Chapter 4 Transition to Microcomputers

The 1970's were a period of transition for personal computing. There was a change from the common usage of time sharing on large computers to the use of low-cost personal computers. This cost aspect changed our general understanding of what defined a computer as being personal. Previously the definition only required that a computer be designed for use by a single person, such as those developed by DEC, IBM and MIT in the 1960's. During the 1970's, the definition evolved to include a price level that was affordable to the average consumer. This change became possible by a period of hardware transition. The microprocessor and memory chips replaced discrete components and core memory. This reduced the complexity and cost of building a personal computer. Then factory-built "turn-key" units changed the market from the computer hobbyist and software enthusiast to the "appliance user" and a larger consumer market.

This was also a decade in which the main computer companies failed to develop personal computer products for the consumer market. Intel created systems for software development. However, they did not extend these products into a consumer computer. Digital Equipment Corporation (DEC) could also have adapted their PDP-8 and LSI-11 designs to a consumer product. A product was proposed by an employee David Ahl, but rejected by the company. Hewlett-Packard also rejected an offer by Stephen Wozniak to market what became the highly successful Apple II computer. Federal antitrust actions discouraged IBM from any product line expansion during the 1970's. Xerox also failed to take advantage of innovations they had created in the Alto computer. These dominant companies had the financial resources, major research facilities and marketing power. However, they did not develop any viable products for the larger consumer market. These companies allowed entrepreneurs to start what became the "microcomputer revolution."

4.1 ... The 1970-74 Transition

The first microprocessor became available from Intel in 1971. However, commercial use of the new processors by companies other than Intel, did not occur in North America until 1974. Companies did use integrated circuits in calculators and computer products, but most of the early computer products had limited exposure. Though, the CTC "smart" terminal received some interesting exposure when used as a computer by some customers.

Phil Ray and Gus Roche founded Computer Terminal Corporation (CTC) in July 1968 to make terminals for other companies. In 1969, the company decided to develop a "smart" terminal with a processor. Vic Poor, the technical director, hired Jack Frassanito to help with the design. CTC designed the unit as a replacement for IBM keypunch machines and other vendors terminals. The company contracted with Intel and Texas Instruments to integrate a number of functions on a single large-scale chip. However, CTC decided to complete the design using discrete components. This design became the Datapoint 2200 computer terminal that CTC introduced in June 1970. The terminal had a cost of about $5,000. In 1972, the company name changed to Datapoint Corporation. An article in *Invention & Technology* [276] credited Frassanito as being "The Man Who Invented the PC." The article states that a company had "written a payroll program on the 2200 itself, using machine language" and that "Other buyers were applying the Datapoint to accounting and process control."

The Datapoint unit was not a computer; but in 1970, DEC released the small PDP-8/E and PDP-11 computers. The PDP-11 was a 16-bit computer with a price of $20,000 that shipped in the spring. Then in July, DEC introduced the low-cost PDP-8/E 12-bit computer with a price of $4,990. Sales of the PDP-8 and PDP-11 series of computers were outstanding. This helped to position DEC, as the major supplier in the minicomputer market.

The market for small computers had also attracted another major company. IBM announced the System/3 Model

6 BASIC computer system in October 1970. This was a small personal disk based system, with a BASIC language user interface for a display unit. A typical system cost of $48,250 excluded the computer from the personal consumer market. However in 1971, a shift to low cost products began with the National Radio Institute computer kit and John Blankenbaker's Kenbak-1 computer.

In 1971, the National Radio Institute (NRI) offered one of the earliest low cost computer kits for a computer electronics course. Louis E. Frenzel designed the NRI 832 kit that cost $503.

The Kenbak Corporation, advertised one of the earliest personal computers, called the Kenbak-1 in the September 1971 issue of the *Scientific American* magazine. John V. Blankenbaker who had founded the company, priced the computer at $750, but sold only 40 units. An Early Model Personal Computer Contest, sponsored by The Computer Museum of Boston, ComputerLand and CW Communications in 1986, selected the Kenbak-1 as the winner. The criterion for selection of the winner was "interest, significance and date of each model" [235, page 288].

The Kenbak-1 was the first commercially assembled, low cost personal computer. However, computer enthusiasts had been building their own low cost computers. An example of such a computer was the HAL-4096 designed by Hal Chamberlain. The computer was described in the September 1972 issue of the *ACS Newsletter,* published by the Amateur Computer Society (ACS). Chamberlain offered construction plans for $2.

Low cost computers started to evolve from a different direction as some companies developed more powerful calculators. An example of this was the 9800 series of products from Hewlett-Packard. HP extended the capabilities of their desktop calculator product line with the release of the HP 9830A calculator in 1973, which had a BASIC programming capability. HP had also been working on a low-cost 16-bit general-purpose computer with the code name of Alpha, which it released in 1972 as the HP 3000 minicomputer.

A significantly smaller company than HP, the EPD Company, advertised a computer kit called the System One at a price of $695 in May 1973.

Also during the first half of 1973, IBM developed the first portable computer called SCAMP (Special Computer APL Machine Portable). The IBM General Systems Division in Atlanta proposed the product to raise the visibility of APL (A Programming Language). Paul Friedl developed the computer design at the IBM Scientific Center in Palo Alto, California. The processor was an IBM Palm microcontroller. Although not marketed commercially, it was the basis for the development of the IBM 5100 computer in 1975.

Unlike IBM, the Digital Equipment Corporation (DEC) continued to develop and market products with lower prices. In 1973, DEC began marketing the EduSystem series of low-cost PDP-8 computers for educational users. Then in May 1974, DEC announced the PDP-8/A computer with a Model 100 priced at $1,835. The PDP-8/A had a lower cost due to the use of medium scale integrated (MSI) chips and smaller circuit boards. Although DEC had achieved a pricing level whereby they could have entered the personal consumer market, they chose not to personalize their products. However, a new research center of the Xerox Corporation would personalize a computer that significantly affected the future personal computer market.

Xerox Alto

Xerox, a copier manufacturing company, decided to diversify and enter the computer market in 1970. It wanted to offer a "system of interrelated products to manage information in the office" and establish itself as a leader in "the architecture of information" [144]. In 1970, it founded the Palo Alto Research Center (PARC) in Northern California and acquired Scientific Data Systems (SDS). SDS was a manufacturer of computers for the engineering and scientific market. Xerox intended to use SDS as a basis for its entry into the general computer market.

PARC started development of a personal computer called Alto as a research project. It evolved from human

interface ideas for the computer developed by Ivan Sutherland, Douglas Engelbart, and Alan Kay in the 1960's.

In September 1969, Kay described in a doctoral thesis *The Reactive Engine*; an interactive programming language and a computer called FLEX. By 1972, Kay had extended the concepts of FLEX to a proposed computer he named Dynabook. He envisaged a portable notebook computer that would contain a knowledge manipulator with extensive personalized reference materials, which could also be a dynamic interactive medium for creative thought. It was beyond the hardware capabilities then, so the Alto computer became an interim design.

Xerox started the Alto design in late 1972 and completed the first unit in April 1973. Although not produced commercially, the technology was of historical significance. Charles "Chuck" P. Thacker was a principal in the Alto hardware design; with significant design input from Alan Kay, Butler Lampson and Bob Taylor. The Alto hardware consisted of four units: the processor and disk storage cabinet, bit-mapped graphics display, keyboard and a mouse to facilitate graphics manipulation and control. The CPU used a 16-bit custom-made processor similar to the Data General Nova 1220. The system had estimated costs ranging from $20,000 to $32,000.

The research group introduced the desktop metaphor and extended Engelbart's windows graphical environment to include an intuitive user interface. By 1976, the group had created overlapping windows, pop-up menus and icons. Dan Ingalls facilitated this by developing a procedure known as BitBlt, for manipulating a bit-block of the screen display. Software system designers used BCPL, a language similar to C, to create the Alto operating system. Later, the MESA programming language, which was similar to Pascal, replaced BCPL. Butler Lampson and Charles Simonyi developed a word processing program called Bravo, which used a new idea called "what you see is what you get." Alan Kay developed a new interactive object-oriented programming language called Smalltalk. Another new system was the Ethernet network used to connect the Alto computers and peripherals. Robert Metcalfe designed the initial

communications software called PUP (PARC Universal Packet) based on ARPANET concepts. Other principals in software design at PARC were William K. English and Lawrence G. Tesler.

Xerox PARC had created significant innovations in personal computer technology. The synthesis of hardware and software to facilitate a friendly user interface was unique. Subsequently, Apple Computer and Microsoft would use various concepts developed by PARC in their technology for the new microcomputers.

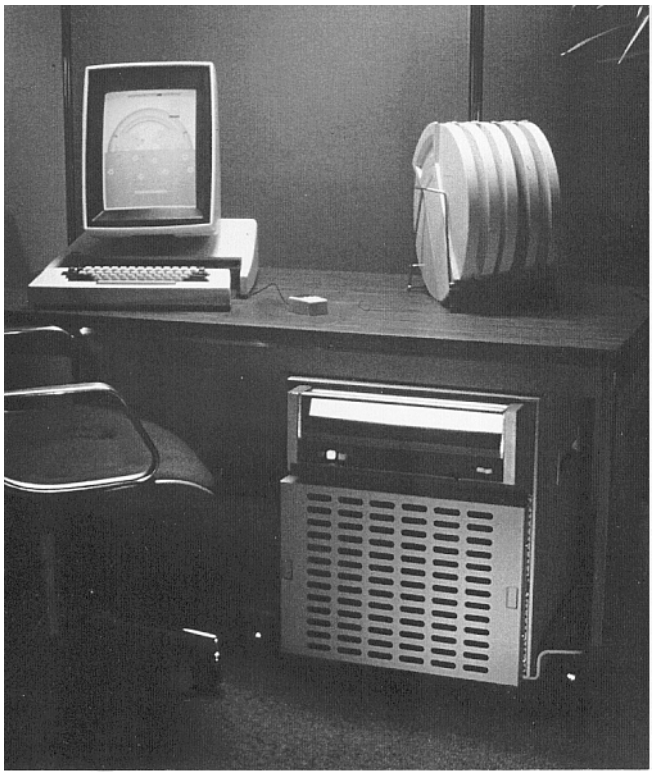

Figure 4.1: Xerox PARC Alto computer.

Photograph is courtesy of Xerox Corporation.

The Early Microcomputers

Intel developed the first 1K dynamic random access memory (DRAM) chip in 1970. Then in 1971, Intel created the 4-bit 4004 microprocessor, followed by the 8-bit 8008 microprocessor in 1972. The first application of the Intel 4-bit microprocessor was in the Japanese Busicom calculator. This was the technology that changed personal computing -- large scale integrated (LSI) memory chips and the early Intel microprocessors.

Intel Corporation released the SIM4 simulator board that used the 4004 processor in May 1972, and shortly after the SIM8 that used the 8008 processor. The company then introduced the Intellec 4 and 8 Development Systems in August 1973. These computers facilitated the development of software for new microprocessor products. Initially, Intel made significantly more money from the Development Systems, than from the sale of microprocessor chips. The simulator board was the first application of a microprocessor to a computer product. However, Intel designed the board as a development aid, not as a personal computer.

The first personal computer to use a microprocessor was the French built Micral developed by Realisations Études Électroniques S.A. (REE), also known as R2E. Truong Trong Thi, a French-Vietnamese engineer, cofounded the company and is credited with being inventor of the first microcomputer. Francois Gernelle was a principal in the design. The computer used an Intel 8008 processor and was released in January 1973 at a price of $1,900. Poor sales resulted in the company filing for bankruptcy in October 1975. However, France had the distinction of preceding the USA in producing the first microcomputer.

In the USA, the first personal computer to use a microprocessor was the Scelbi-8H from Scelbi Computer Consulting, Inc. Scelbi was an acronym for Scientific, electronic and biological. Nat Wadsworth formed the company in August 1973 and advertised the computer in the March 1974 issue of *QST*, an amateur radio magazine. Scelbi described it as “The totally new and the very first Mini-Computer.” Wadsworth and Robert Findley designed the Scelbi-8H using the Intel 8008 processor. A

kit sold for "as low as $440." In April 1975, Scelbi introduced the Scelbi-8B computer for business applications. Subsequently the company changed its business orientation to software and book publishing. The Scelbi computers were not successful. However, a computer called the Mark-8 obtained a certain amount of success when details of it appeared in a national magazine.

Jonathan A. Titus described how to build the Mark-8 Minicomputer in the July 1974 issue of *Radio-Electronics* magazine [282]. The computer used the Intel 8008 processor. The article advertised the 8008 processor as being available from Intel for $120.00 and a set of six boards for $47.50. The popularity of the computer resulted in Mark-8 clubs being formed and clubs' newsletters being published.

The Mark-8 and the other early microcomputers were important, but 1974 was significant for another reason. With the release of the Motorola MC6800 microprocessor, Intel now had a strong competitor that would affect future personal computer products. However, the personal computer industry really started in 1975 with the introduction of the MITS Altair computer.

4.2 ... MITS Altair

H. Edward Roberts, Forrest M. Mims and two other officers from the Effects Branch of the Air Force Weapons Laboratory in Albuquerque, New Mexico, founded MITS (Micro Instrumentation and Telemetry Systems), Inc., in 1969. Their initial interest was in telemetry systems for amateur rockets and an infrared voice communicator, but these were not a commercial success. In November 1970, Roberts bought out the other founders and started working on an electronic calculator kit. The November 1971 issue of *Popular Electronics* featured the new MITS 816 calculator. MITS sold thousands of the calculator kits, but by early 1974 competition from low-priced ready-made products forced the company out of the market. MITS required a new product. After evaluating

the Intel microprocessors, especially the new 8080 chip, Roberts decided to create a computer kit.

After the article describing the Mark-8 computer appeared in the July 1974 issue of *Radio-Electronics*, the editors at *Popular Electronics* were eager to have an article on a superior computer for their magazine. The timing was right for Roberts, who agreed to provide an article on a design that used the Intel 8080 processor for the January 1975 issue. The magazine cover headline for an article written by Roberts and William Yates read, "World's First Minicomputer Kit to Rival Commercial Models ... Altair 8800" [301]. Yates and Jim Bybe assisted Roberts in the engineering design. Roberts initially selected the name PE-8 (Popular Electronics 8-bit) for the computer. However, Leslie Solomon, who was the technical editor of the *Popular Electronic* magazine, thought the name PE-8 dull, and selected the celestial name "Altair" for the computer. The introduction of the Altair 8800 became a major event in the start of the personal computing industry.

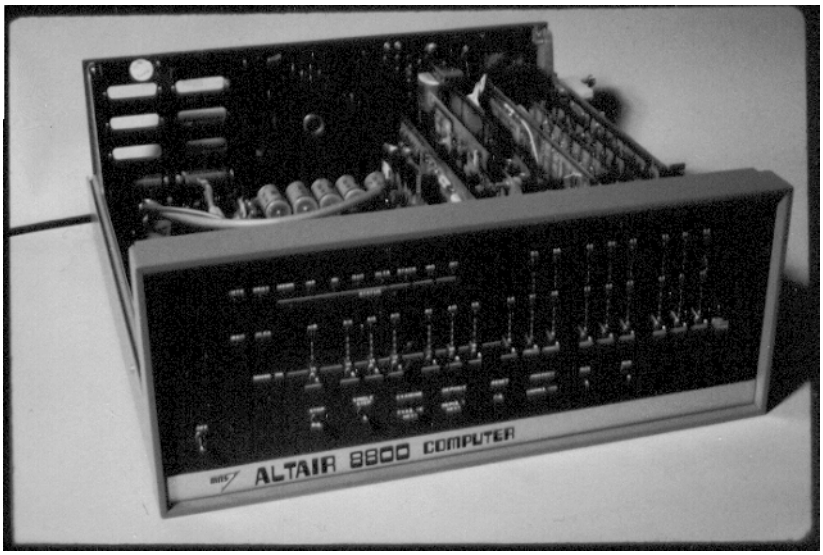

Figure 4.2: MITS Altair 8800 microcomputer.
Photograph is courtesy of Intel Corporation.

The computer had a front panel with toggle switches for control and input, and light emitting diodes (LED's) for output display. Roberts had negotiated with Intel to obtain a special high volume price of $75 for the 8080 microprocessor. The computer sold as a kit for $397, or completely assembled for $498. MITS hoped to sell about eight hundred computers a year. However a flood of orders overwhelmed MITS and created delivery problems due to inadequate production capacity.

A significant design decision by MITS was the use of an open bus architecture similar to that used in minicomputers. This provided expansion capabilities, for additional memory and peripherals. Originally called the "Altair Bus," it later became known as the "S-100 Bus" because the bus had 100 connection points. Memory cards were available as a kit or assembled at prices ranging from $90 to $400. The 4K memory card was the minimum size required to run Altair BASIC. However, the MITS memory cards used dynamic RAM chips that were unreliable. Providing reliable replacements for these cards and extending the capabilities of the Altair 8800 led to the founding of a number of other companies such as Cromemco and Processor Technology. MITS released an improved version, the Altair 8800b in April 1977.

To compete with companies that used the Motorola MC6800 processor, MITS announced a new computer called the Altair 680 in October 1975. The Altair *Computer Notes* newsletter announced that it would be less expensive than the Altair 8800. It would use the MC6800 processor, be smaller and have a limited expansion capability. However, a kit would only cost $293. Design problems delayed the release of the computer until 1976, by which time MITS had also changed the designation to the Altair 680b and the price to $466 as a kit or $625 assembled.

William Gates and Paul Allen developed the BASIC interpreter for the Altair. This development resulted in Roberts hiring Paul Allen, who became the director of software for MITS. During the development of the Altair 680b, Allen hired Mark Chamberlain to work on software for the new computer. In late 1976 Allen left MITS to

work full time at Microsoft and Chamberlain became the new director of software.

Roberts started to have misgivings about the competition and his company in 1976. This resulted in a letter of intent being signed for the purchase of MITS, by the Pertec Computer Corporation in December. Pertec completed the purchase in May 1977. However, MITS was bankrupt by 1979.

MITS did not survive the transition from electronic hobbyist to the plug-and-play user market. However it left a significant legacy. It created a popular product, established the personal computer industry and started the "personal computer revolution."

4.3 ... Other Computers - - 1975-76

The years 1975 and 1976 were significant for personal computing. In 1975 MITS released the Altair 8800, the Homebrew Computer Club started in California, William Gates and Paul Allen founded Microsoft and *Byte* magazine published its first issue. In 1976 *Dr. Dobb's Journal* appeared, MITS held the first microcomputer convention and Intel announced the 8085 microprocessor. These were just a few of the more significant events that accompanied innovations by various companies and numerous microcomputer entrepreneurs. This was a period of significant growth. The following describes some of the more dominant companies and the computers they introduced.

The larger computer companies were slow to incorporate the microprocessor in their products. However, in April 1975, Digital Equipment Corporation (DEC) released its first microprocessor based product, the LSI-11 microcomputer board. The LSI-11 used a 16-bit processor designed and manufactured by DEC that incorporated features of the DEC PDP-11 minicomputer. Early applications of the board were in the DEC LSI-11/23, DEC PDP-11/03 microcomputer systems and the Heathkit H11 computer.

IBM announced the IBM 5100; the first commercially produced portable computer in September

1975. This evolved from the SCAMP computer designed in 1973. The unit weighed 50 pounds and the company described it as being "slightly larger than an IBM typewriter." Targeted primarily at the scientific market, it was capable of running APL and BASIC programming languages. The price at introduction ranged from $8,975 to $19,975 depending on the memory and programming language configuration. In 1977, the company introduced the IBM 5110 model with two diskette drives for the commercial market.

Mike Wise developed the Sphere microcomputers and advertised them in the first issue of the *Byte* magazine (September 1975). The Sphere Corporation advertised three models that used the Motorola MC6800 processor. The Hobbiest computer kit sold for $650, the Intelligent computer kit had additional features with a price of $750 and a computer named BASIC sold for $1,345. Sphere then released the System 340 that had an integrated monitor and keyboard. However, Sphere had a number of problems with their computers that resulted in the failure of the company.

In the fall of 1975, MOS Technology (who manufactured the 6502 processor) announced the KIM-1 computer designed by Chuck Peddle. The name was an acronym for Keyboard Input Monitor. The computer used a MOS 6502 processor and cost $250 fully assembled.

In November 1975, an established low-cost electronic kit company called Southwest Technical Products Corporation (SwTPC), founded by Dan Meyer, introduced the SwTPC 6800 Computer System. Before releasing their computer they had produced a Digital Logic Microlab for digital experimentation, a KBD-2 Keyboard and an Encoder Kit. Gary Kay, Don Lancaster and Meyer designed the SwTPC 6800 computer that used the Motorola MC6800 processor. The kit sold for $395. The SwTPC 6800 was one of the first computers to incorporate the Motorola mini-operating system called Mikbug. The unit used an SS-50 bus for expansion boards. It had no front panel switches for input; the system automatically started (booted) on power-up or by pushing the reset button. SwTPC was primarily a kit supplier and was not

successful in the transition to complete computer systems for a larger consumer oriented market.

William H. Millard was a principal in the 1973 founding of a computer consulting company called IMS Associates, Inc. Two other personnel involved in the early development of IMS were physicist Joseph Killian and a computer science graduate, Bruce Van Natta. The company entered the microcomputer market through various attempts to network Wang computers for an automobile dealer. IMS considered the Altair for use in the network then discarded it due to financial and delivery problems with MITS. This resulted in Killian designing an improved version of the Altair 8800. IMS called the new computer the IMSAI 8080 and released it in December 1975. It used the Intel 8080A processor and a kit had a price of $499. The IMSAI 8080 became a successful alternative to the Altair 8800 and is notable for being the first clone! In October 1976, Millard made IMS Associates Inc., a holding company for IMSAI Manufacturing Corporation and the ComputerLand retail store organization.

Robert Marsh and Gary Ingram founded Processor Technology Corporation in April 1975. The initial products were input/output and memory expansion boards for the MITS Altair 8800 computer. Then in mid 1975, Leslie Solomon, who was the technical editor of *Popular Electronics*, approached Processor Technology with a request to develop a computer terminal suitable for an article in the magazine. By February 1976, Marsh and Lee Felsenstein developed not just a terminal, but a complete computer design that appeared in the July 1976 issue of *Popular Electronics*. The company named the unit "Sol Terminal Computer." Sol was an abbreviation of Solomon's name. The Sol-10 Terminal Computer kit used the Intel 8080A processor. The computer also had an attractive low profile style cabinet with wooden sides made of walnut. The ROM memory featured a "Personality Module" that facilitated an easy change of the operating system. Steve Dompier created the minimal operating system called CONSOL. The company introduced the factory assembled Sol-20 model at the Personal Computing 76 show in Atlantic City. The Sol-20 used an Intel 8080

processor and an advanced operating system called SOLOS. Processor Technology released later a dual eight-inch disk drive named Helios with a PT-DOS disk operating system. However the company did not maintain a competitive product line and terminated business in May 1979.

Two Stanford University professors, Harry Garland and Roger Melen, started a business called Cromemco Inc. in 1975. The company name was derived from their dormitory called Crothers Memorial Hall, at Stanford University. The first products were add-on boards for the MITS Altair 8800 computer. The company introduced the Cromemco Z-1 computer that used the Zilog Z-80 processor in 1976. The Z-2 Computer System followed in March 1977 and the System Zero, One, Two and Three computers later. Cromemco subsequently changed its market orientation to engineers and scientists, but it was not successful, which resulted in it being sold in 1986.

Mike and Charity Cheiky founded Ohio Scientific Instruments (OSI) in 1975. The company announced the OSI 400 Superboard computer in September 1976, that used either a Motorola MC6800, MOS 6501 or 6502 processors. OSI also released a Model 300 computer training board based on the MOS 6502 processor.

Rich Peterson, John Stephensen and Brian Wilcox established PolyMorphic Systems in December 1975. The company announced their first computer in October 1976. PolyMorphic initially named the computer the "Micro-Altair." However after objections from Ed Roberts of MITS, PolyMorphic changed the computer name to "POLY 88." It used the Intel 8080A processor, and sold for $685 as a kit. PolyMorphic then released the System 8813 that consisted of a main unit with a walnut cabinet, which used an Intel 8080 processor and had a detached keyboard. The system price started at $2,795. PolyMorphic developed its own operating system and Disk BASIC. The company ceased operations in the early 1980's.

John Ellenby headed the design group at Xerox PARC that started working on the design of the Alto II computer in June 1975. Company personnel received the

Alto II's in mid 1976. Ellenby proposed the design and manufacture of Alto III's in late 1976. However, Xerox executive staff did not support the future potential of the Alto computer and rejected the proposal.

Numerous other small companies released microcomputers between 1975 and 1979. *A Collectors Guide to Personal Computers and Pocket Calculators* [197] provides details of these computers.

The personal computer market changed in 1977. The dominant pioneering manufacturers such as Cromemco, IMSAI, MITS, OSI, PolyMorphic Systems, Processor Technology and SwTPC had attracted the electronic hobbyist. However they failed to develop products that were more applicable to a non-technical type of general user. New companies started offering products that were "plug in" systems for personal or business use. These new systems did not require any assembly or technical training. The Apple II computer as detailed in Chapter 5 was one of those new systems. The other dominant manufacturers in this new second generation of personal computers would be Atari, Commodore and Tandy/Radio Shack.

4.4 ... Commodore

In 1954, Jack Tramiel and a friend founded a typewriter repair business in New York called Commodore Portable Typewriter. The company moved to Toronto, Canada and became known as the Commodore Business Machines Company in 1956. In the 1960's the company sold adding machines, then hand-held calculators in the early 1970's. The company went public and became Commodore International Inc., in May 1974. However, competitive problems in the calculator market created financial difficulties for Commodore.

After corporate refinancing, Commodore bought MOS Technology (who supplied their chips) in October 1976. Chuck Peddle, who was the designer of the MOS 6502 processor, impressed Tramiel with the potential of the chip. Tramiel decided that the MOS 6502 could be "...the

makings of the first low-cost personal computer" [180]. Commodore announced the PET 2001 computer in December 1976 and introduced it at the National Computer Conference (NCC) in June 1977. The name PET denoted "Personal Electronic Transacter" officially, or "Programmable Educational Terminal" at other times.

The PET 2001 used a MOS 6502 processor and had an integrated CPU, video display, keyboard and cassette tape drive. The ROM chip contained the cassette operating system and a Microsoft BASIC interpreter. Commodore priced the computer at $595 with 4K bytes of memory and $795 with 8K. Initially the company had an interesting policy of "pay now, delivery later."

Commodore then introduced the PET 4000 series in 1978 for educational and scientific users. The system had a MOS 6502 processor, an improved keyboard, but omitted the integrated cassette drive that had been on the original PET.

4.5 ... Tandy/Radio Shack

Dave Tandy and Norton Hinckley founded the Hinckley-Tandy Leather Company in 1927 as a retailer of leathercraft products. In 1961, they changed the company name to Tandy Corporation. Then Charles Tandy, a son of the founder, decided to enter the consumer electronics market in 1962. Tandy acquired control of Radio Shack, a distributor of electronic parts and products, by 1965. Donald H. French who was a buyer for the company and a computer hobbyist, promoted the release of a computer product. This resulted in Tandy deciding to enter the personal computer market in 1976.

Radio Shack announced the TRS-80 Micro Computer System designed by Steven Leininger in August 1977. TRS is an acronym for Tandy Radio Shack. Although the computer was not a single physical unit like the Commodore PET, it was a complete system with keyboard, video display and cassette tape recorder. The computer CPU and keyboard were a single unit. The power supply, video monitor and cassette recorder were separate units of the system. The computer system used a Zilog Z-80 processor and the ROM chip contained a Level-I BASIC

interpreter. Leininger developed the BASIC interpreter by adaptation of a public domain program called "Tiny BASIC." Later, the company released a vastly improved Level II BASIC, developed by Microsoft. The complete system with processor and keyboard unit, power supply, video monitor and cassette recorder sold for $599.95. The processor/keyboard unit was available separately at a price of $399.95 with 4K bytes of RAM. With orders greater than initially expected, the TRS-80 was a success.

Radio Shack subsequently released an Expansion Unit with a TRS-80 Mini Disk System. Radio Shack developed a TRSDOS operating system that was not compatible with the popular CP/M operating system. The company then designed the TRS-80 Model II for business applications and announced the computer in May 1979. It used the faster Zilog Z-80A processor. It also had a floppy disk drive, additional functions, more memory and sold for $3,450 as a state-of-the-art computer. With the introduction of the Model II, the company changed the name of original TRS-80 to the TRS-80 Model I.

4.6 ... Atari

Nolan K. Bushnell and Ted Dabney founded the Atari Corporation in June 1972. They introduced a video table tennis game called "Pong" in November that was a huge success. The co-founders of Apple Computer, Steven Jobs and Stephen Wozniak designed a computer game called “Breakout” for Atari. Bushnell sold Atari to Warner Communications Inc., for $26 million in 1976 and shortly after left the company. Warner then appointed Raymond Kassar to replace Bushnell and manage the company. Atari announced the Atari 400 and Atari 800 computers in December 1978, although the units did not become available until late 1979.

The Atari 400 used a MOS 6502 processor and the housing included a plastic membrane keyboard. The Atari 400 had a price of $499 with 8K bytes of memory and a price of $630 with 16K bytes. The Atari 800 model also

used the MOS 6502 processor, an improved keyboard and had a price of $1,000.

Atari had a restrictive policy in providing system information to software companies. This limited the development of application programs for the Atari computers that adversely affected sales.

4.7 ... Other Computers -- 1977-79

This section describes other computers developed from 1977 to 1979. Two major companies were the Heath Company and Texas Instruments.

Heath Company

The Heath Company was a subsidiary of Schlumberger Ltd., and was the dominant manufacturer of electronic kits in the 1970's. The company entered the personal computer market in June 1977 with the announcement of the H8 and H11 computer kits.

The H8 computer used the Intel 8080A processor, had a front panel with a 16-key keypad for octal input and a LED display. The price of the computer kit was $375. The H11 computer was an early 16-bit computer using the DEC LSI-11 microcomputer board. The LSI-11 had operating characteristics of a DEC PDP-11 16-bit minicomputer. This computer kit had a price of $1,295. Peripheral products included the H9 video terminal kit that had a price of $530 and the H10 paper tape reader and punch kit had a price of $350. Memory, parallel and serial interface cards were also available.

A Benton Harbor BASIC interpreter was available in 8K and 12K versions. The HDOS operating system was also available for a H7 floppy disk drive assembly. Gordon Letwin developed the software.

Zenith Radio Corporation acquired the Heath Company for $64.5 million in 1979. Following the acquisition, Zenith introduced a completely new computer called the Heath/Zenith-89. Zenith designated the factory assembled version the Z-89 and the Heathkit version the H89. It was an integrated desktop unit that included the CRT, keyboard and a single 5.25-inch floppy disk drive. The Heath/Zenith-89 used a Zilog Z-80

processor. A kit sold for $1,595 or an assembled unit for $2,295. Heath/Zenith provided a Text Editor, Assembler, HDOS operating system and an Extended Benton Harbor BASIC interpreter.

Texas Instruments (TI)

An early 1978 headline for the Texas Instruments SR-60A read "TI's First Personal Computer?" TI described the SR-60A as a "personal computer/calculator" having "the power of a computer with the simplicity of use and low cost of a calculator." It cost $1,995.

Texas Instruments introduced the TI-99/4 computer in June 1979. TI described it as "featuring easy-to-use computing power for personal finance, home management, family entertainment and education." The basic system consisted of a TI TMS9900 16-bit processor, an integrated keyboard within the housing and a separate 13-inch color monitor with 16 colors. TI provided BASIC software that was a full floating point, expanded version compatible with the ANSI standard. The price for the TI-99/4 system was $1,150. Also available was a range of Solid State Software command modules at prices ranging from $20 to $70 and a Solid State Speech synthesizer accessory for $150.

Other Computer Releases

Hewlett-Packard (HP) introduced a new generation of the HP 9800 series of computers between 1976 and 1979. This new generation changed the processor from TTL logic to a proprietary 16-bit NMOS processor called the "BPC." An example of the computers in this series was the HP 9831A desktop computer, introduced in mid 1977. The computer had a BASIC interpreter and a price of $7,200.

Noval Inc., introduced the Noval 760 computer that used an Intel 8080A processor in June 1977. The computer system was a unique package in a desk console with drawers, retractable keyboard and a fold-down top. The console had a 12-inch monitor, cassette drive and sold for $2,995.

In July 1977, the Digital Equipment Corporation introduced the DECstation, also known as the VT78 that

was compatible with PDP-8 computers. DEC physically configured the computer similar to the VT52 terminal. The VT78 used an Intersil 6100 CPU, had 16K bytes of RAM and was advertised at a price of $7,995.

The Digital Group Inc., was a company that developed a unique computer design that enabled one to change the processor by inserting the appropriate CPU board. Robert Suding designed the Digital Computer System in the mid 1970's. It was available with one of four processors: AMD 8080A, MOS 6502, Mostek 6800 or Zilog Z-80. An 8080 computer system with 10K bytes of memory had a cost of $645.

Charles Grant and Mark Greenberg founded North Star Computers, Inc. They had also founded Applied Computer Technology, G&G Systems and Kentucky Fried Computers. The initial products were plug-in boards for the S-100 Bus and floppy disk systems. North Star released the Horizon-I computer that used a Zilog Z-80A processor in October 1977. The company developed their disk operating system and BASIC interpreter. North Star subsequently released the Horizon-II computer with higher capacity disk drives.

IMSAI Manufacturing Corporation introduced a desktop business computer called the VDP-80 in late 1977. The computer was an integrated unit; with a video monitor, 8-inch disk drives and keyboard. However, the computer had a number of technical problems. IMSAI replaced it with the VDP-40 that used 5.25-inch disk drives, but the product was too late. IMSAI then failed to respond to a market change from electronic hacker to the mass consumer user. William Millard, a founder of IMSAI, had also shifted corporate resources to his ComputerLand retail organization. This resulted in IMSAI going bankrupt in March 1979.

Xerox established a Systems Development Division (SDD) in California to advance PARC inventions into commercial products. SDD then started development of an Alto based office automation computer with the project code name of Janus. The code name changed to Star in late 1977. Then in January 1978, Xerox established an Advanced Systems Division (ASD) that implemented a market evaluation program to determine the feasibility

of personal computing and the Alto computer. Xerox selected four test sites that included the White House and the U.S. House of Representatives. By the end of 1978, over 1,500 Alto computers were in use. However, Xerox terminated manufacture of the Alto computer in January 1979.

Ohio Scientific Instruments introduced various models in the Challenger series between 1977 and 1979. The Challenger III model was unique in having multiple processors: a 6502, Z-80 and a MC6800 on the same CPU board. OSI was an early developer of floppy-disk drives for their computers that used an operating system called OS 65. OSI had problems competing with other companies such as Apple Computer, Atari and Tandy/Radio Shack. This resulted in Ohio Scientific Instruments being acquired by MaCom, a large communications firm who sold OSI again to a company that went bankrupt.

The microprocessor and LSI memory chips enabled development of microcomputers, the electronic hobbyist and software enthusiast provided the market in the 1970's. However, most of the early dominant microcomputer manufacturers did not retain their market position. Other companies and entrepreneurs introduced personal computers for a new consumer market. Significant suppliers to that mass market were Apple Computer, Commodore and Tandy/Radio Shack. New processors such as the Intel 8088 and the Motorola MC68000 introduced in 1979 would start another new era in personal computing. The dominant producers would change from small entrepreneurs to larger corporations such as IBM. However, Apple Computer, as described in the following Chapter, was an exception. It started as a small entrepreneurial company, then attained a position as a leading supplier of personal computers.

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