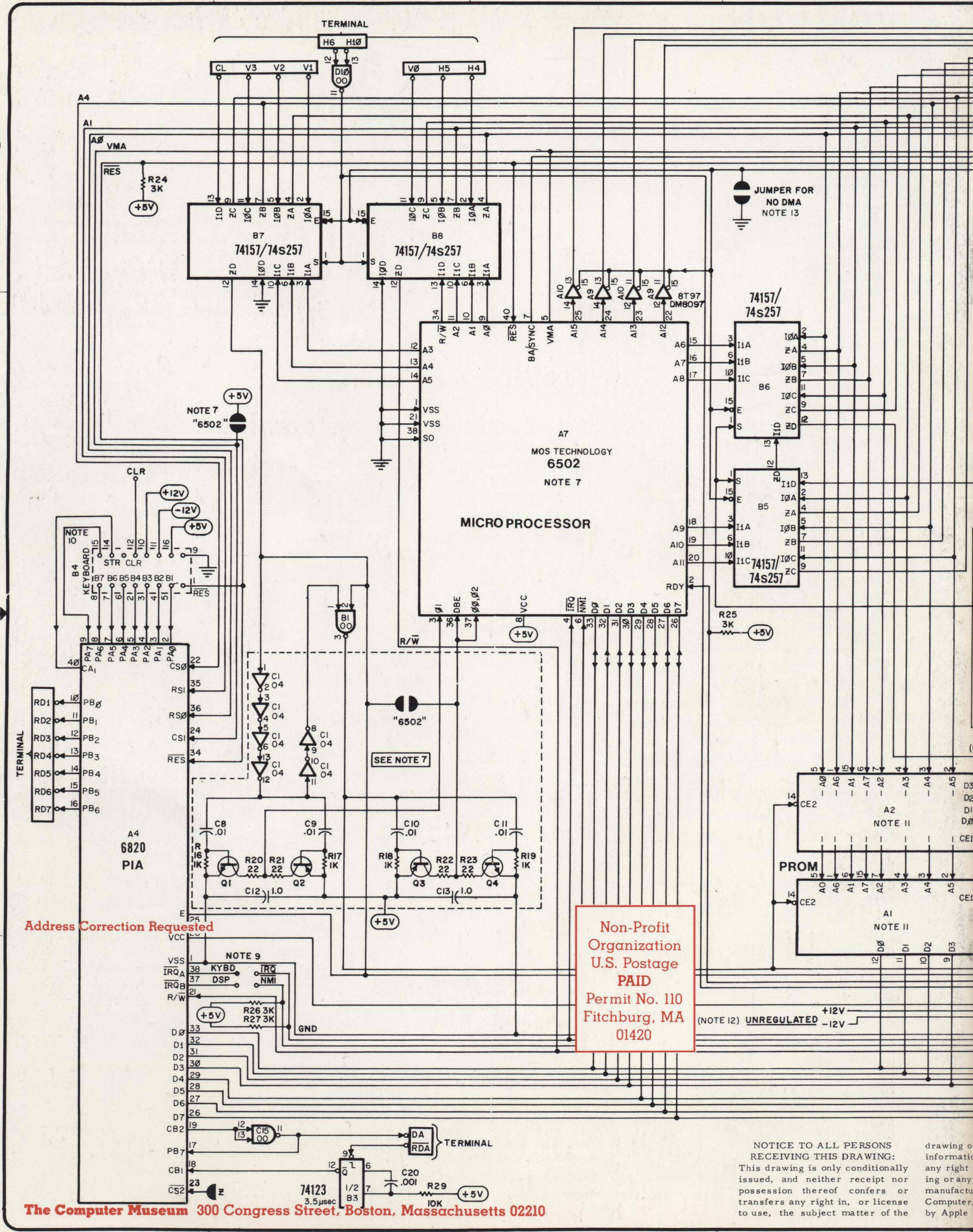
TERMINAL
H6 H1Ø
D1Ø
CL V3 V2 V1
VØ H5 H4
A4
A1
AØ
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R24 3K
+5V
B7
74157/74S257
B8
74157/74S257
JUMPER FOR NO DMA NOTE 13
8T97 DM8097
74157/ 74S257
B6
B5
A7
MOS TECHNOLOGY
6502
NOTE 7
MICROPROCESSOR
NOTE 7 "6502"
CLR
+12V
-12V
NOTE 10
B4 KEYBOARD
STR CLR
R25 3K
R/W
B1
"6502"
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RD1 RD2 RD3 RD4 RD5 RD6 RD7
A4
6820
PIA
Q1 Q2 Q3 Q4
A2 NOTE 11
PROM
A1 NOTE 11
NOTE 9
KYBD DSP
R26 3K
R27 3K
GND
(NOTE 12) UNREGULATED +12V -12V
C15
DA RDA
TERMINAL
74123 3.5µsec
1/2 B3
C20 .001
R29 10K