Part V

Bits and Bytes.

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Chapter 17   Hardware and Peripherals

17.1 ... Memory

The microprocessor was a significant key to lowering the cost of the personal computer. However the other key and an equally important one was low-cost semiconductor memory. Semiconductor memory started replacing magnetic core memory around 1967.

Their are two types of semiconductor Random Access Memory (RAM). Dynamic RAM (DRAM) requires periodic refresh of the memory contents and Static RAM (SRAM) retains the contents without refresh. Both types of RAM loose their contents when the power is turned off. Read only memory (ROM) retains its contents once it is programmed, even when the power is turned off.

The first commercial 1K metal oxide semiconductor DRAM was the Intel 1103 released in October 1970. This chip had a pivotal role in undercutting the price and replacement of core memory. Intel continued to improve DRAM capacities with the release of the 4K 2107 chip in 1972 and the 16K 2117 chip in 1977. However, competitive challenges from Japanese companies, would have a significant impact on Intel and other North American producers of memory chips.

Japan decided to make a strategic investment in the semiconductor memory industry around in the late 1970's. The effect of this was the first open market release of a 64K DRAM chip by Fujitsu Limited in 1979, and introduction of the first 1-megabit DRAM chip by the Toshiba Corporation in 1985. A number of other factors contributed to the dominance of Japanese manufacturers in the 1980's. Some of these were: a cooperative relationship between various companies in the Japanese industry, illegal use of U.S. technology, superior quality that contributed to lower costs and a significant investment in new facilities to produce memory chips. This resulted in a price war by the Japanese producers to increase their market share through the early 1980's. By 1985 the market situation

for North American producers had so deteriorated, that the U.S. Government accused Japan of unfair trading practices and filed an antidumping complaint against the Japanese manufacturers. A semiconductor agreement was signed by the governments of Japan and the United States in 1986. However, by this time it had adversely affected many U.S. companies such as the Intel Corporation that had already decided to withdraw from the DRAM market. The company also withdrew from the EPROM chip market in 1989.

Erasable Programmable Read-Only Memory (EPROM) was invented by Dov Frohman at Intel. The memory contents can be programmed then erased by exposing the chip to ultraviolet light. Intel released the 2K-bit 1702 EPROM chip in September 1971. This alterable storage medium provided a low cost way to store microcomputer programs and became a successful and extremely profitable product for Intel until the mid 1980's.

Flash memory was developed by Toshiba. It provided the non-volatility of EPROM but the memory could be erased electrically. Electrically Erasable Programmable Read-Only Memory (EEPROM) was developed by National Cash Register (NCR) and Westinghouse companies.

17.2 ... Storage Devices

Tape Drives

Paper tape was one of the earliest forms of storage for personal computing. However it normally required a teletype machine for input/output that was too expensive for the average user.

Another early storage medium for personal computers was the magnetic audio cassette tape and the subsequent digital data cassette. Information Terminals Corporation (ITC) was the first producer of high quality data cassettes. The company was founded by J. Reid Anderson in April 1969. Anderson had previously developed acoustic-coupler modems and a prototype for a "smart" computer display terminal. During the development of the computer display terminal, Anderson

determined that audio tape cassettes were not a sufficiently reliable storage medium for recording digital data. The audio cassettes did not have a uniform magnetic coating or a precise cassette body that resulted in "dropouts" or lost data. This resulted in the development of a high quality, precision data cassette that ITC started producing in 1970. The company became the dominant supplier of digital data cassettes in the 1970's. ITC introduced a mini cassette for portable data processors and a quarter-inch data cartridge in 1975. A new superior coating media for tapes and disks named Verbatim, was announced in February 1977. The company changed its name to Verbatim Corporation in late 1978, and went public in February 1979.

The 3M company introduced quarter-inch tape drive media in 1971. The capacity of these early drives was only 30 megabytes.

Jerry Ogdin developed the concept of using two tones on magnetic tape to represent digital data. This was implemented in a *Popular Electronics* construction article with the name of HITS (Hobbyists' Interchange Tape System) in September 1975. It was inexpensive and was adapted by many manufacturers. Initially each company had their own formatting standards. However in November 1975 *BYTE* magazine organized a meeting in Kansas City, Missouri of interested companies. The companies agreed to a format that became known as the "Kansas City Standard." This standard facilitated the exchange and use of magnetic tapes on different systems.

Disk Drives

The Beginning at IBM

Hard disk drive technology was developed by IBM in the 1950's as described in Section 1.3. The first Winchester hard disk drive was announced by IBM in March 1973 as the Model 3340 Disk Storage Unit. It was developed as a low-cost drive for small to intermediate computer systems. The term Winchester was used by the engineers due to the storage capacity characteristics and similarities to the name of a popular rifle as

described in Section 20.4. A principal in the development was Kenneth E. Haughton who had assumed responsibility for the project in 1969. The drive assembly used a removable sealed cartridge with 14-inch diameter disks and was available in 35 and 70 megabyte storage capacities.

Floppy disk drives were developed at IBM laboratories by David L. Noble during the period of 1967 to 1971. They were initially developed by IBM as a means of storing and shipping microcode for Initial Control Program Load (ICPL) software programs on mainframe computers. The jacket enclosing the diskette was developed to protect the disk during handling and shipping.

The initial eight inch diameter read only units had a product designation of 23FD, a code name of Minnow and shipped in 1971. The diskette on the read only units rotated at 90 revolutions per minute and data was recorded on one side only. The diskette capacity was 81,664 bytes on 32 tracks which were hard sectored with eight holes around the outer edge of the disk.

The eight inch diameter read-write units had a product designation of 33FD, a code name of Igar and shipped in 1973. The diskette on the read-write drive units rotated at 360 revolutions per minute, had a capacity of 242,944 bytes on 77 tracks which was recorded on one side only and used magnetic soft sectoring (no sector holes). The 33FD diskette drive was a success and was used in data entry products which started to replace IBM card systems.

In 1976 the 43FD unit was shipped with data being recorded on both sides and capacity increased to 568,320 bytes on 154 tracks. In 1977 the 53FD double-density unit was shipped with capacity increased to 1,212,416 bytes.

IBM's research and development activities created the Winchester hard disk drives and the floppy disk drives. However other companies entered the market to compete with IBM products and to provide disk drives for other computer systems. Some of these manufacturers were Control Data Corporation (CDC), Conner Peripherals,

Maxtor, Micropolis Corporation, MiniScribe, Quantum Corporation, Seagate Technology, Shugart Associates and Western Digital Corporation. In the mid 1970's, hard disk drives were not suitable for use with microcomputers due to their large size and high cost. However by 1976, inexpensive floppy disk drives became available for personal computers.

Floppy Disk Drives

Alan F. Shugart joined IBM as a customer engineer in 1951. After a number of positions related to memory and storage technology he became manager for direct access storage products. Shugart left IBM in 1969 to become manager of storage products at Memorex. In 1973 Shugart left Memorex and with Finis F. Connor and Donald J. Massaro founded Shugart Associates. The company announced the SA-900 8-inch floppy diskette drive that retailed for $500 in the summer of 1973. After two years Shugart had a dispute regarding capitalization of the company and left. Shugart Associates announced the SA-400 5.25-inch minifloppy disk drive for $390 in December 1976. The drive used a single-sided single-density floppy disk with a capacity of 110 kilobytes. Shugart Associates was acquired by Xerox Corporation in 1977. However it was not profitable and resulted in Xerox terminating Shugart operations in 1985.

The first advertisement for a microcomputer floppy disk drive in the *Byte* magazine appeared in the August 1976 issue. The eight inch drive is described as "iCOM's Frugal Floppy. At $995, your microprocessors best friend." It was produced by iCOM Microperipherals that was a division of the Pertec Computer Corporation. Then in the February 1977 issue of *Byte*, iCOM advertised a 5.25-inch Microfloppy disk drive system for $1,095.

North Star Computers, was another early manufacturer of floppy disk drives for MITS Altair and compatible microcomputers. The company advertised the Micro-Disk System (MDS) in the January 1977 issue of *Byte* magazine. The unit used a Shugart SA-400 mini floppy disk drive and sold for $599 as a kit, or $699 assembled.

Reference Section 5.5 for information on the Apple Disk II floppy disk drive introduced by Apple Computer in 1978. In the late 1970's, other companies such as Alps Electric Company of Japan (who supplied Apple Computer), Sony Corporation and Tandon Corporation entered the floppy disk drive market. During 1982, various Japanese manufacturers offered half-height 5.25 inch floppy disk drives.

Microfloppy disk drives were introduced in the early 1980's for portable computers and to provide a more durable diskette and a less expensive drive assembly. The term floppy was not accurate as the disk was contained in a hard-shell cartridge. It also included an automatic shutter that closed over the recording surface when it was removed from the drive. Initially there were different incompatible disk sizes. Companies such as Hitachi introduced a 3.0 inch drive, Seagate supported a 3.25 inch dive, Sony and Shugart a 3.5 inch drive, Canon a 3.8 inch drive and IBM a 4.0 inch drive. This resulted in the Microfloppy Industry Committee (MIC) being formed in May 1982 to reach a consensus on a common configuration standard. In September a 3.5 inch system was proposed. Sony became a dominant supplier of 3.5 inch disk drives in 1983. The initial Sony disk drive had a storage capacity of 438 kilobytes that was subsequently increased to 1 megabyte (720 kilobytes formatted). Early applications of the 3.5 inch drive were in the Hewlett-Packard HP-150 computer and the Apple Macintosh computer.

Hard Disk Drives

Hard disk drive technology changed significantly in the years following its initial development by IBM. The storage capacity, access time and physical size have been dramatically improved. The original 14-inch diameter disk was reduced to 8-inches in 1978, then to 5.25-inches in 1980, to 3.5-inches in 1984 and to 2.5-inches in 1989.

The first Winchester 8-inch hard disk drive was introduced by Shugart Associates in 1978. Alan Shugart and Finis F. Conner who had been cofounders of Shugart Associates founded Shugart Technology in 1979. A major

investment was made in the new company by the Dysan Corporation, a disk manufacturer. Shortly after the company name was changed to Seagate Technology, Inc. The first Winchester 5.25-inch hard disk drive with a storage capacity of 10 megabytes was announced in June 1980. Conner left Seagate and founded his own disk drive company called Conner Peripherals, Inc. in 1985. Seagate Technology became a dominant supplier of disk drives when it acquired the disk operations of Control Data Corporation in 1989. In early 1996, Seagate purchased Conner Peripherals and became the largest U.S. manufacturer of hard disk drives.

David Brown, James Patterson and others founded the Quantum Corporation in 1980. The companies first 8-inch hard disk drive was produced in early 1981 and a 3.5-inch hard disk drive was introduced in 1988. The company is now the second largest manufacturer of hard disk drives.

Western Digital Corporation was founded as a manufacturer of calculators and semiconductors in 1970. In the mid 1980's, the company reorganized and changed product lines to concentrate on storage devices. The company acquired the disk drive operations of Tandon Corporation in 1988. Western Digital is now the third largest U.S. manufacturer of hard disk drives.

Apple Computer's first mass storage system called the ProFile was introduced in September 1981 for the Apple III computer. The unit used Winchester technology, had a 5 megabyte storage capacity and was priced at $3,495. The hard drive within the ProFile unit was the ST-506, a 5.25-inch drive manufactured by Seagate Technology. The drive had a built-in power supply and a Z-8 based controller.

Compact Disk

Compact disk (CD) technology was developed as a joint effort by N.V. Philips of the Netherlands and Sony Corporation of Japan in 1976. This led to a number of specifications to define the disk format standards for the various types of media by the early 1980's (see Section 20.3). Compact Disk - Read Only Memory (CD-ROM) drives with a capacity of 550 megabytes were introduced

in the USA in the fall of 1984. However with an initial price of over $2,000 they were expensive. High price, lack of applications and a need for format recording standards inhibited the early proliferation of the device.

Bernoulli Drive

David Bailey and David Norton founded the Iomega Corporation in 1980. Iomega introduced the Bernoulli removable disk drive with a storage capacity of 44 megabytes for personal computers in 1983. It is also known as a Bernoulli Box and features capacity comparable to a hard disk and a removable assembly for portability.

The name Bernoulli is from an eighteenth century mathematician Daniel Bernoulli who described the air dynamics utilized in the drive. The concept enables an extremely close read/write head to disk relationship but also a more tolerant protection from drive-head crashes.

A 100 megabytes Zip drive was introduced in 1995 and became quite popular as a removable high capacity disk storage system. The larger Jaz drive was introduced later, but had a number of problems.

Optical Drives

The first 12 inch diameter optical drives with Write Once, Read Many Times (WORM) recording capabilities were introduced in 1983. This was followed by 5.25 inch drives that were introduced in 1985. The principal feature of the optical drive is its extremely large storage capacity, up to 1 gigabyte. The NeXT computer was one of the earliest applications of the optical disk drive.

17.3 ... Input/Output Devices

Prior to the introduction of low cost monitors, printers and storage devices the teleprinter was a common computer input/output device. The teleprinter had an alphanumeric keyboard for input and a character printer to produce hardcopy output. It could also

include a communications interface, magnetic tape unit or a paper tape punch and reader for data storage input/output. The teleprinter was often loosely referred to as a "Teletype" due to the dominant position of the Teletype Corporation in the market.

The other significant supplier of teleprinters was IBM. The market was generally divided between Teletype and IBM compatible teleprinters.

Teletype

The Teletype Corporation produced many different teleprinter models, however popular units included the Models 33 and 35 which were announced in 1963. Three versions of each model were produced with different system designs. The ASR-33 (Automatic Send-Receive) version was priced from $755 to $2,000 depending on the configuration. The printer speed was 10 characters per second.

For the personal computer user a new machine was not only expensive but difficult to obtain. The use of used or rebuilt machines at more affordable prices was more common.

17.4 ... Displays

The September 1972 issue of *Electronic Design* had an article describing how to build a circuit that could display 1,024 ASCII characters on a TV set.

Don Lancaster was an electrical engineer who in the late 1960's started writing articles for *Popular Electronics* and *Radio-Electronics* magazines. One of Lancaster's articles described a project on how to build a decimal counting unit. Then in the September 1973 issue of *Radio-Electronics* Lancaster had an article entitled "TV Typewriter" [433] that described how the computer could be connected to a television set. A TVT-1 prototype was built by Lancaster and sold as a kit for $120 in 1973. The unit could store up to 1,024 characters and display 16 lines of 32 characters. The unit had text editing capabilities and construction details were available for $2.

The VDM-1 Video Display Terminal was a prototype only that was developed by Lee Felsenstein in 1974. It was the first video terminal to be used interactively with a personal computer.

In 1972 the IBM 3270 Information Display system was announced. This provided improved speed and silence of operation. It also facilitated interaction between the user and the computer.

Lear Siegler Inc. (LSI) was an early supplier of "glass teletype" terminals after introducing the LSI ADM-1 terminal at a price of $1,500. Another major supplier of microcomputer monitors was Amdek, founded by Go Sugiura in 1977.

17.5 ... Printers

Wire Matrix

The initial development of wire matrix printing was by Reynold B. Johnson at IBM. The initial concept used a 5 by 7 array of wires to form a character. It was introduced with the Type 26 keypunch in 1949.

In 1954 Burroughs Corporation announced a wire printer producing 100 character lines printing at 1000 lines per minute. In 1955 IBM announced two high speed printers capable of printing 1000 lines per minute. These high speed wire printers experienced numerous problems and were not successful.

In 1969 IBM introduced the Model 2213 seven-wire printer. This printer was unidirectional and printed at a rate of 66 characters per second.

Centronics

Centronics Data Computer Corporation was founded by Robert Howard as a computer systems company. The company designed a dot matrix printer called the Model 101 which was introduced in the spring of 1970. It had a speed of 165 CPS (Characters Per Second) using a 5 by 7 matrix and sold for $2,995. The Micro-1 printer with a print speed of 240 CPS and a price of $595 was released in 1977. Then in 1979, the company introduced the Centronics 700 series that included the Model 779 that

was priced at less than $1,000. Centronics was a dominant supplier of dot matrix printers in the 1970's.

Epson

Epson was one of the initial developers of low cost dot matrix printer technology. Epson's technology evolved from a printing device developed to print results from Seiko's quartz watch which was introduced at the 1964 Olympics in Japan. Subsequently a miniature printing device called the EP-101 was marketed by Seiko.

In 1975 Seiko established a subsidiary which they named Epson America, Inc. It was established to market and distribute microcomputer products worldwide. The name Epson was derived from the "son" of the EP-101 printer. Initially the company sold component parts to original equipment manufacturers (OEM's) who manufactured printers under their own brand name. Epson released its own dot-matrix printer, the TX-80 in 1978. This was the first low cost printer for microcomputers and was an immediate success.

The MX series of printers were introduced in 1980. This series was sold for the IBM Personal Computer under an OEM agreement. Subsequently Epson has developed an extensive range of printers using various technologies.

Reference Section 11.7 for Epson computer developments.

IBM

The IBM ProPrinter was introduced in the spring of 1985. It had a speed of 200 CPS, NLQ (Near Letter Quality) and was priced at $549.

Other Printers and Developments

In the late 1970's additional wires were added to the printhead to improve the resolution of dot matrix printers. The early 7-wire heads were changed to include 9, 12, 14, 18 and by the early 1980's the 24-wire head was introduced. These improvements have provided what is called "Near Letter Quality" (NLQ) and "Letter Quality" (LQ) printed output.

Color dot matrix printers became available in the late 1970's. A four color ribbon was used with overprinting to obtain various colors.

C.Itoh Electronics (CIE), Inc. was established in December of 1973. It was an early supplier of low cost printers for personal computers. A low cost, 80-column desktop printer was developed in June 1976. The Apple Computer company marketed the C.Itoh printer under the name of ImageWriter. Apple introduced the ImageWriter in December 1983 at a price of $675.

In the 1980's many other companies started competing in the low cost dot matrix printer market. Some of these were NEC, Okidata and TEC. Currently there is a rapid shift in the market to move from wire matrix printers to ink jet and laser type printers. This is due to the noise, print quality and print speed of the wire matrix printer. Also the decreasing cost of ink jet and laser printers is a significant factor.

Ink Jet

Ink jet printing technology has evolved from a long history of development. However during the 1960/70's research and development accelerated. In 1976 IBM introduced the Model 6640 continuous ink jet printer which set new standards for print quality.

Canon Inc., a Japanese camera company founded in the 1930's, introduced what they called "Bubble Jet" concept of printing in 1978. Then starting in 1978 Hewlett-Packard developed a thermal drop-on-demand concept of printing. Color printing capabilities were introduced in the 1980's.

Hewlett-Packard

The ThinkJet printer was introduced by Hewlett-Packard in 1984. The printer used a disposable printhead with twelve individually controlled chambers that expelled drops of ink from the nozzle. The printer had a speed of 150 CPS with a 11 by 12 dot character and a resolution of 96 dots per inch. The printer ink had some limitations on the type of paper that could be used. The price of the ThinkJet printer was $495.

Laser

Laser printing technology evolved from Chester Charlson's electrophotographic inventions in 1938. It was further developed as a copying technology at Haloid Corporation which became Xerox Corporation in 1961.

Electrophotographic printing is a complex process involving six steps: Charge of a photoconductor (PC) surface, exposure of the PC surface to a light pattern of the print image, movement of the toner to the appropriately charged areas of the PC surface, transfer of the developed image to a sheet of paper, fusing the transferred image to the paper and finally cleaning the PC surface in preparation for the next printing. Most electrophotographic printers use either a gas or diode laser printhead to scan the PC surface. Typical resolutions for laser printers are from 240 to over 800 dots per inch.

The first laser printer was developed by Gary Starkweather at Xerox PARC in 1971. Starkweather modified a Xerox 7000 copier and named the machine "SLOT," an acronym for Scanned Laser Output Terminal. The digital control system and character generator for the printer were developed by Butler Lampson and Ronald Rider in 1972. The combined efforts resulted in a printer named EARS (Ethernet, Alto, Research character generator, Scanned laser output terminal). The EARS printer was used with the Alto computer system network and subsequently became the Xerox 9700 laser printing system.

An inexpensive laser printer was introduced by Canon in 1983. The Canon LPB-CX had a resolution of 300 by 300 dots per inch and a operator changeable disposable cartridge. The Canon engine was sold to Hewlett-Packard and Apple Computer. The engine includes the laser diode, lens and mirror system, photosensitive roller, toner cartridge and paper handler. The Hewlett-Packard printer was named the HP LaserJet and was priced at $2,500. The Apple Computer printer was named the LaserWriter and was priced at $6,000. Hewlett-Packard subsequently became a dominant supplier of laser printers.

Burrell Smith was a principal in the development of the Apple LaserWriter printer. The printer was developed for the Macintosh computer and included a Motorola MC68020 microprocessor. The LaserWriter Plus was introduced in January 1986 and the LaserWriter II family of printers in January 1988.

Thermal Printers

The concept of thermal printing was developed during the 1960/70's using special sensitive paper. Thermal wax transfer printers were introduced by Brother, Toshiba and others in 1982. A resistive ribbon thermal transfer printer was introduced by IBM in 1983.

17.6 ... Peripheral Cards

Manufacturers developed many peripheral or add-on cards for various personal computers. These add-on cards extended and enhanced personal computer capabilities beyond those envisioned by the computer manufacturers. The following is representative of some of the more significant cards.

Creative Technology

Sim Wong Hoo, Chay Kwong Soon and Ng Kai Wa founded the Singapore company Creative Technology Ltd., in 1981. The company started by producing Apple II and IBM PC clones. Subsequently the focus was changed from clones to peripherals with the introduction of the Sound Blaster audio card in 1989. The company is a world leader in the manufacture of sound cards and multimedia accessories. Creative Labs, Inc., is a wholly-owned U.S. subsidiary and Creative Technology became a public company in 1992.

Cromemco Inc.

Cromemco was founded by two Stanford University professors, Harry Garland and Roger Melen in 1975. The first product was an add-on board called "Bytesaver" for the MITS Altair 8800 microcomputer. The board had a 2704 EPROM memory chip that could be programmed to load a monitor program to simplify the startup or "booting" of

the computer. A kit cost $195 or $295 assembled. The second board produced by Cromemco was called the "TV Dazzler" and enabled the microcomputer to be connected to a color television set. The board provided a 128-by-128 pixel display. A software program called Kaleidoscope provided an impressive demonstration of the board capabilities. A kit cost $215 or $350 assembled. In October 1976 the company released a Zilog Z-80 board for the MITS Altair 8800 microcomputer. The Z-80 microprocessor was faster and had more extensive instruction set. The Z-80 board cost $195 as a kit or $295 assembled.

Microsoft

Microsoft conceived the concept of an add-on card that would enable their software to run on an Apple II computer. The Apple II computer used a 6502 microprocessor, but most of Microsoft's software had been developed for the Intel series of microprocessors and the CP/M operating system. With the increasing sales of Apple II computers, this segment of the software market was growing.

Microsoft had Tim Paterson of Seattle Computer Products develop what became the Z-80 SoftCard. Microsoft announced the Z-80 SoftCard with a price of $399 in March 1980. Included with the card was the CP/M operating system from Digital Research and two versions of BASIC: MBASIC (which was compatible with Microsoft BASIC-80) and GBASIC with high resolution graphic enhancements. The card was an immediate success.

The RamCard was released around 1981/82 for the Apple II Plus computer to extend the memory by 16K to 64K bytes. This additional memory allowed the computer to run CP/M applications that required 64K bytes.

Processor Technology

Processor Technology Corporation was founded by Robert Marsh and Gary Ingram in April 1975. The first product was a 4K static RAM memory expansion board for the MITS Altair 8800 microcomputer. This computer only had 256 bytes of memory in the standard unit and the 4K memory board produced by MITS was not reliable. The

memory board was first advertised at the Homebrew Computer Club in April 1975 and the first order was from Cromemco. It cost $218 as a kit or $280 assembled. A 2K memory board was also available. The company also made other boards for the S-100 bus such as a 2K ROM Board, a 3P+S (parallel/serial) board, VDM-1 (Video Display Module) board designed by Lee Felsenstein and an improved motherboard for the Altair 8800.

Seattle Computer Products

Rod Brock owned Seattle Computer Products, Inc., that supplied memory cards for the S-100 bus computers around 1978. In late 1978 Tim Paterson, an employee of the company started developing a card using the new Intel 8086 microprocessor. The first prototype card was completed in May 1979. It was then demonstrated using the new Microsoft 8086 BASIC interpreter at the June 1979 National Computer Conference in New York City. Production units shipped in November 1979.

Tim Paterson also developed the operating system called QDOS for the CPU card in 1980 (see Section 13.1). This operating system later became MS-DOS.

Other Early Manufacturers

Robert Metcalfe, Greg Shaw and Howard Charney founded 3Com Corporation in 1979. 3Com is an acronym for the three *com*'s in computer, communication and compatibility. The company's main product is communication interface hardware for computer networks. Metcalfe had previously been a principal in the development of the Ethernet communications software at Xerox PARC. 3Com became a public company in 1984, and acquired U.S. Robotics Corporation in 1997.

Applied Engineering released the Transwarp accelerator card which more than tripled the speed of the Apple IIe was released in January 1986. In November 1987 the PC Transporter card was introduced to run MS-DOS programs on an Apple II computer.

The Hercules Card is a display adapter card developed by Hercules Computer Technology to display high resolution text.

North Star Computers advertised in the January 1977 issue of *Byte* magazine, a FPB Model A floating-point board to provide faster mathematical calculations. The board sold for $359 as a kit or $499 assembled. They also developed cassette tape and floppy disk interface boards.

Howard Fulmer founded Parasitic Engineering. The company initially provided add-on boards for the MITS Altair 8800 microcomputer.

SwyftCard is a card developed for the Apple II computer by Jef Raskin at Information Appliance Inc., in the early 1980's. It facilitated a number of convenient operations such as printing, calculations, telecommunications and sold for $89.95.

Vector Graphic is a company operated by Lore Harp and Carol Elly. They manufactured memory and other boards in the late 1970's. The boards were designed by Bob Harp.

IBM PC Cards

Tecmar, Inc. is a company founded by Martin A. Alpert around 1974, that provided add-on cards for the IBM Personal Computer.

In April 1982 the Xedex Corporation announced the Z-80 coprocessor card named "Baby Blue" for the IBM Personal Computer. The card had a Z-80B microprocessor that enabled CP/M programs to be run on an IBM PC.

Some other suppliers were: Quadram's Quadboard, which provided a clock, 64K bytes of additional memory, parallel and serial ports for $595 and the AST Research Combo Card.

17.7 ... Modems

The modem was invented by AT&T in 1960 and one of the earliest hobby modems called the Pennywhistle was described in the March 1976 issue of *Popular Electronics*.

Paul Collard, Casey G. Cowell and Steve Muka founded the U.S. Robotics Corporation in 1975. The first product was an acoustic coupler followed by modems. U.S.

Robotics became a public company in 1991 and was acquired by the 3Com Corporation in 1997.

Dennis C. Hayes and partner Dale Heatherington founded D.C. Hayes Associates Inc., in January of 1978. The company name changed later to the Hayes Microcomputer Products Inc., then to the Hayes Corporation. Although modems were common in the business world, Hayes was an early commercial developer of modems for microcomputers. Hayes introduced the 80-103A Data Communications Adapter modem for professional and hobby communicators in April 1978. The unit was priced at $49.95 for a bare board and $279.95 assembled. The Micromodem 100 was introduced for S-100 bus microcomputers in 1979. It could transmit data at 110 to 300 bbs and had a price of $399. In mid 1981 the Smartmodem 300 was released. Hayes also developed software to facilitate the transfer of information by modem on a phone line.

In late 1979, a company called Novation, Inc., introduced the CAT acoustic modem that was advertised at a price of "less than $199."

The VICMODEM was introduced by Commodore in March 1982 for use with the VIC computer. An interface program named VICTERM was included with the unit. The modem was priced at only $109.95 and included free offers from CompuServe, Dow Jones News and The Source.

17.8 ... Miscellaneous

Bus Systems

A bus system is a set of hardware connections used for power, signal and data transfer between components of a computer system. The bus system is characterized by its size, such as 8-bit or 16-bit and the number of lines or connection points. One of the earliest bus systems for a personal computer was the Altair Bus developed by MITS, Inc., for the Altair 8800 in January 1975. Other manufacturers adapted this bus and it became known as the S-100 Bus.

Subsequently the IEEE established a standard for the S-100 Bus. Then a working group of the IEEE Computer

Society developed the IEEE 696 bus standard. It is an augmentation and extension of the S-100 bus to 16 bits

Southwest Technical Products Corporation (SwTPC) developed the SS-50 bus for the SwTPC 6800 Computer System that they released in November 1975. It was used by a number of other manufacturers in computers using the Motorola 6800 microprocessor, such as the Smoke Signal Broadcasting Chieftain and the Gimix Ghost.

The release of the IBM Personal Computer in August 1981 established another new bus standard, the PC Bus. This was an 8-bit bus with 62 connection lines. IBM then added additional connection lines to the bus with the release of the 16-bit AT computer in August 1984. The AT Bus subsequently became known as the Industry Standard Architecture (ISA) bus.

Micro Channel Architecture (MCA) is a proprietary 32-bit multitasking bus architecture of IBM. It was a design feature of the Personal System/2 (PS/2) family of computers that were released by IBM in April 1987.

The Extended Industry Standard Architecture (EISA) was developed by a consortium of nine companies: AST Research, Compaq, Epson, Hewlett-Packard, NEC, Olivetti, Tandy, Wyse and Zenith and was announced in September 1988. It was developed as an alternative to the IBM MCA (Micro Channel Architecture) bus used on the PS/2 computers and provided some of the MCA features. EISA has a 32-bit data path and maintained compatibility with the earlier ISA architecture.

NuBus is a high-performance expansion bus used in the Apple Macintosh computer that was developed at the Massachusetts Institute of Technology (MIT). SCSI (Small Computer System Interface) that is pronounced "scuzzi," is an input output bus that provides a high-speed interface for connecting personal computers to peripheral devices. The VL Bus is a design established by the Video Electronics Standards Association (VESA) in 1992.

Digitizers

The first digitizer was called the Bit Pad with a 11-inch active area and was advertised by the Summagraphics Corporation in November 1977. The unit had a price of $555.

Floppy Disks

Development of the floppy disk drive by IBM in 1971, created a requirement for floppy disks. Significant suppliers of floppy-disks were 3M, Dysan, Elephant, IBM, ITC (later Verbatim), Maxell, Memorex, Sony and Xidex.

Information Terminals Corporation (ITC), a dominant supplier of digital data cassettes, obtained a license from IBM to manufacture 8-inch floppy disks in June 1973. The company produced its first floppy disks in December and became a dominant supplier of floppy disks. ITC collaborated with Shugart Associates to provide disks for the new 5.25-inch disk drive introduced in December 1976. The single-sided, single-density disks had a storage capacity of 180 kilobytes. Then in July 1978, ITC introduced a 720 kilobyte double-sided, double-density disk. The company name changed to Verbatim Corporation in 1978. Between 1979 and 1980 Verbatim had severe and costly quality problems. A license was obtained from the Sony Corporation to manufacture 3.5-inch diameter hard plastic case microdisks in the spring of 1983. Verbatim also introduced a high-density minidisk with a storage capacity of 1.2 megabytes in 1983 and increased it to 1.44 megabytes in 1986.

Between 1984 and 1985, Verbatim started encountering significant financial difficulties due to increasing competition and falling prices for disks. This resulted in the company being purchased by the Eastman Kodak company in June 1985 for $175 million. But by 1990, Kodak was also having problems and sold Verbatim to Mitsubishi Kasei, a large diversified Japanese company in May. Mitsubishi Kasei changed its name to Mitsubishi Chemical Company in October 1984. Verbatim is still a dominant supplier in the floppy disk market.

Keyboards

An article entitled "A Short History of the Keyboard" in the November 1982 issue of *Byte* magazine describes variations in keyboard layouts.

Another article entitled "Keyboard Karma" in *DIGITAL DELI* [190, pages 267-269] describes the problems the Japanese have with keyboards.

Microsoft introduced a new ergonomic Natural Keyboard in 1994.

Mouse

The mouse concept was invented by Douglas C. Engelbart at the Stanford Research Institute in 1964. Roger Bates and William K. English assisted in the development. The first public demonstration was at the ACM/IEEE Fall Joint Computer Conference in December 1968. Engelbart's mouse was an analog device with a wooden housing that contained a button (subsequently three buttons) and wheels that rotated two potentiometers. The potentiometers converted the movement of the mouse on a surface into electrical signals that controlled the position of the cursor on a terminal screen. The buttons were used for selection and to enter commands.

A digital wheeled type of mouse was developed by Jack Hawley for the Alto research computer at the Xerox PARC (Palo Alto Research Center) in 1972. Also at PARC in 1972, Ronald Rider developed the ball type of mouse that was subsequently changed by Hawley to improve its operation.

The first commercial implementations were on the Xerox Star in 1981, and on the Apple Lisa and Macintosh computers in 1983 and 1984 respectively. The Xerox Star digital mouse used two buttons for control purposes. Apple Computer designed a new digital mouse for the Lisa computer that used a rubber ball with optical scanners to detect motion and one button for control purposes. A degree of controversy exists regarding the number of buttons to include on a mouse. Human factor studies to determine the simplest operation, tend to favor a two button mouse.

A company called Mouse Systems introduced the first commercial mouse for the IBM Personal Computer in 1982. It was a three-button mouse.

Microsoft introduced a mouse with an add-on card for the IBM Personal Computer and a mouse for any MS-DOS computer using the serial port in May 1983 (see Section 12.1). It was priced at $195 with interface software. A new design resembling a bar of soap was released in September 1987. In late 1996, Microsoft announced the Intellimouse priced at $85. The principal new feature of the Intellimouse was an additional miniature wheel located between the left and right buttons that could be used for scrolling in application programs.