COMPUTER TECHNOLOGY

Minicomputers

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The characteristics and costs of minicomputers are discussed along with peripherals, time-sharing, and turnkey systems. The article concludes with a survey of over 100 small computer systems.

For the purpose of this paper, a survey was made of binary computer systems with basic system costs of less than \$30,000. Perhaps this is misleading as a price definition of minicomputers, since some of the machines are expandable to such a degree that a fully instrumented system with maximum memory and attached options can run well over \$100,000. Some manufacturers design their machines so that the basic processor can be sold at minicomputer prices and then expanded modularly into a system to meet most needs. So a more appropriate definition might have limited the basic system cost to about \$18,000 or less. The \$30,000 limit was exercised because it provides the reader with a broader comparative view and incorporates systems which are presently in use in academic and research facilities. Opinions differ over what really constitutes a minicomputer. An oft-quoted figure is \$25,000 or less. Other differences relate to capacity and function.

A 4,096-word memory can be considered a minicomputer basic, with most memories expandable at extra cost to 16k or 32k. Several are expandable to 65k, and a few basic processors are cited at 1k or 2k (a few companies offer central processors with no memory). Memory cycle times range from 775 nsec (one machine lists .5/30 microsec) to 8.0 microsec. Computer word lengths are 8, 12, 16, 18, 20, and 24 bits, with the 16-bit-word machines being the most popular. The 16-bit outnumber the 8-bit-word computers by a factor of 3 or 4 to 1. The other word lengths make up about 10% of the total.

Minicomputer central processors operate in a manner similar to that of the larger computers—they are not, however, considered in the electronic desk calculator category, although the machines can fulfill most of the functions. The processors are typically fixed-point systems with single address instructions which contain core memory, registers, an arithmetic unit, and

I/O buses. Multiply/divide, read-only memory (ROM), special instructions, and other features are standard with some machines, but optional with many others. A real-time clock is generally an additional cost.

Although alike in many respects, minicomputers differ in regard to memory cycle and access times, input/output methods, interrupt systems, addressing, software, options, and so on. Perhaps the most common characteristics of the great majority of these machines, in addition to low cost, is dedication to a particular task. Large-scale computers are often used for a variety of purposes and handle large problems; they cost more, generally, because of greater memory size, word lengths, and attachments, such as disks, tapes, printers, and so on.

The potential buyer, of course, should know what he wants out of the machine in terms of task performance(s), future demands or plans for system expansion, and how much he is willing to pay. In laboratories, the minicomputer has functioned as a monitor, a controller, a data-acquisition unit, and as a data reducer and analyzer. If the buyer's interest is merely to use the machine as an oversize calculator or a mini number cruncher, he is better advised to travel another route. The real laboratory value of the small computer is in its capacity for on-line real-time functioning. A realistic feel for the necessary equipment and the costs of on-line real-time laboratory computer systems can be obtained from the reports by Haber (1968), Huesmann (1969), Mayzner (1968), Moise and Jarrard (1969), and Restle and Brown (1969). Of course, the machines can be connected to a common mass data base, e.g., a mag tape or disk. They can also be tied to larger computers and to a common data base so that the smaller machine can call for assistance when its capabilities are strained. In a data communication system, the minicomputer can be utilized as a terminal and as a preprocessor of data before sending it on to a larger computer.

Whatever the need, there are many companies to choose from. The number of minicomputers on the market has increased tremendously over the last 2-3 years. New manufacturers have appeared, older firms have introduced new models or altered old ones, and middlemen have emerged who take computers manufactured by others

and then develop and sell applied systems. At the same time, increased competition and the introduction of new modular components have sent the prices of minis down so that less than \$3,000 will purchase a machine with 4k memory, 8-bit word length, and a 1-microsec cycle time. The newest addition to the Digital Equipment Corporation (DEC) line, the PDP-8/E, is priced at \$4,990 for the basic package and \$6,500 with ASR-33 teletypewriter. The DEC PDP-1, introduced in 1958, sold for approximately \$120,000. Its more capable grandson, the PDP-8/L, was introduced 10 years later at \$8,500.

Although prices are down, it is important to note that the basic units offered by many manufacturers are stripped-down models offering little flexibility. Some companies offer a relatively inexpensive basic package, but accelerate the prices of optional, but necessary, units. If a teletypewriter (the basic minicomputer I/O device) is optional, the added cost may range from \$800 to \$2,000. Expanding the memory of a basic \$8,000 4k system, including teletypewriter, to 8k could cost \$6,000 merely for the additional 4k. Yet 8k may be needed for the use of FORTRAN, which the user may require. (Typically, memory costs represent about 50% of the total processor cost for minis.) Fortunately, as prices drop, it may be possible to trade off between program efficiency and memory size. As the prices of additional memory units go down, the languages designed for on-line operations will be used more.

Technological trends are toward more cost-effective minicomputer processors and peripherals. The costs of bipolar and MOS (metal oxide semiconductors) digital logic electronics are decreasing while speeds improve. And thin film and semiconductor memories should challenge core memories. In projecting 10^6 -capacity memory trends, Zimbel¹ cites core memory costs over the next 5 years as 2¢-4¢/bit (0.25- to 1-microsec cycle time), magnetic thin film costs at 1¢-3¢/bit (0.10- to 0.5-microsec cycle time), and semiconductor memories at ½¢-2¢/bit (0.025- to 0.2-microsec cycle time). Plated wire memories provide nondestructive readout, and stored data can be modified easily. They also consume little power or space. An all-MOS central processor might have memory-centered

logic, erasable and ROM stores, and more complex interrupt logic.

Industry projections made in 1969 indicated an annual growth of 35%-50% in the minicomputer market. The most recent consensus (September 1970) is that the mark will be missed by a substantial amount. Some of the smaller firms are finding sales outlets drying up, and a few firms have decided to postpone public stock issues until market conditions improve.

Of course, the most substantial minicomputer manufacturer has been the Digital Equipment Corporation. Thousands of the DEC machines have been sold, and their service network is worldwide. But other companies turn out very fine machines also, and their products warrant investigation. For the behavioral scientist, the DEC Users Society (DECUS) offers an advantage because of the opportunity for information exchange between users of similar machines; selected DECUS Conference Proceedings are reported in the September 1969 and March 1970 issues of this journal. Several other companies have recently organized users' societies (e.g., Data General Corporation and Varian Data Machines), which, in time, should grow and become more valuable. A number of companies have substantial, tested software program libraries available.

Ollivier (1970) has developed a quick and effective technique for selecting small computers that places heavy emphasis on evaluating the vendor as well as the machine. Both are rated on various factors which are weighted. Manufacturer criteria that are evaluated include delivery time, past performance, number installed, and others. Several of the computer criteria are word size, cycle time, addressing, and interrupts. Prior to the evaluation, however, the task is analyzed, an envelope of constraints is defined, minimum specifications and maximum dollars are established, initial hardware/software tradeoffs are made, and a list of qualified vendors is developed for contact.

In comparing machines, it is important to note that there is no standardization in nomenclature and no restriction on the use of descriptive terms. The same type of equipment supplied by various manufacturers may have different names. An input/output bus may be described as a multiplexer bus of some type, a party line, or something else. And the same name may be applied to different items.

The remainder of this report will address itself to a brief discussion of factors influencing minicomputer operations, a somewhat cursory review of peripherals (the purchase of which often quadruple or quintuple the cost of the computer), some

time sharing, and a survey of over 100 small computer systems. Obviously, this information is not new. Minicomputer hardware and software characteristics are cited in company brochures and reviewed in a number of technical publications. Many articles in this journal and elsewhere describe computer-controlled laboratory systems; Utall's volume (1968) provides information on real-time computer techniques in psychology. And the small computer handbooks supplied by manufacturers (e.g., Digital Equipment Corporation, Varian, Data General, Raytheon, and others provide a wealth of information.

FACTORS INFLUENCING MINICOMPUTER OPERATIONS

Several of the important factors influencing minicomputer operations and comparisons are listed below. As noted earlier, the most critical requirements are that the computer perform the task required at the necessary speeds, and that the price is right. Comparisons of hardware and software capacities are important only insofar as they satisfy the critical requirements. Routing data in and out of the machine is obviously important, and so is the capability of the peripherals associated with the job.

Hardware

A core memory of 4,096 words should be considered minimum. For many laboratory applications, and for the use of some software, at least 8,192 words are required. Obviously, if 4k will do the job, there is no need to pay for more memory. But in many on-line real-time experiments, researchers have gone to optional disk memories and other means of increasing capacity. The amount of memory necessary to do the job should be evaluated realistically. It is not unusual to find a user struggling to make a program fit the memory. One should also be certain to inquire as to which of the manufacturer's software will and will not operate with the basic computer configuration.

An 8-bit-word module will cost less than a 12- or 16-bit-word module, but the 8-bit computer is not as powerful, although it is satisfactory if high performance and sophistication are not required. The longer words allow more bits for data addressing and for instruction codes. However, evaluating or comparing machines strictly on the basis of word length is difficult.

Memory cycle time is an important characteristic as an indicator of speed, but it is the time that it takes the machine to execute a program which indicates the relative speed of the machine in actual use. For some applications, Computer A with a

faster memory cycle time may have a longer run time than Computer B.

Memory parity checks and memory protection features are included in some machines, but generally are optional. Parity check systems are used to facilitate error detection. Memory protect requires that special instructions be used to write in certain regions of memory; otherwise, the protect prevents writing in that region. Lower- and upper-bound registers frequently define the restricted core area.

Paging techniques are used by most minicomputers to address core. The size of the page is determined by the number of adjacent core locations that are specified by the address field. Although page sizes range from 256 to 2,048 words, the most common is 256. So the memory might be thought of as being divided into sections of 256 words each.

Instruction sets and speeds must be considered also. For data and instructions to be stored interchangeably in memory, data word length and instruction word length should be the same. Some 8-bit machines use two words per instructions, operating like the 16-bit processors. Others expand instruction set by a byte-sharing technique—the instructions are divided into two acts, with one byte stored as part of the program. The other is stored as a shared byte and is referenced by the first.

A discussion of addressing is involved; suffice it to say, facilities are provided for addressing the entire core. Generally, indirect addressing and indexing are provided for addressing locations outside of the page boundaries. Indirect memory addressing is a cross-reference technique and can refer to any level of addressing other than the first level of direct addressing; for example, an address specifies a storage location which contains another address rather than the actual data. Indirect addressing provides great flexibility, and some machines allow multilevels of indirect. An index register augments addressing. Some computers provide one, some, two or more, and a few have no registers of this type. Index addressing refers to an operation in which a given address is added to the contents of the index register on command.

Reference to double-word-length instructions means that the word is twice the length (or width, if one prefers) of the normal word. This increases the address bits by an additional word length. If the machine length is 16 bits, a double-word instruction contains 32 bits.

Multiply/divide can be executed with hardware or carried out by software routines. The hardware unit is optional with many machines, and the cost is high. On the other hand, execution is faster and

the hardware units save memory space because of the requirements made on memory by the software subroutines.

The number of hardware registers and accumulators provided in different minicomputers varies. Additional units provide programming efficiency, but also increase costs. General-purpose registers can be used as accumulators, as well as for indexing and other operations.

Read-only memories (ROM) are standard with only a small number of machines. ROM speeds are much faster than the main core; the computers noted in the survey range from 200 to 470 nsec. One function of the read-only memory is to store microprograms which are used to execute microinstructions, an operation which requires that ROM be faster than core memory. The memories are applied also to applications in which one program is executed repeatedly. Some manufacturers use ROM to protect and decrease real-time program execution time.

In real-time operations, it is obvious that input/output (I/O) capabilities are important. One of the two basic types of I/O channels transfers data under direct control of the processor program with the data flowing through the registers. The second type transfers data directly to the memory. A direct-memory-access channel (DMA) is generally optional. DMA permits very high-speed data transfer rates.

Of course, data transfers between external devices and the computer have to be initiated. It is the interrupts that coordinate data flow in and out of the computer, an especially important function in real-time operations. External interrupts are used under these conditions. Internal interrupts usually deal with memory parity, memory protect, power fail, and real-time clock interrupt. Now interrupts can also be categorized as single or multiple level. The multilevel priority interrupt is the most sophisticated and is required for most real-time applications, although it is often optional. Priority refers to the fact that the multiple levels, with devices connected to each level, are ranked so that a more important priority interrupt will be executed immediately, even if another level is active. A real-time clock (optional for nearly all machines) is essential in the timing functions associated with the real-time operations.

For interacting with the computer, peripherals can be connected through an I/O bus, a direct-memory-access (DMA) channel, and a data channel. The I/O bus is standard and is generally the main artery with address lines, data paths, etc. The bus can handle more than one device simultaneously, but timing is crucial. As noted earlier, direct memory access (DMA)

is not generally standard. The DMA channel transfers data directly to and out of memory, an important feature when extreme demands are placed on the central processor by, e.g., special-purpose instruments. The third method for interacting with the computer, the data channels, may or may not be part of the basic computer package. The primary function of the data channel is to handle peripherals with relatively high data transfer rates, e.g., disks and tape drives.

Multiplexer channels are generally optional and are used for time sharing. Optional general-purpose interface devices are used for transferring data and controlling peripherals.

Software

A few years ago, there were complaints concerning software support for minicomputers, particularly the availability of compilers. That argument no longer holds, although only a minimum software package is provided with most basic minicomputer systems.

All manufacturers supply assemblers, loaders, and certain utilities as basic, and nearly all provide debugging. Some provide assemblers with macrocapabilities. With higher languages, macrocapability enables an operator to execute these programs on other machines with a relatively small amount of programming. Macroassemblers have other uses, of course; e.g., they are useful when a series of instructions needs to be repeated.

Although out of style with larger machines, assemblers provide the primary language for minicomputers. (An assembler converts easy-to-remember mnemonics into binary machine code.) One- and two-pass assemblers are generally cited as standard. The two-pass is easier to use and a third pass helps with ASR-33 Teletype input and output. With a pass, the assembler scans the source program; the number of passes refers to how often the assembler does the scanning. Simulator programs are provided with many machines, and these allow the programmer to debug his program on a larger machine. Separate debugging programs are especially valuable since they allow the user to alter portions of the program. He should be able to change the content of memory locations through the teletypewriter, the printout of certain registers, and the display section contents.

Compilers such as the FORTRAN IV most often require 8k memories. (A compiler translates English or math expressions into binary object programs which may create subroutines of machine instructions.) And one should be aware of the many varieties of FORTRAN; not all

have standard specifications. Basic and Focal are interactive languages available with minicomputers.

For real-time configurations, real-time executive monitors are important, and these usually require 8k core and, perhaps, disk storage. Some real-time operations handle multiprogramming environments. But systems using foreground-background programs are expensive (the background program handles batch jobs such as compiling, and the foreground handles the real-time program).

Finally, the minicomputer user is closer to his system than is the large-computer person and requires detailed knowledge at the machine level—experience that often comes hard and necessitates a great deal of hands on practice.

This discussion of factors influencing minicomputer operations has been, admittedly, brief, and many variables of importance have been omitted. It does, however, provide descriptions of some of the important characteristics mentioned in the computer system specifications.

PERIPHERALS

Peripherals are units that are used in conjunction, or in combination, with the computer. They are not, however, considered an integral part of the computing machine itself. They deal mainly with input/output operations. Included in this category are I/O devices (card, tape, or printer units), terminals (typewriters, CRT, keyboards), drum and disk memories, controllers and interfaces, and other miscellaneous devices. Instruments such as multiplexers and D/A and A/D converters are considered peripherals by some computer people, but not by others.

Virtually all minicomputer manufacturers offer a full line of peripherals. But there is a growing number of independent vendors who offer compatible units also. One can find numerous supporters in the research community for purchasing either way. A primary reason for purchasing from independent vendors is cost; the buyer expects a substantial saving for identical units. And he expects better performance or additional features for his money. On the other hand, buying the computer system from one source and the peripherals from another may result in compatibility problems.

Several factors can influence the ability of separate elements to be connected together and to function properly. There are, for example, hardware incompatibilities. For example, are the code and control logics compatible? The two devices should interpret the same bit

sequences in the same way, and they both should be parallel or serial. Are the electrical characteristics, such as voltage levels, rise and fall times, and loads, compatible? Is there a speed mismatch that requires buffering? Is there a problem in matching the software? These are some of the problems which might require consideration. Fortunately, the number of companies marketing peripherals compatible with specific minicomputer system requirements is accelerating. And there are techniques for overcoming or accommodating most mismatches. "Plug-to-plug compatibility" generally means that the unit is software- and hardware-compatible and that the connecting hardware is the same. So you merely "plug it in."

Since the volume of data handled in minicomputer systems tends to be small compared to that of large machines, the speeds of peripherals can be slower for many applications. And, as a result, many peripheral units are relatively low in cost, e.g., disks, printers, cassette devices, some mag tapes, and other units. But even with this advantage, the peripherals can cost as much or more than some minicomputing machines.

The most common input/output, batch or conversational, terminal is the teletypewriter. Of these, the most widely used is the Teletype ASR-33, which is often offered as part of the basic system package. Model 33 is built for medium work loads; Model 35 is a heavy-duty machine designed for high-volume work, but it has a higher price tag. The Teletype Corporation ASR-33 operates at up to 10 ASCII-8 characters/second, or 100 bits/second in half- or full-duplex modes. Of course, the input of most teletypewriters is the keyboard; paper-tape readers are added to provide ASR (automatic send-receive) capability.

The IBM Selectric typewriter, when properly instrumented, might be used as a terminal also. Modular attachments may be purchased which provide the Selectric with on-line terminal characteristics, yet do not destroy the machine as an ordinary typewriter. Information concerning such units may be obtained from the Terminal Equipment Co., 750 Hamburg Turnpike, Pompton Lakes, New Jersey 07442, or Microdyne, 1600 South Hicks Road, Rolling Meadows, Illinois 60068.

If a keyboard and a CRT are combined, an alphanumeric and/or graphic display terminal results which allows for the display, receipt, and transmission of data. Hard copy of the received data can be obtained by photographing with a camera. Alphanumeric CRT terminals can be used as stand-alone items or in multiterminal systems. They are, however, expensive;

single terminals can cost in the neighborhood of \$10,000. Some of the minicomputer firms offer lower prices for CRT terminals incorporated into fairly large systems. But multiterminal systems have a broad range of prices. A common screen size is about 7 x 9 in.

With terminals, there is also a communication distance consideration because of signal deterioration possibilities at greater distances from the computer. The direct I/O cables of the Raytheon 706 computer may have a length of 50 ft; the direct-memory-access cables may have a maximum total length of 24 ft. Data General cites data transmission distances up to 50 ft (including internal wiring) as providing good noise margins and low signal delays for the Nova and Supernova. But this problem can be handled by interfacing components between the computer and external equipment.

The most efficient use of computer time can be made with high-speed I/O peripherals. A number of minicomputer manufacturers offer (generally as options) various punched tape, punched card, magnetic tape, printer, plotter, and other configurations. Punched tape, with its serial organization, is considered in the slow category of the high-speed I/O devices, but it is relatively low in cost. Magnetic tape units are much faster and have greater capacity, but the cost is generally higher.

The methods for reading punched tape are mechanical (holes are detected by mechanical means of some sort, such as sensors) or photoelectric. The latter can read up to 1,000 characters/second. Although mechanical readers are slower, they are also less expensive. The Model 33 and Model 35 Teletype units provide hardcopy output at 10 characters/second at 72 characters/line. On eight-level tape, the paper-tape punch and reader operate at 10 characters/second. Other paper punches are available which operate at 60 to 110 characters/second. Eight-channel ASCII is the most common punched-tape code. Of course, there are paper-tape readers available operating at upwards of 300 characters/second. (Because of high costs, card punches and card readers are seldom used with minicomputers. This is not to deny the fact that some laboratory or educational systems require and incorporate them.)

Most magnetic tape units for minicomputer use are advertised as IBM-compatible, but care should be taken in verifying the claim. The tapes for these machines have seven or nine tracks with packing densities of 200, 556, or 800 bits/inch. Conventional tape drives may be used, but incremental drives are less expensive. Incremental drives are similar to

conventional computer mag tape drives, but data blocks are written one at a time instead of continuously. Also, data transfer rate is much slower, e.g., several hundred characters/second compared to several thousand characters/second. Faster speeds are often available as options. For example, the Kennedy Company (540 West Woodbury Road, Altadena, California 91001) Model 1600 incremental recorder can operate at speeds of 0-300 characters/second, with speeds of 0-750 and 1,500 characters/second available as options.

Cassette and cartridge digital tape units are rapidly gaining in popularity, although at this writing they are offered by a relatively small number of computer manufacturers. Units are available with minicomputer interfaces from several peripheral manufacturers. Cassette and cartridge recorders should be priced competitively with paper-tape transports and, in general, offer the advantages of incremental mag tape units. But computer tape compatibility is a problem. At present, few appear to be interchangeable.

As data storage devices, cores, drums, disks, and tapes may function in support of the computer memory. They may also have data-handling tasks in the peripheral configurations. Disk storage units can be obtained from just about all minicomputer manufacturers as well as from several peripheral vendors who supply interfaces for most small computer machines. Fixed-head, nonremovable disks are popular. (An 18-microsec access time, with 32,000-word capacity and 100,000-word/second transfer rate might describe a typical unit.) In purchasing, it is wise to compare access times and transfer rates, especially in regard to the record length being read out at each accessing.

A mass storage system which is neither disk nor drum is the DA-060 magnetic tape system for small computers. The unit has a 4-million-word capacity, bidirectional random access, and a 16.6-kC word rate. It is compatible with the DEC PDP-8 machines. The manufacturer is Systems Industries, Inc., 535 Del Rey Avenue, Sunnyvale, California 94086.

There are, of course, many other peripheral devices that have not been mentioned in this section. But more detailed descriptions and explanations of function are best left to other sources.

Several peripherals are listed below. These are merely representative of a large number of peripherals in numerous categories and indicate no preference for any single unit listed or otherwise. Computer manufacturers market similar devices.

Printers

The Nortec 200 is a 132-column

machine for minicomputers that prints at 200 lines/minute and is slightly larger than an electric typewriter. It is not a drum unit. The printer is IBM-compatible and accepts ASCII-coded alphanumeric 6-bit data at rates up to 500 kHz. Price: Over \$6,000 for single units (Nortec Computer Devices, Inc., Ashland, Massachusetts 01721).

The Di/An Pony Printer mates directly with a number of minicomputers and is priced at approximately \$9,900. Printing speed is 1,280 characters/second for numeric and 640 characters/second for alphanumeric. The 32-column machine prints 2,400 lines/minute for numeric and 1,200 lines/minute for alphanumeric (Di/An Controls, Inc., 944 Dorchester Avenue, Boston, Massachusetts 02155).

The Data Products miniprinter costs over \$6,000 for single units and has a drum speed of 1,760 rpm, 80 columns, and listings as fast as 111 lines/minute for 20 columns (Data Products Corporation, 6219 De Soto Avenue, Woodland Hills, California 91364).

The Eclectic Model 740 printer system allows a 136-character line width to be printed in 8 in. or less. The machine prints at 250 characters/second and is priced at \$7,500 (Eclectic Computer Corporation, Suite 301, 3707 Rawlins, Dallas, Texas 75219).

Magnetic Tape Systems

Datum, Inc., markets magnetic tape systems with software for virtually all minicomputers. The system is IBM-compatible, with data densities of 800 bpi for nine-track and 800/556, 800/200 for seven-track.

The ECC 640 mag tape system for PDP-8 computers reads and writes seven- or nine-track 200-, 556-, or 800-bpi records. Standard tape speed is 24 ips. Data is transferred at 10k 12-bit words/second. The system is priced from \$10,400. (Eclectic Computer Corporation, Suite 301, 3707 Rawlins, Dallas, Texas 75219).

Over 25 minicomputer interfaces are available for CartriFile, an EDP system with four mag tape transports, cartridge loaded, starting at \$2,900. (TRI-DATA, 800 Maude Avenue, Mt. View, California 94040).

The Computer Equipment Corporation mag tape system is IBM-compatible, with controller, interface, and software for PDP-8 computers. The system consists of a CEC Model 640 controller interface and an Ampex Model TMZ tape transport. With seven-track, read and write is 800 bpi. A nine-track system is available. Computer access transfer rate is 10k 12-bit words/second at tape speeds of 24 in./second. Price: \$8,200 (Computer Equipment Corporation, Suite 214, 3707 Rawlins, Dallas, Texas 75219).

Model 2914 Daconics mag tape subsystems sell at a ballpark price of \$11,500. The equipment includes a Peripheral Equipment Corporation 6840-9 tape unit, connecting cables, Daconic's interface and controller 2914-1, and software. Packing density for the nine channels is 800 bpi and the tape speed is up to 37.5 ips. Data transfer rate is up to 30,000 bytes/second. Models are equipped for interfacing with Hewlett-Packard Computers HP-2114 A/B, 2115A, and 2116B, and the DEC PDP-8 and -9 (Daconics, 505 West Olive Avenue, Sunnyvale, California 94086).

The Infotec mag tape system is compatible with and designed for the PDP-8 series processor. With read/write speeds of 25 ips, the TS-8C mag tape system has data transfer rates of 20k characters/second. Direct memory access is possible. Data density for the nine-track configuration is 800 bpi; for seven-track, 200/556 or 556/800 bpi. Tape velocity of 5.0 ips is standard. Data transfer rate is 4k Hz at 800 bpi. Price: \$11,300 (Infotec, Inc., 70 Newton Road, Plainview, New York 11803).

Digital Scientific Corporation (11455 Sorrento Valley Road, San Diego, California 92121) manufactures a magnetic tape controller compatible with the DEC PDP-8 computers, the Honeywell DDP family, the Varian 620i and 520i, Interdata 2, 3, and 4, and HP-2114, -2115, and -2116.

The CO-600 LINC tape system provides a randomly addressable mass-storage device with dual tape drive and controller. Capacity of each tape is 204,800 bytes. Data transfer rate is 8,400 bytes/second. The system uses phase recording, 400 bits/inch in density. On-line storage can be increased to 3.2 million bytes. Interfaces are available for the Varian 620 series computers, the Honeywell 315 and 516 machines, the HP-2114, -2115, and -2116, and the General Automation SPC-12 (Computer Operations, Inc., 10774 Tucker Street, Beltsville, Maryland 20705).

Cassette System

A cassette tape-transport system, the Compu/corder 100, enables minicomputers to access any tape file within an average time of 15 sec. The system comes complete with software and interface to DEC, Varian, and Data General computers. Standard features include read/write speeds of 5 in./second. Typical tape may contain 3.6 million bits. Recording density is 1,000 bpi; a bit-serial, biphase-encoded widefield recording technique provides a transfer rate of 5,000 bpi. Each cassette has 300 ft of computer-grade tape preformatted with address track. Price: \$2,950 (Sykes Datatronics, Inc., 375

Orchard Street, Rochester, New York 14606).

Disk Memory

Computer Systems and Software, Inc., is marketing two disk memories, one for the Nova and one for the PDP-8 systems. The Nova-compatible memory has storage capacity of 250k 8-bit characters and a transfer rate of 62.5k words/second. The PDP-8-compatible system has 512k 6-bit character capacity and 128k words/second transfer rate. Access time is 8.4 msec for both systems. Price: \$9,000 (Computer Systems and Software, Inc., 811 North Magnolia Avenue, Orlando, Florida 32803).

Information Data Systems has a disk memory system with a capacity approaching 145k bits of storage. The system has eight data tracks, each with a capacity of 18,125 bits. Access time is 8.5 msec. Price: \$1,812 (Information Data Systems, 8620 East Eight Mile Road, Detroit, Michigan 48234).

Memory Drum Controller

Datum, Inc., markets memory drum controller systems for HP-2114, -2115, and -2116 computers. The system contains a drum memory, a controller, and all necessary connecting cables. Depending on the model, storage capacity (16-bit words) ranges from 32,768 to 262,000. Up to four drums can be controlled. The price of one drum memory with connectors (32,768 16-bit-word storage) is \$5,800; drum memory with 262,000-word storage is \$11,500. Transfer rates of 88,000, 120,000, or 130,000 words/second are dependent on the drum selected. Software is compatible with HP (Datum, Inc., Peripheral Equipment Division, 170 East Liberty Avenue, Anaheim, California 92801).

Controller

The Progress Electronics Me-16 Multiple Device Controller is an off-the-shelf interface between the MAC-16 computer and devices normally used in small computer systems for real-time control of multiple parallel-data peripherals. The data transfer rates are up to 200,000 16-bit words/second, with selection of up to 16 addressable devices. The instrument features control of one 60-channel analog/digital converter system under one device address, control for eight addressable digital/analog converters, 16 control lines expandable to 128, 16 sense lines expandable to 128, and four coded interrupt lines organized under one interrupt level. The price with D/A General Data Channel and Multiplex A/D Control is \$910 (Progress Electronics, 5160 North Lagoon Avenue, Portland, Oregon 97217).

Disk Controller

Information Data Systems 5000 Disk Controller is designed for the Interdata 3 and the Data General Nova computers. The controller for Interdata 3 can handle up to 256k 8-bit words, expandable in increments of 32k to eight times that amount. The unit can also handle rates up to 1.2 million bits/second. The Nova unit can handle up to 128k of 16-bit words. Prices start at \$3,580 (Information Data Systems, 8260 Eight Mile Road, Detroit, Michigan 48224).

Disk-Drive Interface

Bedford Associates, Inc., market an interface for the control of as many as eight Memorex 630 or 660 disk drives by the PDP-8 family of computers. Price: \$13,500. An optional automatic 630-660 select permits any mix of Memorex 630 or 660 disk drives to be controlled by interface (Bedford Associates, Inc., P.O. Box 327, Bedford, Massachusetts 01730).

Interface

The Fabri-Tek Signal Averager and Processor provides interface boards to the PDP-8 for \$1,500, the PDP-8/I or PDP-8/L for \$1,000, the PDP-9 for \$2,000, the PDP-12 for \$1,000, and the PDP-15 for \$1,500 (Fabri-Tek, Inc., 5225 Verona Road, Madison, Wisconsin 53711).

Software Package

Digiscan Services, Inc. (425 Broad Hollow Road, Melville, New York 11746) markets a software package which allows almost any minicomputer to act as a remote batch terminal and to communicate with a central IBM-360 computer over telephone lines. Residing in the computer, the software simulates 360 communications hardware, so the programmer can use the BTAM conventions governing 360-360 transmission. The software controls the entire transmission sequence. Price: \$10,000.

Audio Response Systems

MARS (multiplexed audio response system) is a free-standing system for information retrieval by means of an electronic voice output. MARS is equipped with computer and dataset interface circuitry and is multiplexed to allow computer output of many voice responses over lines simultaneously. The multiplexing capability is modular and can be increased as demand grows. Vocabularies are available in 31, 62, 93, or 189 words. Inquiries are initiated by the user's telephoning the computer by using Touch-Tone phone, rotary dial phone with Touch-Tone adapter, or inexpensive

remote terminals. The system provides automatic answering of incoming calls and voice response to the inquiries.

MARS interfaces with the PDP-8 family of computers, their available peripherals, and with Dataset. Special configurations are available, compatible with other minicomputers. Query time is 0.3 sec/four lines. Processor time depends on the associated computer—typically 0.1 to 0.5 sec. Number of words in response: 0.53 sec/word plus 0.26-sec average access to first word.

MARS consists of a Cognitronics multiplex SPEECHMAKER system with power supply and interfacing circuitry. Price of the MARS system alone is \$17,820 to \$24,660, depending on the size of vocabulary and the number of lines (SPEECHMAKER, Division of Cognitronics Corporation, 333 North Bedford Road, Mt. Kisco, New York 10549).

TIME SHARING

With time sharing, numerous terminal devices can utilize a computer concurrently for input, processing, and output. Several individual users, or one user with a number of experimental stations or inputs, can share the machine for different purposes at the same time. The speed of the computer, of course, makes it appear that they are all sharing simultaneously. Actually, the machine is handling each in sequence.

A large number of time-sharing systems are available. Three are briefly noted here. Two others, the Wang and Mini-Comp systems are mentioned later in the computer review section, as are individual descriptions of the DEC, Hewlett-Packard, and Data General computing machines.

Digital Equipment Corporation

One of the systems marketed by Digital Equipment Corporation, Timeshared-8, is capable of running up to 32 different terminals simultaneously. The system starts at four users and is expanded by adding memory and mass storage devices: 32,000 words of core memory, four 250,000-word disks, eight DECtape units, and expanded system software. Organized around the PDP-8/I computer, the Timeshared-8 can be interfaced to a larger time-sharing machine like Digital's PDP-10.

The basic eight-user system with PDP-8/I computer has 8,000 words of core memory, 250,000 words of disk storage, a high-speed reader, and time-sharing hardware and interface equipment for about \$45,000. With 16,000 words of core memory, 500,000 words of disk storage, a high-speed reader and punch, and necessary interface equipment, the cost increases to \$65,000. A 36-month service contract for

this expanded system is an additional \$9,000, bringing the total price to \$74,000. The expanded 16-user system has 20,000 words of core memory, one million words of disk storage, high-speed reader and punch, four DECtapes and control, card reader, PDP-10 interface, data phone interface, and time-sharing hardware and interface equipment for approximately \$110,000.

Hewlett-Packard

Hewlett-Packard offers the HP-2000B system with a capability of 32 terminals or users. The HP-2000B is an extension of the HP-2000A 16-terminal computer system.

This new system provides Basic language processing for the 32 terminals at a 30% increase in price. The 2000B costs about \$120,000, as opposed to about \$91,000 for the 2000A, and is built around the HP-2116 B computer, a 16-bit machine with a 16k memory and 1.6-microsec memory cycle time. In the 2000B configuration, a second computer handles the HP-2114B with a 8k core memory; additional storage may be added. Any terminals can be wired directly to the system if it is located within a 1-mile radius of them. Telephone communications are used for greater distances. Terminals in the system are ASR-33 or -35 Teletypes. The standard configuration with an ASR Teletype and 12-megabits of mass storage can be leased at \$3,117 per month. Deliveries began in late 1970.

Data General

The Data General Nova 4-user system costs \$5,585 per terminal for a \$22,340 total. The Nova provides 2,728 8-bit bytes of core storage per terminal, 16-bit word length, and multiaccumulators.

A 16-user Supernova system is priced at about \$3,142.69 per terminal, or a total of \$50,283. The Supernova provides 1,496 8-bit bytes of core storage, 16-bit word length, multiaccumulator, and an 800-nsec cycle time. Basic time-sharing language is used with full extensions. For stand-alone use, software includes: FORTRAN IV, ALGOL 60, a disk operating system, and others.

TURNKEY SYSTEMS

Lehigh Valley Electronics, Inc., and Grason-Stadler have developed computer/interface installations for the behavioral scientist which are essentially "turnkey" systems for on-line real-time research or teaching applications. Both will provide programmed, installed systems ready for the buyer to sit down and start flipping switches. The customer can describe what he wants to control and what the control parameters will be, and

the company will try to do the rest by setting up the computer/interface system, install peripherals, provide the software, debug the system, set it up ready to go, and provide instructions on how to operate it. This, of course, is the "custom made" extreme, both in demands and in price. Either company will also provide hardware-interface/software packages to the buyer who has his own computer or prefers to buy a machine independently.

At the present time, the Lehigh Valley ACT language is written for the DEC PDP-8 series and for the Data General Nova 4,096-word machines; however, the INTERACT system can be adjusted for other computers in the same category. The Grason-Stadler SCAT system is designed specifically for the DEC PDP-8, PDP-8i, and PDP-12 computers with extended arithmetics. As of this date, several SCAT systems are in operation in psychological laboratories, including installations at Florida State University, the University of Texas at Austin, and the Wisconsin Regional Primate Research Center. INTERACT is a new system which is now being installed under contract with several buyers.

Both INTERACT and SCAT attempt to deal with a problem of primary concern in on-line real-time multiple-station time-shared behavioral research efforts, namely, interface and software.

The total INTERACT system consists essentially of the ACT language, the interface hardware INTERACT, an ASR-33 teleprinter, and the computer. Lehigh Valley Electronics's behavioral test equipment, animal or human, is optional. The software segment is ACT (Automatic Contingency Translator), a general language for on-line control of psychological experimentation developed by J. R. Millenson, which enables the user to write programs in English. The INTERACT control has a built-in time generator which generates unit time pulses to measure all actions; it also has a random-number generator. Eleven stimulus/response outputs are offered per station. The control panel is equipped with driver packages so that the outputs can be tied directly to feeders, stimulus lights, buzzers, etc., although no special driver packages are required for many standard devices. As with most computerized time-sharing systems, the number of stations is defined by the size of the memory, roughly one station per 1k of core memory. So a 4k machine could control four stations, possibly more, depending on the complexity of the program.

The Grason-Stadler SCAT language, an acronym for State Change Algorithm Terminology, is constructed around the

basic concept of STATE (Stadler, 1969). STATE is characterized by two primary attributes: the initiation of a set of physical events (e.g., stimuli that can be controlled by interface hardware, control conditions such as D/A conversions, etc.), and the continuance of the set of events until a condition has been met, at which time transition is made to a new state (e.g., a time interval completion, the termination of a D/A conversion, etc.). The interface package provides provisions for: accepting binary information on three input lines from each station and for combining unusual input lines for communication with any single station, issuing control information to eight output devices in each station, timing operations, and necessary signal shapers, logic, etc.

Prices of the INTERFACE system with a 4k memory NOVA computer and four stations is \$29,995; with 8k and eight stations the price is \$39,995. The interface/software package, less DEC or NOVA computer and Teletype, is installed for \$19,795 with four stations and for \$25,795 with eight stations, less NOVA.

SCAT costs \$40,750 for the basic package with the PDP-8 series computer (with extended arithmetic, PTO, and ASR-33) and five stations. SCAT alone, with your computer, is priced at about \$20,000. An additional five-station expansion costs \$10,600.

MAINTENANCE

A computer buyer should assess and make provisions for maintenance needs. Some estimates cite the price of minicomputer maintenance per annum at about 6%-8% of the system's purchase price.

Now there are several things that one might do. A potential purchaser might investigate failure and reliability statistics covering the computer, and check with individuals who use the machine, preferably more than one or two. Since field maintenance capabilities are important, the location of the service representatives warrants consideration, as does reputation for service, and the repairman's response time. Field engineers untrained or inexperienced in maintaining peripheral equipment might also present a problem, unless computer and peripherals are purchased from different vendors. But then, if the system becomes inoperative, must two service calls be made? And, if one serviceman is called, will he pass the buck to the other?

Another consideration, after the initial warranty period, is whether to assume the more general maintenance responsibilities yourself, have another laboratory person trained for the job, or hire an experienced minicomputer technician. Finally, there is

the possibility of contracting for maintenance with a local organization with experience on similar machines. If so, fees may be negotiable.

In any case, warranties need examination for coverage of parts and labor, and the length of such services. It is probably wise to negotiate the maintenance agreement and warranty as a package at the time of hardware acquisition. It is then that the buyer has some leverage.

MINICOMPUTER SURVEY

The computer systems are listed alphabetically according to company name. As noted earlier, the basic minicomputer price is defined here as below \$30,000; expanded systems, of course, can cost much more. Time-sharing systems generally exceed this limit, but the control computing machines fall within the scale. A few higher-cost machines are cited merely for comparison with the same company's minicomputer product. Finally, the reader should be alert to the fact that a computer firm will occasionally change prices or specs from one announcement to the next. Fortunately these are most often in the form of lower costs and faster operating speeds resulting from market demands and competition.

Applied Systems Corporation
18325 West McNichols
Detroit, Michigan 48219

ASC-1100

The ASC-1100 system is designed to operate as either an independent, self-contained computer system or to communicate optionally with larger central computer facilities over communication networks. The central processing unit includes a magnetic core memory expandable to 32 kbytes in 4k modules. A basic memory configuration of 1,024 bytes is also available. Byte length is 8, 9, or 10 bits. Core memory speed is 1.1 microsec full cycle.

The processor also incorporates read-only memory with a 220-nsec cycle time. Optional capacities range from 256 to 1,024 words of 16-bit length.

The ASC-1100 can be programmed at either the micro- or macroinstruction level. At the macro level there are 89 standard instructions. Instruction format is variable, from 8 to 32 bits, dependent upon operation and addressing mode. At the microprogramming level, a set of 26 types of commands are provided, using three basic command formats. Each command is 16 bits in length and execution time is 220 nsec. Software includes FORTRAN

and an assembler. The Communications Support packages provide software necessary for using the system as a remote terminal. Normal communication transmission rates are employed from 2,000 baud to 4,800 baud, full or half duplex, with EBCDIC or USASCII.

Price of the system depends on the configuration. The basic model is \$5,950 but includes only the computer processor with 256-word read-only storage, a real-time clock, and control console. Additional 256-word modules of read-only storage cost \$750. A 1,024-byte module of magnetic core memory is \$1,500; a 4,096 module is \$2,850. So a reasonable system will range upwards from \$12,000.

Atron Corporation
1256 Trapp Road
St. Paul, Minnesota 55118

Atron

The Atron was originally designed for data handling and business processing. The basic processor offers three-address binary and decimal arithmetic, instruction set consisting almost entirely of macros, and variable-length words of up to 256 8-bit bytes. The memory has a 2-microsec cycle time for an 8-bit byte and is expandable from 4k to 32k bytes. The basic computer costs about \$7,500 in single quantities. A system with 4k of memory, a 400-card/minute reader, a 300-line/minute printer, and half-duplex communications capability would cost about \$37,000.

Beckman Instruments, Inc.
2500 Harbor Boulevard
Fullerton, California 92634

Beckman Model 816

The Model 816 is a 16-bit-word-length computer with a 4.8-microsec memory cycle time. Minimum memory size is 2,048 words; maximum is 4,096. The machine has 16 hardware instructions, one hardware index register, and two accumulators. Input-output data path is 16 bits at a maximum word transfer rate of 6 kHz. A full line of peripherals is available, as is an extensive software library. Rack height is 12.25 in. Basic unit price is \$8,800 with 2,048 words of memory. With ASR-33 and 4,096 words, the cost is approximately \$13,000.

Business Information Technology, Inc.
5 Strathmore Road
Natick, Massachusetts 01760

BIT-480

The 480 has a maximum capacity of 65k

bytes, a minimum of 1,024. Memory cycle time is 3 microsec; word length is 8 bits (variable). The machine has eight hardware registers (no index registers) and one accumulator. Maximum DMA word transfer rate is 250 kHz. The basic software includes two assemblers, one macroassembler, editor routines, a real-time executive monitor, and ASA basic FORTRAN, which requires 8k memory. The only peripheral device required is an ASR-33 teletypewriter. Operations with a few of the I/O devices are as follows: paper-tape reader and control, 60 or 30 characters/second; paper-tape punch and control, 60 characters/second; incremental magnetic tape and controller operates at 300 steps/second 200 bpi; digital magnetic tape transport operates at 200, 556, or 800 bpi at 35 ips. The rack is about 10-11 in. high. Price of the basic unit with ASR-33 and a 1k memory is \$7,100. With 4k it is about \$9,300.

BIT-483

The BIT-483 is a newer and less expensive model than the 480. The basic unit price is \$6,900 with 1k, \$7,130 for 2k, and \$9,310 for 4k with ASR-33. The memory is expandable to 65k. Both machines are I/O-compatible, and programs prepared for the 480 will operate the 483. Four interrupt levels are offered, and the 483 provides peripheral and transfer instructions unavailable in the older machine. Memory cycle time is .98 microsec, full word store time is 4 microsec, and add time is variable. Word length is 8 bits/word (variable). There are 125 instructions, with one address per, and 4 to 32 priority interrupts. Maximum transfer rate is 1 MHz. Peripheral options include a punched card input of 200 cards/minute with the output at 100 cards/minute, up to 15 million bytes of mass storage, a 300-characters/second tape reader, a 450-lines/minute printer, and a seven-channel magnetic tape (30 kC characters/second). Direct-memory-access channel is standard. Software includes a two-pass assembler, Basic, FORTRAN, a real-time executive monitor, and a disk operating system. The first BIT computer was delivered about a year ago.

Cincinnati Milacron
Department R-50
Lebanon, Ohio 45036

CIP/2000

Memory speed of the CIP/2000 is 1.1 microsec full cycle, 0.66 microsec half cycle. The memory is 4,096 bytes (8- or 9-bit), expandable to 32,768. Microprogramming allows the user to reorganize the instruction set by changing

the hard-wired read-only memory (ROM) in the control unit. ROM speed is 220 nsec per instruction, with 256 to 1,024 words in modules of 256 16-bit words. The CIP/2000 comes with one ROM board; up to three additional boards can be accommodated at a price of \$600 each, with programming. The machine has an 8-bit parallel byte I/O bus for programmed and fully automatic concurrent transfers, and serial I/O interfaces for Teletypes or similar devices. Direct-memory-access (DMA) channel has a maximum transfer rate of 909,000 bytes/second. There are 15 general-purpose 8-bit registers, with 7 working registers. Software includes a Cross Assembler written in FORTRAN IV to generate microprograms for the read-only store. Instructions are microprogrammed to suit applications; there are 16 basic commands. The entire unit is enclosed in a cabinet 8½ in. high and weighs 75 lbs. The 4k machine is \$2,720.

CIP/2100

The CIP/2100 is an expanded version of the 2000, with variable-length instructions, a 16-bit accumulator, and variable 8-, 16-, 24-, and 32-bit operations. The 2100 includes six operational registers, 89 instructions in the set, eight operand addressing modes, a built-in bootstrap loader, and one operand addressing up to 4 bytes. Software includes a two-pass assembler, an assembler written in FORTRAN IV, a tape editor, and a Teletype operating system. There are up to 64 priority interrupts, expandable in groups of 8. Price of the basic CIP/2000 with 4k and Teletype is \$6,162. The CIP/2000 and 2100 were first shipped nearly a year ago by the Cincinnati Milling Machine Company, now Milacron.

Clary DATACOMP Systems, Inc.
404 Junipero Serra Drive
San Gabriel, California 91776

DATACOMP-404

The 404 computer starts at \$6,800, but the price range can go as high as \$85,000. Word length is 16-bit, memory cycle time is 2 microsec, and access time is .750 microsec. Word length operating modes built into the hardware can be programmed for 16, 32, 48, or 64 bits, doing away with multiprecision routines. Sixteen addressing modes include double-index and relative. Hardware decimal arithmetic includes multiply and divide, with automatic scaling. There are 15 to 256 priority interrupts. On I/O, automatic formatting eliminates editing software. The 404 executive hardware

time-shares its own terminals while acting as an intelligent terminal in a time-shared network. Executive time-share software serves 2 to 16 users.

Pricing of the System 404, with a 4k x 16-bit memory, decimal arithmetic, hardware editing, and Teletype controller, is \$8,700. Deliveries have been made for over a year.

Compiler Systems, Inc.
P.O. Box 366
Ridgefield, Connecticut 06877

CSI-16 and CSI-24

Designed for the execution of high-level languages, CSI-16 and CSI-24 have four levels of operating systems available. These are batch, time sharing, and multiprogramming with disk-resident or core-resident programs. According to the manufacturer, only 4k of core is needed for time sharing the most complex operating system. Offered are a one-pass assembler, Basic, Algol, and FORTRAN IV, which supposedly operate in less than 4k of core. Various utilities are offered also. The number of instructions is 32 for both machines. Add time is 1.8 microsec. Number of priority interrupts: 4 to 256. The CSI-16 is a 16-bit processor with a memory of up to 32k. Price of the basic unit is \$10,750.

The CSI-24, priced at \$14,950, is a 24-bit processor with a maximum of 32k. This computer has the ability to access up to eight million words of direct-access memory. Input/output is handled by a series of up to 256 microprogrammed processors. Floating-point hardware is included in the cost of both machines. Also available: Teletype cassette tape, disk, drum, and line printer. Cycle time is 1 microsec for both computers. Rack height is 21 in.

Computer Automation, Inc.
895 West 16th Street
Newport Beach, California 92660

PDC-808 and 816

Basic word size for the PDC-808 is 4k expandable to 16k. Word length is 8 bits and memory cycle time is 8 microsec. Operation is parallel, single address, and utilizes a random access. The machine has core memory, eight hardware registers, and a party line I/O bus. There are two priority-interrupt lines as well as a request line. Additional interrupt lines are available in groups of eight. The number of hardware instructions is 73, with one and two addresses per instruction; number of priority interrupts, 3 to 64. Punched cards

can be input at the rate of 300/minute and output at 100/minute. The optional magnetic tape handles 8 or 10 kC characters/second. The basic Model 808 sells for \$4,990. Over 100 machines have been sold.

The PDC-816 is priced at \$9,980, a markdown. (Original price was approximately \$13,800, including ASR-33.) The basic configuration is 4k words also. Word size is 16 bits and memory cycle time is 8 microsec. Full-word add time is 16 microsec, as compared to the 808's 24 microsec. Maximum DMA word transfer rate is 125 kHz. Number of priority interrupts: 3 to 64.

The 808 entered the market in 1968, the 816 about a year later.

PDC-208 and -216; PDC-108 and -116

The 208 and 216 are newer computers, 8- and 16-bit, respectively. Both machines offer 2.6-microsec memory cycle times, compared with 8 microsec for the original models. Three new instructions have been incorporated into the 208 which were not in the 808. In Model 208, an add instruction can be performed in 8 microsec; the 216 can do the job in 5 microsec. Maximum word transfer rate is 250 kHz for the 208 and 800 kHz for the 216. The four machines, 808, 816, 208, and 216, are compatible in all peripheral gear and software. Rack height is 8.75 in.

Model 208 sells for \$5,990. The 216 has recently been reduced by nearly \$5,000—from \$12,890 to \$7,990. The 216 has 42-microsec software multiply, 122 instructions, three levels of hardware priority interrupts, automatic I/O multiplexing, 500,000-bytes/second I/O block transfers, indirect and indexed addressing, two accumulators, an index register, and 4,096 x 16 core memory. Both machines have been around for about 1-1½ years.

The PDC-108 (8-bit) and -116 (16-bit) computers have just been introduced. Both have 1.6-microsec cycle times.

Computer Development Corporation
3001 South Daimler Street
Santa Ana, California 92705

CD-200

A 1k version of the CD-200 sells for \$3,500. The small processor has a 1.2-microsec cycle time, with 1k to over 60k 8-bit bytes of memory. Add time is 2.0 microsec. The number of instructions is 69, and addressing is direct. Number of priority interrupts: 16. Software includes an assembler and a simulator to enable one to write and test CD-200 programs on larger computers.

The machine utilizes a flexible universal bus and provides an asynchronous memory interface, which permits various sizes, speeds, and types of memory to be used. The CD-200 controls processor speed and instruction execution time, and the universal bus allows direct memory access for peripheral devices and communication between peripherals without going through the central processor. The computer is a new addition to the field.

Computer Logic Systems, Inc.
49 Pollard Street
North Billerica, Massachusetts 01862

CLS-18

The CLS-18 computer is new and priced at \$9,870 for the basic 4k unit. Word length is 18 bits, with the 4k memory expandable to 32k. Memory cycle time is 0.96 microsec, add time is 1.9 microsec, and multiply is 7 microsec. The machine has 120 instructions, with the addressing being direct, indirect, extended, indexed, and push-pop. The number of priority interrupts is 8 to 144. DMA channels: 1 to 8. Maximum I/O is 1,250 kbytes/second. Software includes FORTRAN IV and a two-pass assembler.

Control Data Corporation
8100 34th Avenue, South
Minneapolis, Minnesota 55420

CDC-1700

The CDC-1700 is one of the higher-priced small machines, with the basic system price, with 4k, at \$29,000. Adding an ASR-35 brings the price up to approximately \$35,000.

Memory cycle time is 1.1 microsec and word length is 18 bits. Minimum memory size is 4k; maximum is 32k. Full-word add time is 2.2 microsec; hardware multiply time is 7 microsec. The maximum DMA word transfer rate is 900 kHz.

SC-1700

The SC-1700 has 4,096 words of 18-bit memory and can either operate as a stand-alone system or assist the CDC-1700. The SC machine has a 1.5-microsec memory cycle time, a 3.0-microsec add time, 196 real-time-oriented hardware instructions, two hardware index registers, hardware multiply/divide multilevel indirect addressing, and multilevel hardware interrupts with program priority assignment. In tandem with other CDC computers, this machine can operate as a satellite data preprocessor or concentrator, and can provide control applications. Software for the CDC 1700 series can be

used, including an assembly system, tape FORTRAN, mass storage FORTRAN, and macroassembler (COMPASS). The SC-1700 can be used alone for process control and graphics. The 4k memory can be expanded to 32k, with each 4k increment costing \$4,500. Basic price for the 4k SC-1700 is \$15,900. Deliveries began in mid-1970.

Datacraft Corporation
776 N.E. 40th Court
P.O. Box 23550
Fort Lauderdale, Florida 33307

DC-6024

The basic price of the DC-6024 is approximately \$29,800, but the machine is advertised as providing rapid memory access and a real-time capability approaching that of a multiprocessor or larger-scale system. The basic system includes five 24-bit general-purpose registers, three of which may be used for indexing, and a 8,192-word memory with parity expandable to 65,536 words in increments of 8,192. Hardware multiply/divide/square root, four levels of priority interrupt, and a basic software package are included also. Memory cycle time is 1.2 microsec with 24-bit word size. Full-word add time is 2.4 microsec. Maximum word transfer rate is 834 MHz. An ASR-33 is part of the basic I/O structure. The instruction set includes more than 500 discrete operations. Software: FORTRAN IV. The Model DC-22 magnetic core memory is available with 750-nsec cycle time.

Data General Corporation
Route 9
Southboro, Massachusetts 01772

Nova

Nova is a 16-bit machine with four accumulators, two of which may be used as index registers. It offers a choice of core or read-only memory of 1k, 2k, 4k, 8k, and up to 32k (using an optional expansion chassis) 16-bit words. Direct addressing is required for the balance of memory. Number of instructions: 200. Total memory cycle time depends on the type of module accessed; 2.6 microsec is required for a 4k module, 3.9 microsec for a 2k core, 6.5 microsec for a 1k core, and 2.4 microsec for a 1k read-only module. With a 4k core module, typical add instruction time is less than 5.9 microsec. Up to 62 devices may be connected to the I/O bus and may be individually selected by the central processor.

Nova comes in desk-top console or a

5½-in.-tall standard rack-mount package. Both basic versions can hold up to 20k 16-bit words of memory or interfaces without expansion chassis. The standard 4k configuration with Teletype interface was priced at \$7,950.

Supernova

Supernova has the same basic configuration as the Nova: 16-bit word, four accumulators, interchangeable core and read-only memory, and the same packaging design. This computer, however, is considerably faster than the Nova. A full memory cycle using core takes 800 nsec for the Supernova (2.6 microsec for the Nova). Using read-only memory, cycle time is 300 nsec for Supernova and 2.4 microsec for the Nova. Supernova overlaps the fetch and execute portions of arithmetic and logical instructions from read-only memory, so two numbers can be added in one 300-nsec memory cycle. The machine operates in fully parallel fashion on its 16-bit words—all 16 bits at once in a single 300-nsec machine cycle. With the Nova, the word is divided into four 4-bit nibbles that require four 400-nsec cycles to process.

With 4k of core memory, Teletype interface, and automatic program load, Supernova had been priced at \$11,700. As of August 1, 1970, a new price of \$9,600 was announced for the same configuration. The Supernova central processor has been reduced from \$6,850 to \$5,600, and 4k 16-bit memory subsystems have been reduced from \$4,500 to \$3,650. The ASR-33 is priced at about \$1,400. Multiply/divide and memory protection are options.

Recently, at the 1970 Spring Joint Computer Conference, Data General Corporation announced a new software package. Before this time, Basic had been offered for both machines. The new software includes a complete ALGOL 60, two varieties of FORTRAN IV, and a device-independent disk operating system.

Nova was announced in 1968 and first shipped about 2 years ago. The Supernova was introduced in 1969 and the first machines were delivered in 1970. Both models are selling exceptionally well.

Datamate Computer Systems, Inc.
P.O. Box 310
Big Spring, Texas 79720

DM-16

The Datamate 16 is a 4k computer, expandable to 32k, with parallel 16-bit operation. Memory cycle time is 1.0 microsec, add time is 2.0 microsec, and multiply time is 5-7 microsec. DMA is 16

megabits/second. The machine has seven hardware registers and 115 instructions. It has eight levels of nested, self-identifying priority interrupts, field expandable up to 64 levels. Priority interrupts have 2-microsec response times. Software includes a macroassembler, symbolic editor, library routines, on-line debug, and USA Standard Basic FORTRAN.

The main frame weighs 50 lbs and is 5½ in. high. The 4k unit was priced at \$14,900; increments of 4,096 words cost \$6,500. As of September 1, 1970, an 8k computer costs \$14,900 and increments of 4,096 words are \$4,500.

DM-70

The DM-70 is a new machine (first units delivered in mid-1970), named the Skinny Mini, which is small in size and low in price. The cabinet is 1½ in. high x 19 in. wide x 20 in. deep.

A 16-bit computer, the Datamate 70 has 11 registers, 4 of which are 16-bit arithmetic accumulators, with two available as index registers. An index I/O register is included also. A wide range of optional memories include a 1.0-microsec core, plus semiconductor memories of the read-only and read/write type, which operate at much higher rates. Direct memory access is built in. Over 144 instructions are included in five classes of microprogrammed format.

The machine is expandable to 32k with 1.0-microsec add/subtract. DMA rate is 16 megabits. A symbolic editor, relocating loader, I/O drives, diagnostics, and a debug package are included.

The basic Datamate 70 is housed in the 1½ in.-high cabinet. The unit may include the CPU, full power, and up to 1,024 words of ROM, 256 words of scratch-pad memory, plus space for I/O device controllers. For applications requiring extended memory, a 5½-in.-high package houses the above plus 16k of core memory. The basic 4k computer sold for \$6,400; it is now \$6,100.

Data Technology Corporation
1050 East Meadow Circle
Palo Alto, California 94303

DR-1600

The DT-1600 computer is a 16-bit-word machine with 4k memory expandable to 32k. Memory cycle time is 8.0 microsec. The machine has 73 hardware instructions. I/O devices include paper tape, disk, and magnetic tape; incremental mag tape and controller (800 bpi IBM-compatible read/write) is priced at \$9,950. The interface electronics alone is \$1,900. The

basic 4k DT-1600 costs \$6,600 including processor, console, and power supply, 73 instructions, power for up to 16k, two priority interrupt lines, block transfer ability, and software package. An additional 4,096 words of memory costs \$2,200. Rack height is about 9 in.

Decade Computer Corporation
7457 Lorge Circle
Huntington Beach, California 92647

Decade 70/2

Memory cycle time for this machine is .860 microsec and word length is 18 bits. Minimum word size is 4k expandable to 16k. Full-word add time is 1.9 microsec; hardware multiply time is 6.5 microsec; divide time is 12.5 microsec. The machine has one accumulator, five hardware registers, and one memory index register. Maximum DMA word transfer rate is 1.1 MHz; maximum number of external interrupts is 32. The basic system with 4k words is \$12,800. An ASR-33 Teletype costs \$1,200. FORTRAN IV is available, as is the conversational compiler CHAT. Various I/O peripherals are optional. (Refer to the Redcor 70 for a description of the Decade 70 machine.)

Digiac Corporation
Ames Court
Plainview, New York 11803

Digiac-3080

The Digiac-3080 is a drum machine with a word length of 25 bits for a basic 4k memory. Price is \$19,500 for a unit with 50 hardware instructions and software that includes FORTRAN.

Digital Computer Controls, Inc.
Fairfield, New Jersey 07006

DCC-112

The Model DCC-112 is a newly announced 4,096-word (expandable to 32,768) general-purpose minicomputer which features 1.2 microsec random-access time, an arithmetic processor, and a buffered I/O control. The unit also provides eight auto-index registers, indirect addressing, and a high-speed channel. DCC-112 is advertised as hardware-, software-, and plug-compatible with DEC's PDP-8 family, with 1.5-microsec cycle time.

Digital Equipment Corporation
146 Main Street
Maynard, Massachusetts 01754

A number of the earlier DEC machines

may be found on the used-computer market, e.g., the dated PDP-1, PDP-5, PDP-7, LINC-8, and PDP-8. Two of these will be described briefly before proceeding to the other computers on the Digital Equipment Corporation list.

The PDP-5, for example, includes a CPU, 1,024- to 32,768-word, 12-bit random access, magnetic core memory, I/O control, and I/O tape teleprinter. Standard features include a FORTRAN compiler, symbolic assembler, 12- or 24-bit arithmetic, indirect addressing, data and program interrupts, and eight auto-indexing core memory locations. Memory cycle time of the PDP-5 is 6 microsec.

The popular LINC-8 comprises two subsystems, a standard PDP-8 and the LINC. The two subsystems share a dual console and are connected by means of a special interface section which mediates exchange of data and control. The LINC-8 was designed to operate in one of two modes. In the first mode, it operates as a LINC having certain special in-out and speed characteristics but otherwise identical with the original LINC (Laboratory Instrument Computer). The LINC and the PDP-8 are both single-address, fixed-word-length, parallel computers using 12-bit binary arithmetic. Cycle time of the 4,096-word core memory shared by both computers is 1.5 microsec. This cycle time in either mode provides a computation rate of 333,333 additions/second. In the LINC mode, multiplication is carried out in approximately 32 microsec. The 4k core is expandable to 32k. Standard equipment for the LINC-8 includes an ASR-33 teletypewriter, audio control, cathode ray oscilloscope, dual magnetic tape unit, a 6-bit relay register, and a data terminal panel, behind which are provisions for mounting 60 Flip Chip modules as well as 11 I/O signal lines. A standard analog-to-digital converter has 16 multiplexed channels, with 16 additional channels optional. Standard cabinet size: 69-1/8 in. high x 32 1/2 in. wide x 33 in. deep.

PDP-8

PDP-8 computers are found in all sorts of laboratories, but the machine has been succeeded by other computers in the series. There are, however, a tremendous number of the units in use.

The PDP-8 is a 4k computer, expandable to 32,768k, with a word length of 12 bits and memory cycle time of 1.5 microsec. Programmed I/O data transfers are handled at up to two million bits/second. Device-initiated I/O transfer rates are up to 7.9 million bits/second. The machine can service up to 64 external devices, each requiring up to three commands, and 96

devices, each requiring two commands. Software includes FORTRAN and mathematical subroutines. The programming system also includes the MACRO-8 symbolic assembler, symbolic on-line debugging, tape editor, and a floating-point package. The basic system includes 4k words, keyboard printer and tape reader-punch, eight auto-index registers, wired-in analog-to-digital converter, program interrupt, data interrupt, and indirect addressing. Original price of the system was about \$18,000.

PDP-8/S

The PDP-8/S has been succeeded by later models also. With many of the PDP-8 features and fully compatible, this unit has slower speed and is less expensive. The 4k-expandable-to-32k memory has a memory cycle time of 8 microsec compared to the PDP-8 1.5-microsec time. Add time is 36 microsec vs 3 microsec for the PDP-8.

The 8/S sold for slightly less than \$10,000, and is smaller in physical size than the PDP-8. Memory size, I/O capabilities, standard options, and software are the same as the PDP-8. An ASR-33 Teletype is standard.

PDP-8/I

The PDP-8/I has most of the characteristics of the PDP-8, except for expanded software, new options, a new method for interfacing, and a lower price.

External devices are interfaced to the PDP-8/I via a flexible I/O bus so the central processor does not have to be modified. Built-in instruction capability provides a convenient method for checking the status of peripherals. Data is transferred between the external devices and computer by program interrupts, programmed data transfers, and data break transfers. The user chooses the most efficient method, depending on I/O requirements.

Cycle time is 1.5 microsec, add time is 3.0 microsec, and subtract takes 6.0 microsec, as with the PDP-8. An extended arithmetic option permits multiply/divide in approximately 6 and 6.5 microsec, respectively, against 21.2 and 37.2 microsec for the PDP-8. Maximum I/O is 500 kbytes/second. The machine has eight auto-index registers.

Pedestal model size is 36 1/2 in. high x 30 in. wide x 31-3/8 in. deep. The table model measures 8 1/2 in. high x 30 in. wide x 31-3/8 in. deep. Rack-mounted size is 30-7/8 in. high x 19 in. wide x 23-5/16 in. deep. Weight for all of the configurations is 250 lbs. An ASR-33 is standard for the 8/I system, which was introduced in 1967 and first delivered in 1968. Software includes FORTRAN, Pal-D, Basic, ALGOL, and Macro-8. Price: \$12,500 with teletypewriter.

PDP-8/L

The PDP-8/L is a smaller version of the 8/I. The internal plug-in expansion features of the 8/I were left out to keep the price and size down. Expansion of core memory for the PDP-8/L is limited to 8,192 (double its basic core of 4k) with 12-bit word length. And the memory cycle time is slightly lower at 1.6 instead of 1.5 microsec. The machine also requires expansion options to add most of the input/output peripherals that plug into the 8/I. Both have eight basic instructions, six memory reference and two augmented. Software packages are the same.

Physically, the table model of the 8/L is 8½ in. high x 19 in. wide x 20½ in. deep and weighs 83 lbs. The rack-mounted model is 3 in. deeper and weighs 70 lbs. The ASR-33 is standard. Basic price is \$8,500.

LAB-8

The LAB-8 is a signal averager featuring the PDP-8/L computer with ASR-33 teleprinter. AX08 laboratory peripherals include: 4 channels of analog-to-digital input (expandable to 24), 9-bit conversion at all sampling speeds, sample and hold circuitry, two Schmitt trigger inputs expandable to three, one pulse output, a 19-kHz crystal clock, a variable-frequency (16-Hz to 200-kHz) RC clock, an X-Y display and plotter control. An RM503 oscilloscope is used as an X-Y display for computer output. A number of options are available for extending capabilities. The LAB-8 can also include the PDP-8/I with the AX08 lab peripheral. The system was priced in the \$20,000 range with actual price dependent on computer (8/I or 8/L) and options.

PDP-8/E

The PDP-8/E is the most recent addition to the 8 series and is upward-compatible with PDP-8-series software and peripheral devices. At the heart of the PDP-8/E is a parallel bus organization board. The latter eliminates all cross wiring. Circuit boards are plugged in above the 10.5-sq-in. organization board, including three memory boards (4k), four processor boards, a Teletype control board, a console board, and a PDP-8-compatible I/O board.

Memory cycle time for the 8/E is 1.2 microsec, add time is 2.6 microsec, and multiply is 7.4 microsec. Maximum I/O is 830 kbytes/second. The computer is byte-oriented (6 bits) and has a 12-bit word. An optional read-only memory is available in 256-word increments. The PDP-8/E has 23 instructions with direct addressing, up to 12 direct-memory-access channels, and up to four priority interrupts. The basic computer with 4k

memory is priced at \$4,990. With a teletypewriter, it is \$6,500. Additional memory can be added up to the 32k maximum at \$3,000 per 4k.

PDP-9/L

The PDP-9/L is a smaller, slower version of the PDP-9. It is also cheaper. Price of the basic system with ASR-33, 4k memory, and cabinet is \$19,900.

The PDP-9/L has 4,096 18-bit words of core memory, expandable to 32,768 words. Memory cycle time is 1.5 microsec, add time is 3 microsec, multiply is 13 microsec, and divide is 14 microsec. The machine has directly addressable memory, eight data channels, auto-index registers, and an automatic program loader in the basic model. The 4k standard software includes a two-pass assembler, utility programs, editor, math package, and debugging. With 8k memory or more, the 9/L can accept advanced PDP-9 software, including FORTRAN IV, a macroassembler, symbolic editor, I/O monitor, and others. A statistical package written in FORTRAN (STATPAC) and a translator package, making it possible to adapt a major part of the code written for the PDP-8 family of computers, were introduced in 1969. Expanded to 16k, the machine has capability for background-foreground programming. That is, program development can be carried out along with on-line activities.

In comparison, the PDP-9 has an 18-bit word length, with a basic 8,192-word memory expandable to 32,768 in 8,192-word increments. Cycle time is 1.0 microsec, add time is 2 microsec, and I/O transfer rate is up to 18,000,000 bits/second. Standard equipment includes a paper-tape reader, a paper-tape punch, and an ASR-33 Teletype.

PDP-11/20

The PDP-11/20 was first delivered to customers in early 1970. It is a 16-bit-word-length computer with 4k-expandable-to-8k memory. Memory cycle time is 1.2 microsec, add time is 2.3 microsec, and multiply is 4.5 microsec. Maximum I/O is 1,660 kbytes/second. The machine has four levels of priority interrupts, expandable to 256, and 400 hard-wired instructions with direct addressing. The general registers are program-accessible. Software routines available include assembler, Basic, and FORTRAN. Price of the unit with 4k memory, console, and ASR-33 Teletype is \$10,800. The table-top model is 11 in. high x 20 in. wide x 24 in. deep and weighs 100 lbs. The rack-mounted model is 10½ in. high x 19 in. wide x 23 in. deep and weighs 90 lbs.

PDP-12

The PDP-12 is a complete laboratory system with a large display (7 x 9 in. CRT), 16-channel A/D converter expandable to 32, and two tape units. The computer has a 4k memory, expandable to 32k, with 12-bit word length. Memory cycle time is 1.6 microsec and add time is 3.2 microsec. Hardware multiply is standard. Maximum word transfer rate is 625 kHz. There are 43 basic instructions, 12 hardware registers, and 15 auto-index registers.

Advised as the successor to the LINC-8, the PDP-12 is faster and more powerful, yet \$10,600 less. The PDP-12 has buffered I/O, including a mag-tape processor. The display-based programming system is not difficult to use for PDP-12 programs, LINC-8, or PDP-8 programs. The machine can execute two complete instruction sets, the LINC and the PDP-8 family of instructions. A signal averaging program requires peripherals and allows for handling up to 1,024 data points per sweep and the averaging of the data over a maximum of 4,096 sweeps. FORTRAN, FOCAL, and floating-point packages are available. Standard cabinet size is 69 in. high x 32½ in. wide x 33 in. deep, and the weight is 500 lbs. The table model is slightly smaller. For about \$29,000, the system includes a 4k memory, a DMA channel, LINCtape automatic control, two mag tape transports, LINCscope control and character buffer, CRT display, A/D converter and multiplexer (16 channels), a data terminal panel, and ASR-33 teletypewriter.

PDP-14

The PDP-14 was announced by DEC in March of 1969. The machine has modular design with 1,024 nondestructive 12-bit read-only memory, expandable to 4,096 in blocks of 1,024 words. The interface unit is expandable in blocks of 32 inputs to 256. Output interface is expandable in blocks of 16 outputs to 255. A computer interface is available between the PDP-14 and the PDP-8/I or 8/L machines. The machine is 24 x 18 x 8 in. and weighs 80 lbs, excluding interfacing.

PDP-15/10

The PDP-15/10 is an 18-bit-word-length computer with 4k basic, expandable to 131k. Memory cycle time is 0.80 microsec, add time is 1.6 microsec, and multiply is 7.4 microsec. The machine has 28 priority interrupts, expandable to 64, and eight DMA channels. Addressing is direct to 4k words and indirect to 32k. Two memory cycles are required for indirect. There are nine hardware registers, one index register. The machine is the basic PDP-15 and can be expanded to capabilities of larger systems.

Software includes FOCAL, a two-pass assembler, Basic, and FORTRAN IV. A real-time executive monitor is optional. Price of the computer is \$16,500 with 4k and a teletypewriter. An additional 4k is priced at \$6,000. The units were first delivered to customers in early 1970.

The 18-bit PDP-15 is offered in four configurations. An advanced monitor system is priced at \$36,000; one designed for background/foreground applications, at \$58,000; a large, disk-based background/foreground system sells for \$92,000. The PDP-15/30 is a background/foreground system developed for use where one or more real-time tasks typically require continuous responsiveness from the computer but do not use its entire capacity. The system includes a 16,384 core memory, magnetic tape storage, and a wide range of software.

Digital Scientific Corporation
11455 Sorrento Valley Road
San Diego, California 92121

Meta 4

The Meta 4 is a 16-bit-word computer with a 4k memory expandable to 65k. Memory cycle time is 0.90 microsec, add time is .90 microsec, and multiply is 3.0 microsec. Addressing is direct, with 27 instructions. There are nine DMA channels and 6 to 32 priority interrupts. Maximum I/O is 2,400 kbytes/second. Software includes a batch monitor and a real-time executive system. Price of the 4k unit is \$15,650. First deliveries were made in early 1970.

Dresser Systems Inc.
P.O. Box 2928
Houston, Texas 77001

Dresser 8000

The 8000 has 16-bit word size with 4k memory expandable to 16; cycle time is 4.0 microsec. There are 27 hardware instructions, two priority-interrupt levels, and two direct-memory-access channels. Software: loaders and real-time monitor. A CRT and ASR-33 Teletype are included. A Selectric and card reader are available as I/O devices.

Elbit Computers, Ltd.
9701 North Kenton
Skokie, Illinois 60076

or

Elron, Inc.
Building 812
Raritan Center
Edison, New Jersey 08811

Elbit-100

The Elbit-100 is a 12-bit machine with a basic memory size of 1k expandable to 4k. The computer has 16 hardware instructions plus modifiers, and cycle time is 2 microsec. Full-word add time is 7 microsec. There are four priority interrupts. I/O devices include Teletype, interface to the IBM-360, paper-tape reader and punch, magnetic drum, A-to-D and D-to-A converters, disk and line printers. Software: logic operations, conversational modified FORTRAN, and DEBUG. Price of the basic unit is approximately \$6,000. About 2 years ago, the Elbit-100 was advertised at \$4,900 by Elbit Computers, Ltd., 88 Hagiborim Street, P.O. Box 5390, Haifa, Israel. Rack height is 9 in.

Electronic Associates, Inc.
185 Monmouth Park Highway
West Long Branch, New Jersey 07764

EAI-640

The EAI-640 has a core-type memory, 8k expandable to 32k, with 16-bit word length. The basic 8k unit costs \$24,500, including ASR-33. Memory cycle time is 1.65 microsec, add time is 3.3 microsec, and multiply time is 18.1 microsec. Maximum word transfer rate is 600 kHz. The machine has 64 hardware instructions with multilevel indirect addressing and 10 hardware registers. Software includes FORTRAN IV, an interpreter, and monitors. The unit was first delivered over 4 years ago and is not one of the smaller rack-size machines.

EMR Computer
8001 Bloomington Freeway
Minneapolis, Minnesota 55420

Advance EMR-6120

The 6120 is a 16-bit-word computer with 4k basic, expandable to 32k. Cycle time is 2 microsec and the machine has 60 hardware instructions. I/O devices include Teletype, paper and mag tapes, disk, and communications interface. Basic price is approximately \$7,700.

Advance EMR-6130

The 6130 is a much more expensive machine at \$46,000, with 8k words, and is merely noted for comparison. Memory cycle time is .775 microsec, with an 18-bit word length. Minimum word size is 8k expandable to 32k. The 32,768 words can be addressed directly in 1.9 microsec and addressed indirectly in 2.9 microsec. DMA word transfer rate is 1.2 mHz.

FOTO-MEM, Inc.
6 Strathmore Road
Natick, Massachusetts 01760

CENTAUR

The basic CENTAUR includes the CPU, a 4,096-byte memory, ASR-33 Teletype, and a basic software package on paper tape. Memory cycle time is 980 nsec and the unit includes eight programmable hardware registers, a 17-bit accumulator, and a 16-bit index register. Seventy-eight basic machine instructions include 15 memory reference instructions. The basic 4k memory is expandable in modules to 65k, 536 bytes. Addition of memory data to the accumulator is accomplished in 3.0 microsec (4.0 microsec in double-precision mode). Multiply time is 7 microsec (16-bit product). In direct memory access, data can be transferred to or from memory at the rate of 800,000 bytes/second or 250,000 bytes/second (alternate mode). Maximum transfer rate normally is 141,000 bytes/second. Priority interrupts: four.

Up to 256 external devices are program-addressable, including mag tape stations, disk files, monitoring consoles, printers, and the Foto-Mem 1/4-trillion-bit FM 390 Mass Memory System.

The rack is 10.5 in. high x 10 in. wide x 15 in. deep, and its weight is 48 lbs, with 8k memory. Price of the basic unit is less than \$10,000, with 4k and Teletype.

Four-Phase Systems, Inc.
10420 North Tantau Avenue
Cupertino, California 95014

System IV/70 Video Terminal

By utilizing the computer memory space to supply the electronics necessary for character generation, the Series Four system can offer video terminals for \$2,500 each. The basic system costs \$16,000 with deliveries beginning in the fourth quarter of 1970. The basic contains 6,144 bytes, 24-bit words of core memory with 1.9-microsec cycle time, 15.2-microsec add/subtract, and ROM may be substituted for 12 kbytes of RAM. The system is expandable to 98 kbytes. At maximum, 32 terminals can be operated in a time-sharing system. The video terminals include alphanumeric keyboard. Display capacity is 50 lines with 48 characters each. The 117 instructions include byte as well as word manipulation. The system will interface with teletypewriters, disks, tapes, card readers, and mag-tape cassettes.

Fujitsu Ltd.
680 Fifth Avenue
New York, New York 10019

or

Fujitsu Ltd.
8, 2-chome
Marunouchi, Chiyoda-ku
Tokyo, Japan

FACOM-R

Word length for the FACOM-R is 17 bits, 16 data bits plus parity, and memory speed is 1.5 microsec. Capacity is 4k minimum, expandable to 32k. There are 28 basic instructions within seven classes. Add and subtract speeds are 6 microsec without address modification and 7.5 microsec with modification. The machine has four index registers. Maximum data transfer rate is 800 kbytes/second for interface mode. Number of priority interrupts: one. The number of I/O unit addresses is 255 maximum. All of the standard I/O devices are available. Software includes FASP (FACOM Automatic Symbolic Program) and mini-FORTRAN. The rack is approximately 11 in. high and 23 in. deep. Basic system cost (4k) is approximately \$10,000.

General Automation, Inc.
706 W. Katella
Orange, California 92667

SPC-12

The standard SPC-12 computer includes a 4,096 by 8-bit word memory expandable to 16,384 words, with full cycle time of 2.16 microsec. Features include a parallel adder, six addressing modes, eight 12-bit hardware registers (including an accumulator, an index, and two index/accumulator registers), 50 basic commands, a priority-interrupt system, a relative-time clock, and a Teletype interface for approximately \$5,000. Maximum DMA word transfer rate is 430 kHz. Add time is 4.3 microsec, access time is 600 nsec. A substantial library of real-time monitors, a one-pass assembler, executive control systems, process control functional programs, utility routines, and I/O drivers are operational and maintained for SPS-12 user projects. The unit weighs 29 lbs and is 5¼ in. high x 17½ in. wide x 20 in. deep.

GA 18/30

The Model GA 18/30 is software-compatible with IBM's 1130 and 1800, hence the designation 18/30. The system has a 16-bit word length, single- and double-precision arithmetic hardware multiply, divide plus parity and storage protection bits. The processor has a 960-nsec memory available in 4k increments to 32k and a 16-word 35-nsec

scratch pad. There are six classes of instructions with over 400 modifications. Add time (single precision) is 2.4 microsec, multiply time is 12.0 microsec, and data channel transfers, 1.2 microsec. Maximum word transfer rate is 960 kHz. Software is program-compatible with the two IBM machines and includes FORTRAN, assemblers, and real-time executives. Price of the basic system is about \$18,000; the cost is \$19,500 with ASR-33. The unit takes 19 x 15¼ x 22½ in. of rack space and weighs 85 to 105 lbs. depending on options.

SPC-16

The SPC-16 is the newest computer in the General Automation line and has a basic price of \$10,000. The machine has a 950-nsec memory cycle time and a 4k core memory expandable to 32k. Read-only memory has a 480-nsec cycle time. The SPC-16 has 16 programmable general-purpose registers, and up to 64 hardware priority interrupts. The machine can do both single- and double-word addressing, direct or indirect, and address up to 512k bits, up to 65k bytes, and up to 32k words. As many as 64 external devices with 200 control functions can be operated through the parallel I/O bus. Service software includes real-time executive systems, disk executive system, FORTRAN, and others. The unit weighs 80 lbs maximum and measures 10.5 in. high x 19 in. wide x 23.6 in. deep.

General Electric Information Systems
1285 Boston Avenue
Bridgeport, Connecticut 06602

GE-PAC 30-1 and 30-2

The average purchase price for either of these systems is approximately \$11,800. Both computers have 16-bit word lengths, a maximum memory capacity of 64k, 15 index registers, and up to 256 CPU I/O channels. Memory cycle time for the 30-1 is 1.0 microsec, for the 30-2, 0.67 microsec. Access times are the same. The 30-1 has 27 instructions and the 30-2 has 93. Software includes interactive FORTRAN.

GRI Computer Corporation
76 Rowe Street
Newton, Massachusetts 02166

GRI-909

The basic computer, with 4,096 words of 16-bit random-access core memory, sells for about \$8,000. The GRI-909 features a 16-bit fully parallel processor with 1.76-microsec cycle time. The 32,768

words of memory are directly accessible; minimum core size is 1,024 words. Sixteen levels of interrupts are available, and more than one device can be operated at each level. The number of instructions is 100, and the addressing is direct. Theoretical limit of instructions is 50,000. I/O rate: direct memory access or device to device at 568,000 16-bit words/second maximum. There are 11 registers in the basic computer, which is mounted in a cabinet 10½ in. high and 20 in. deep; weight is approximately 50 lbs. The machine has been shipped to customers for about a year.

Input/output data and control buses (groups or parallel wires) on which peripheral equipments reside extend inside the computer. All of the internal computer elements are connected across these buses.

Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, California 94304

HP-2114B

The Hewlett-Packard 2114B is a 16-bit-word computer with 4k-expandable-to-8k memory. Memory cycle time is 2.0 microsec, add time is 4.0 microsec, and subtract is 6.0 microsec. The machine has 1,024-word page size, with direct address for two pages and indirect address for any page. The processor has 70 one-word instructions, microprogramming of up to eight instructions. Two addressable accumulators are used to simplify programming. There are seven plug-in I/O channels in the main frame plus 17 additional channels with an optional I/O extender unit. Peripherals are interfaced with plug-in cards. Interface cards are available for many digital instruments and peripherals. Optional multiplexed I/O system allows interfacing up to 56 devices. A direct-memory-access channel is optional at a cost of \$1,500. The latter has a maximum data transfer rate of 500,000 16-bit words/second. Software includes FORTRAN, ALGOL, Basic, a two-pass assembler, and extended assembly, most of which require 8k memory. The basic 4k unit costs \$8,500; an additional 4k is priced at \$4,500. The ASR-33 is \$2,000 and the I/O Extender is priced at \$3,500, with an additional \$1,000 for the computer interface kit. The basic frame is 12 in. high x 16¼ in. wide x 24-3/8 in. deep and weighs 102 lbs. The machine was introduced in 1969.

HP-2115A

The HP-2115A is a 16-bit 4k-8k machine similar to the HP-2114B in speeds and

other characteristics. This computer, however, has 8 external interrupts in the basic system, expandable to 40. Price of the 4k unit is \$14,500.

HP-2116B

The HP-2116B has an 8k memory, expandable to 32k, with 16-bit word length. Memory cycle time is 1.6 microsec, add time is 3.2 microsec, and multiply is 19.2 microsec. The computer has 16 priority interrupts in the standard package, expandable to 48. Maximum I/O is 600 kbytes/second. The machine has 72 basic instructions and seven hardware registers. Software includes FORTRAN IV, ALGOL, Basic, and a real-time executive. Price: \$24,000. An additional 8k memory costs \$10,000. Both the 2115A and the 2116B have been on the market a few years.

Honeywell

Computer Control Division
Old Connecticut Path
Framingham, Massachusetts 01701

DDP-416 and DDP-516

The DDP-416 and -516 offer basic memories of 4,096 16-bit words and full cycle times of 0.96 microsec. The former machine is expandable to 16k and has 34 basic instructions with five address modes. The latter unit is expandable to 32k and has 72 instructions with eight address modes. The DDP-516 has floating point and the -416 does not. Both computers have two external interrupts; the maximum number available is 48. The DDP-516 software consists of over 250 programs, with the standard package containing FORTRAN IV (for a minimum of 8,192 words of core memory), DAP-16 for translating from the programmer's to machine language, and a real-time monitor. The DDP-416 has over 50 programs compatible with the -516. Both machines have one- and two-pass assemblers.

Add time for the DDP-516 is 1.92 microsec and most instructions are executed in that time or less. The maximum word transfer rate for both models is 1.04 MHz. Dimensions are 24 x 24 x 38 in.; weight is 250 lbs.

Approximate price of the DDP-416 is \$16,900, and the DDP-516 costs \$25,000. An ASR-33 Teletype is included in both prices.

H-316

The H-316 is similar to the DDP-516 in having the same register organization, instruction repertoire, and I/O interface characteristics. Memory cycle time for the H-316 is 1.6 microsec and add time is 3.2 microsec. Instruction complement is 72

with eight address modes. Word size is 16 bits, with the 4,096-word memory expandable to 16,384 words. The computer has seven hardware registers; six can be controlled from the front panel and the seventh is an index register. The 16 priority interrupts may be expanded to 64. More than 500 field-proven software packages can be operated. Programs include FORTRAN IV, DAP-16 and I/O selector, a disk-operated program (DOP) and EXEC-16, and executive control package. The 150-lb unit measures 14 in. high x 17½ in. wide x 24½ in. deep. The price is \$9,700 without ASR-33, which costs an additional \$1,700.

H-112

The H-112 is a 12-bit stored-program controller computer for on-line, real-time data collection and reduction applications. The machine has a 4k basic memory plug-in, expandable to 8k. Memory cycle time is 1.69 microsec and add is 7.63 microsec. Five instruction types make up 37 standard instructions. Addressing is indirect. Skip instructions are microprogrammable. Input/output rate: one 12-bit word/3.39 microsec or 295k words/second (direct data channel option). Standard software includes an assembler, debug, diagnostics, loader, and math library.

IBM Corporation

Armonk, New York 10504

IBM-1130

The IBM-1130 is a 16-bit-word machine with a basic 4k memory, expandable to 32k. Memory cycle time is 2.2 microsec, add time is 4.88 microsec, and hardware multiply time is 1.5 microsec. Direct-memory-access channel is standard; maximum word transfer rate is 460 kHz. The machine has seven hardware registers, three memory index registers. The basic system has six external interrupts; the maximum number available is 96. Software includes a two-pass assembler, USASI, Basic, and FORTRAN IV. Price of the 4k system is \$25,880, including an ASR-33 and secondary storage. Additional 4k memory is priced at \$8,000. The "average" purchase price of a 1130 system is \$68,000.

IMLAC Corporation

296 Newton Street
Waltham, Massachusetts 02154

PDS-1

The PDS-1 is a programmable stand-alone display computer system

priced at less than \$10,000. The system comprises a CRT display screen, a central processor, and a solid-state keyboard with software-programmed functions. The CRT screen is capable of displaying about 1,200 flicker-free characters, and it may be oriented horizontally or vertically. The 14-in. CRT is refreshed from local memory at, normally, 40 frames/second. CPU word size is 16 bits, and memory size is 4k words, expandable to 32k. Cycle time is 2 microsec; direct addressing, 2k words, with indirect addressing at 32k single level. The CPU has 16 index registers (auto). I/O maximum word rate is 500 kHz.

As a standard package, the IMLAC PDS-1 comes with a text and graphics editing program. A proprietary interactive graphics pattern permits line drawing graphics editing from the keyboard, as well as limited text.

Information Technology, Inc.

164 Wolfe Road
Sunnyvale, California 94026

ITI-4900

Basic price of the 4900 with 4k memory and an ASR-33 is \$12,450; it is \$9,950 without the Teletype. Memory cycle time is 0.975/1.75 microsec and word length is 16 bits. Memory size is 4k expandable to 32k. The machine has eight accumulators, 16 hardware registers, and 6 hardware index registers. Full-word add time is 1.94/3.5 microsec; hardware multiply time is 10 microsec and divide time is 25 microsec. Maximum DMA word transfer rate is 1 MHz. Various peripherals are available. Software includes FORTRAN IV.

Infotronics Corporation

8500 Cameron Road
Austin, Texas 78753

mini/max

The Infotronics mini/max computer is an 8k machine, expandable to 65k, with 80 basic instructions which allow 3,000 discrete operations through pseudoinstructions. The system has a 2-microsec memory cycle time and can operate up to eight disk controllers. Add time is 3 microsec and multiply is 8 microsec. The maximum I/O is 2,000 kbytes/second. An expanded system of the 16-bit machine can be purchased with 18 levels of priority interrupts, a 60-characters/second tape reader, a 110-character/second tape punch, and a 300-card/minute reader/printer. The basic unit sells for \$16,500. The expanded system costs approximately \$42,100.

Software includes a real-time executive and an assembler.

Interdata
2 Crescent Place
Oceanport, New Jersey 07757

Models 2, 3, and 4

Interdata Models 2, 3, and 4 have a number of similar characteristics. The common features include 16-bit halfword memory, addressable and alterable to an 8-bit byte level, 16 general registers, and direct addressing of up to 256 devices. Software packages include I/O system, editor, and debugging; FORTRAN, micro, and 1, 2, or 3 pass assemblers are available for Models 3 and 4.

All three processors include 16 general-purpose user registers. These act as index registers or accumulators to permit the programmer to keep track of numerous loops and real-time combinations without having to retrieve them from memory. In Models 2 and 3 the registers reside physically in core, but can be manipulated as if they were hardware functions. In Model 4, these registers are implemented in hardware. The ROM is a high-speed (400-nsec) nondestructive memory which stores the microprogram used to interpret and execute the main program. The three machines also have one external interrupt, expandable to eight, and 78 instructions with two address modes.

Model 2 has the slowest speed, with a memory cycle time of 3 microsec and an add time of 45 microsec. Read/write data transfer rate is 5 kbytes/second. No hardware multiply/divide, floating point, hardware block transfer, or high-speed memory access options are available for Model 2. They can be obtained with Models 3 or 4. Model 2 was listed at \$6,600, but introduction of the new Model 1 has dated the machine.

Model 3 has a 1.8-microsec cycle time and a 34-microsec add time. Read/write data transfer rate is 6 kbytes/second and direct-memory-access rate is 750 kbytes/second. Word length is 16 bits, and the 4k memory is expandable to 64k. Model 3 is priced at \$8,900.

Model 4 has a 1.0-microsec cycle time with 4k-64k memory. Add time is 3.2 microsec; read/write data transfer rate is 25 kbytes/second and direct memory access rate is 900 kbytes/second. The basic cost of Model 4 is \$12,300. An ASR-33 is priced at \$1,900 for all Interdata systems. All three machines noted were first delivered over 2 years ago.

Model 1

The Interdata Model 1 is a new (1970),

physically small machine (5¼ in. high x 17½ in. wide x 17 in. deep, weighing 45 lbs) priced at \$4,650, with 2k memory. The basic 2k is expandable to 16,384 8-bit words. The machine has a 1.0-microsec cycle time and 3-microsec add time. There are seven internal registers and 47 instructions. Addressing modes are direct, indirect, and auto-indexing. Read-only memory is available in modules of 2,048 words. Four hardware interrupt levels are standard and expandable to eight. Maximum number of I/O devices: 256. Read/write block transfer rate is 400,000 bytes/second; selector channel rate is 500,000 bytes/second. Power fail protection is optional but a real-time clock is standard. Software includes assembler, monitor, and simulator.

Model 5

The Model 5 is Interdata's largest computer. The basic memory of 8k bytes is expandable to 64k bytes, with 64k bytes of directly addressable memory. Word size is 16 bits; data word length is 8, 16, 32 bits (parity option). Memory cycle time is 1.0 microsec of core memory and 400 nsec of read-only memory. The machine has 16 hardware registers (16 bits each) and eight floating-point registers, each 32 bits long. Fifteen general registers may be used for indexing. There are 113 standard instructions, including floating point and privileged instructions. Typical times: 16-bit load halfword, 2.8 microsec; 16-bit add halfword, 3.2 microsec. Typical microinstruction execution time is 400 nsec; 16-bit micro add time is 0.800 microsec. I/O program transfer rate is 30 kbytes/second; firmware I/O is the same. Priority interrupts: up to 256 levels with automatic queuing. There are 16 hardware priorities, expandable in groups of 16. Software includes an assembler, basic OS, real-time OS, and FORTRAN IV.

The unit in a standard cabinet weighs 175 lbs and measures 66 in. high x 22½ in. wide x 30 in. deep. Basic price with 8k is \$15,600.

IRA Systems, Inc. 332 Second Avenue
Waltham, Massachusetts 02154

SP-65

The SP-65 sells for \$14,900 with 4k basic memory expandable to 64k. Word length is 16 bits and cycle time is 1.8 microsec. The computer has 200 hardware instructions, 30 data channels, and 10 basic priority interrupts with 30 maximum. Standard I/O devices are available.

Lockheed Electronics Company

Data Products Division
6201 East Randolph Street
Los Angeles, California 90022

MAC-16

The basic MAC-16 contains six 16-bit registers plus a full adder and is supplied with a 4,096-core memory, expandable to 65k with add-on units. Memory cycle time is 1 microsec, hardware multiply time is 9 microsec, and divide time is 12 microsec. Add time for a full word is 2.0 microsec. Maximum DMA word transfer rate is 800 kHz.

Four nested interrupt levels in the basic machine are expandable to 64 levels, allowing up to 64 programs to be queued for execution in real time.

Standard software includes the Lockheed Electronics Assemble Program (LEAP) symbolic assembler, program loader, debug and editor programs, math library, I/O driver, and diagnostics. The LEAP assembler and MAC-16 simulator are available in program-coded FORTRAN IV. The basic computer with ASR-33 Teletype was originally priced at \$11,950. With 8k words, the price increased to \$15,900.

The MAC-16 has recently been upgraded by the addition of previously optional CPU and memory features. The new standard MAC includes a DMA channel, eight hardware interrupts, memory expansion adaptor, power fail and restart protection, and a 60-cycle real-time clock. The price is now listed at \$11,200 for a CPU with 4k memory and the above features.

MAC Jr.

The MAC Jr. is a new model (first shipped to customers in 1970) that is compatible with the MAC-16. The smaller machine has a 1-microsec cycle time, 16-bit word, and a standard 4k memory expandable to 8k. Add time is 2 microsec and the machine has 72 instructions. Four standard priority interrupts are included, expandable to 16, with automatic store and restore. Interface and controllers are identical for both MAC computers. The price of the MAC Jr. is \$7,900, including CPU with 4k memory and power supply.

MicroSystems
644 East Young Street
Santa Ana, California 92705

Micro 800

The Micro series computers utilize microprogramming techniques. The Micro 800 features a 1.1-microsec full-cycle core memory with a microcommand execution time of 220 nsec. Add time is 1.22 microsec and maximum word transfer rate is 910 kHz (8-bit). Core memory is 4k, expandable to

32,768 bytes (8, 9, or 10 bits) in 4,096-byte increments. Read-only storage (ROS) uses discrete diodes in printed circuit board modules of 256 16-bit words. File registers are a set of 16 general-purpose 8-bit registers. The machine has 15 basic instructions and one address mode. A direct-memory-access (DMA) channel has a maximum transfer rate of 909,000 bytes/second. AP800 is an assembly program for generating the read-only storage diode maps; it is written in FORTRAN IV. A simulator, which runs on the Micro 810, provides for interactive simulation of firmware programs.

The basic system consists of a central processor containing 16 multipurpose registers, 256 words of read-only memory, console, and power supply to function as a microprogrammed controller. Price is \$3,200. The basic cabinet measures 8¾ in. high x 17-3/5 in. wide x 23 in. deep; fully expanded, it weighs 75 lbs.

Micro 810

The Micro 810 is a microprogrammed adaptation of the 800 system with core. The microprogram (firmware) converts the basic 800 machine into a software-programmable macrolevel general-purpose computer. The unit contains 16-bit registers, variable precision operations, and 89 instructions, including multiply and divide with eight address modes. Maximum word transfer rate is 910 kHz (8-bit). Memory cycle time is 1.1 microsec and full-word add time is 10 microsec (16-bit). The basic Micro 810 price of \$6,900 comprises a Micro 800 system with 768 words of read-only store, a 4,096-word x 8-bit core memory, and a Teletype interface. The ASR-33 is \$1,200 for all Micro models.

Micro 812

The Micro 812 can operate as a data concentrator, a preprocessor for time-sharing and information system networks, and as an interactive processing system of its own. Microprogrammed hardware receives serial data from up to 32 low-speed input lines, with multiple formats and mixed baud rates, and assembles the information into characters for entry into a circulating buffer within the processor's core memory. The 105 general-purpose and communications-oriented instructions include ASCII parity generation, cyclic code generation, and character search. As a data communications processor, the 812 accommodates four signaling rates to 300 baud.

The basic Micro 812 consists of the microprogrammed processor, power supply, 4,096 x 8-bit core memory

(1.1-microsec cycle time), power-fail interrupt, automatic restart, and real-time clock at a cost of approximately \$10,850. Up to 16,384 bytes of core memory and five communications and peripheral interface option boards can be added. An expansion chassis accommodates an additional 16k bytes of core memory and eight interface option boards. Supplemental magnetic storage can be supplied up to 256 kbytes.

Mini-Comp, Inc.
2 Mercer Road
Natick, Massachusetts 01760

MC 232 Time-Sharing System

The MC 232 is a small computer system designed purely for time sharing. A basic 16k-word system supposedly can support up to 32 simultaneous users working from a variety of terminals, including Teletypes, typewriters, and CRT displays. The core memory is expandable from 12k to 32k 16-bit words.

The system has a provision for using a terminal as a desk calculator, an adding machine, or as a programmable calculator. Any seven terminals can be in the programming mode simultaneously. So the other 25 would have to be used as simple desk calculators. Terminals may be hard-wired up to 2,000 ft from the machine or used over conventional communication lines.

The Mini-Comp MC 232 operates in both fixed and floating decimal modes with 12-place accuracy. Programs are limited to only 250 instructions with the minimum system. Mini-Tok, a calculator system language, and Basic are available as software.

The basic 16k MC 232 system costs \$45,000 with eight Teletype units.

Modular Computer Systems, Inc.
2709 North Dixie Highway
Fort Lauderdale, Florida 33308

Modcomp-11 and -111

The Modcomp-11 and -111 are recent entries into the minicomputer market. Both machines have the following characteristics: 16-bit word length, basic 4k memory, .80-microsec memory cycle time, 1.6-microsec add time, and 7.2-microsec multiply. Software includes macro and basic assemblers and FORTRAN IV.

The 4k memory of the Modcomp-11 is expandable to 16k. The machine has 164 instructions with direct addressing and six other modes, 0-8 priority interrupts, and 16 DMA channels. Maximum I/O is 400

kbytes/second. Price of the basic unit is \$9,800.

The Modcomp-111 is priced at \$13,500 for the 4k version and is expandable to 32k. The computer has 182 instructions, 0 to 32 priority interrupts, and 16 DMA channels. Maximum I/O is 1,660 kbytes/second.

Monitor Data Corporation
17805 Sky Park Circle
Irvine, California 92664

MD-708

The basic 4k system of the recently introduced MD-708 is priced at \$3,750. The 1k system sells for \$3,250. The minicomputer is an 8-bit, 1.6-microsec general-purpose machine with 1,024 words, expandable to 65k. Add time is 1.6 microsec. Memory is directly addressable up to 4k words; direct memory access is available as an option. Basic repertoire is 117 instructions (101 standard). Number of priority interrupts: 1 to 8. Hardware registers: 8.

Motorola Instrumentation
and Control, Inc.
P.O. Box 5409
Phoenix, Arizona 85010

MDP-1000

Memory cycle time for the MDP-1000 is 2.16 microsec, word length is 8 bits, and the 4k memory is expandable to 16k. Full-word add time is 4.32 microsec. Maximum DMA word transfer rate is 430 kHz. The machine has five programmable hardware registers of 12-bit length, all of which can be used as accumulators. Three of the five are usable as index registers. Number of instructions: 50. Number of priority interrupts: 0 to 64.

A standard feature is the relative-time clock, which, at programmed time intervals, generates an interrupt request. Acknowledgment of the interrupt causes the program to be branched automatically to the portion associated with the real-time request. Software includes a conversational assembly system, monitor package, I/O drivers, and debug.

Basic unit price was listed at approximately \$8,000, without an ASR-33 Teletype. The newest (March 1970) listing, with 4k memory, is \$6,900. The machine has been on the market about 3 years. Dimensions of the 8k enclosure are 7½ x 19 x 21 in. The weight of the 8k unit is 30 lbs.

Multidata, Inc.
7300 Bolsa Avenue
Westminster, California 92683

Multidata Model A

The Multidata minicomputer was first delivered to customers this year. The Model A basic configuration includes 4,096 16-bit words of core memory in tandem with 32,768 words of disk memory, a memory-access controller, a central processor, an input/output bus, and a teletypewriter (ASR-33). The memory-access controller enables the central processor to execute programs approaching 32,768 words in length from a 4,096-word core. A larger core is necessary only if the time-critical portion of a program, which must be resident, will not fit into the basic module. The controller divides core memory into 256-word pages and transfers program segments a page at a time from disk into core. Any program segment may go into any page, which means that continuous program segments may be scattered in core. A memory map (a complement of 20-nsec registers in the controller) keeps track of the page assigned to each program segment.

The core memory of 4,096 words is expandable to 65,536 words. Disk memory of 32,768 words is expandable to 131,072. The system has eight programmable registers, up to 256 nested interrupts, and a basic complement of 125 instructions. Model A software is based on a 32,768-word memory rather than 4,096 words. Software includes a monitor which maintains system programs in core only while they are active, the FORTRAN IV compiler, a two-pass macroassembler, and utility programs. Price of the basic 4k system with Teletype and disk is \$14,995.

Philco-Ford Corporation
Western Development Laboratories
3939 Fabian Way
Palo Alto, California 94303

Models 1216 and 1220-F

The 1216 and 1220-F computers are alike in the following characteristics: 4k-bit minimum memory size, eight priority-interrupt levels, eight direct memory channels, and 121 hardware instructions. The 1216 is expandable to 65k, with 16-bit word size and 3.4-microsec cycle time. The 1220-F has a 20-bit word size and 2.0-microsec cycle time. Both machines use FORTRAN and have a full line of peripherals. Model 1216, however, is no longer being marketed as a stand-alone component due to a reorientation of marketing approach.

Quantel Corporation
3474 Investment Boulevard
Hayward, California 94545

Quantel

The Quantel computer offers 40 instructions, including arithmetic (decimal and binary), logicals, branching, testing, editing, and I/O with indirect addressing. Microcommands may be taken from main memory. Because of the read-only memory technology, a specified instruction complement can be installed in main memory. The machine has 3.5-microsec cycle time, and is field-expandable from 4,096 8-bit words to 8,192 8-bit words in 4,096 modules. Control includes 1-microsec MOS ROM, with 1,024 words standard. The standard unit allows the read-only type of control to originate from main memory; however, no representative timing is available for instructions run in this manner. Single unit price for the basic system is \$6,400.

Raytheon
2700 South Fairview Street
Santa Ana, California 92704

Model 703

With 4k memory and 16-bit word length, the Raytheon Model 703 has a 1.75-microsec cycle time, a 3.50-microsec add time, and a 12.25-microsec multiply. The machine has 73 instructions, with addressing direct and indexed; there are four addressable registers, one hardware index. The basic system has one external interrupt; a maximum of 16 is available with six DMA channels. Maximum I/O rate is 1,150 kbytes/second. With as many as six active devices in the DMA channel, data rates of 571,285 16-bit words/second can be accommodated. Software includes a two-pass assembler, FORTRAN IV, and a simulator. The basic 4k unit is priced at \$12,750. Each additional 4k up to the maximum of 32k is \$6,500. The machine is available for \$29,500 with 16k core memory and an ASR-33. First deliveries of the Model 703 were made 3 years ago. About 300 machines are in use.

Model 706

The Raytheon Model 706 was introduced early in 1969 as a 16-bit 4k computer with a maximum memory size of 32k. Price: \$19,000.

Add time of the 706 is 1.8 microsec and multiply is 6.3 microsec. Full cycle time of 900 nsec permits data acquisition at byte rates up to 2.2 MHz and a full, automatic priority-interrupt response time of 2.7 microsec. The priority-interrupt system

can be expanded to 16 levels. The standard I/O bus is used for programmed transfers at word rates up to 278 kHz. An optional six-channel DMA can be provided for applications involving word rates up to 1.1 MHz. The machine has 73 instructions. Software is the same as that noted for the Model 703. The main frame is 5½ in. high x 19 in. wide x 25.5 in. deep and weighs 155 lbs. An ASR-33 teletypewriter is included in the basic price.

Model 704

Raytheon's 704 minicomputer was introduced in 1969 as a 16-bit 1.5-microsec unit with 4k memory expandable to 16k. In 1970, the company announced an improvement in speed and memory capacity. The 704 is now available with 1.0-microsec cycle time and a 4k memory, expandable to 32k. Add time is 2.0 microsec and multiply is 7.0 microsec. The basic configuration sells for \$9,750 and includes page size of 2,048 words, 74 instructions, word and byte manipulation, a real-time priority interrupt (maximum number of interrupts, 16), direct I/O to CPU, four addressable hardware registers, and one hardware index register. The AID interface provides plug-in modular interface ability. Options include a real-time clock, hardware multiply/divide, and high-speed direct memory access. An ASR-33 is not included in the basic price. The machine is compatible with 703/706 software, providing over 400 programs and subroutines including over 40 combinations of monitors and executives. Weight of the 704 is 75 lbs. The dimensions are 15¼ in. high x 17½ in. wide x 23½ in. deep.

In the spring of 1970 Raytheon announced a 33% cut in all conversion equipment including the 12-bit multiplex A/D converter which, in the 32-channel configuration, was marked down from \$3,640 to \$2,300.

Redcor Corporation
7800 Deering Avenue
Canoga Park, California 91304

RC-70

The Redcor 70 is a modified version of the Decade 70 designed for data acquisition and control. The basic 4k memory is expandable to 32k with 16-bit word length. Memory cycle time is 1.9 microsec, add time is 1.9 microsec, and multiply is 6.2 microsec. The machine has nine hardware registers and 35 basic instructions, four address modes. Number of priority interrupts: 0 to 32; DMA channels: 0 to 4. Maximum transfer rate is

1 MHz. Software includes a one-pass assembler and FORTRAN IV. Price of the stripped down 4k basic system is \$12,900; an ASR-33 is \$1,800. Additional 4k memory is priced at \$6,000.

Redcor Corporation is marketing a larger computer system, the RC-77, which utilizes RC-70 small computers as processing elements within the system. These are under the control of a software system incorporating a real-time and a batch-processing monitor. The concept of incorporating two processors into the system provides complete backup. The RC-77 has a 20k memory, expandable to 65k, and a million-word disk memory at \$111,000.

Rolm Corporation
10300 North Tantau Avenue
Cupertino, California 95014

Rolm-1601

The ROLM is a ruggedized version of the Data General Corporation Nova computer, built to withstand severe environments. A 4,096 16-bit word model with Teletype, data channel, priority interrupt and power-failure protect, and autorestart costs less than \$20,000.

Scientific Control Corporation
1215 West Crosby Road
P.O. Box 96
Carrollton, Texas 75006

Model 4700

The 4700 has a 4k basic memory, 0.92-microsec cycle time, 16-bit word size, 16-bit hardware index register, 16-bit hardware accumulator, and two priority interrupts (console and I/O channel). Number of maximum external interrupts is 256. Add time is 1.9 microsec. DMA word transfer rate is 1.1 MHz. The basic package also includes a multiplexer I/O channel, maximum of 64 devices, and an ASR-33 for about \$20,000. A microprogrammed instruction repertoire provides the instruction set. All software packages except FORTRAN IV and the real-time monitor run in the basic 4k memory configuration. Software packages include a macroassembler, debug packages, I/O executive, basic FORTRAN system, diagnostics, FORTRAN IV, and the real-time monitor.

Memory can be expanded from 4k to 65,536 words, and up to 16 external priority-interrupt levels are available as options. The wide range of system configurations can run as high as \$200,000. The machine is about 2 years told.

Spiras Systems
332 Second Avenue
Waltham, Massachusetts 20154

Spiras 65

The basic Spiras 65 has a 4k-word (16 bits long) core memory, expandable to 65k. The company also offers a read-only memory (ROM) with 512 words in the basic machine (to 1,024 words), which is used for microprogramming with 32-bit word lengths.

Cycle time is 1.8 microsec and add time is 3.6 microsec. The machine has 125 instructions. Hardware includes floating-point arithmetic, direct memory access, multilevel interrupts, and a parity line input/output. Number of CPU I/O channels: 63 devices. The software includes a symbolic macroassembler, FORTRAN IV, IBM 360 simulator, and conversational basic. Average system purchase price has been about \$14,500, although the minimum configuration has been listed at less.

Systems Engineering Laboratories
6901 West Sunrise Boulevard
Ft. Lauderdale, Florida 33304

SEL 810A, 810B, and Systems 82

The SEL 810A and B are 16-bit machines offering 4k words of memory, expandable to 32k. The A model is slower than the B (1.75 microsec as against 0.75 microsec) and has fewer capabilities. The same peripherals and software can be utilized on both machines.

With the 810A, add time for a full word is 3.5 microsec, hardware multiply time is 7 microsec, divide time is 10.5 microsec. Maximum word transfer rate is 572 kHz. The A model features two priority interrupt levels, pre- and postindexing, double-length accumulator, and multilevel indirect addressing in the basic unit, priced at approximately \$18,000 with ASR-33. There are 57 instructions, and addressing is partial direct. With 8k memory, the machine is priced at about \$23,000. Maximum DMA transfer rate is 572 kHz; maximum available number of individually armable priority interrupts is 96. The 810A has a two-pass assembler, a macroassembler capability, and it uses a FORTRAN IV compiler.

The SEL 810B has a second hardware index register and a real-time monitor for foreground and background handling in addition to the features of the 810A. Add time is 1.58 microsec, multiply time is 4.74 microsec, and divide time is 6.32 microsec, including access and indexing. Maximum word transfer rate is

1.33 MHz. Price is about \$30,000 with ASR-33.

Systems 82 is new (late 1970) with 16-bit, 4-16k words of core, and 900-nsec cycle time.

TEC, Inc.
6700 South Washington Avenue
Eden Prairie, Minnesota 55343

Model 520-PCP

The 520-PCP is a 16-bit-word-length computer with a 4k memory, expandable to 16k, selling at \$9,900 for the basic package. Memory cycle time is 1.0 microsec and add time is 2.0 microsec. Maximum I/O is 2,000 kbytes/second, and the machine has 61 instructions with direct addressing. There are 12 priority interrupts with 0 to 10 DMA channels. Software includes a two-pass external assembler. The rack is approximately 56 in. high.

Tempo Computers, Inc.
1550 South State College Boulevard
Anaheim, California 92806

TEMPO-1

For a basic price of \$15,600, the Tempo system includes a 4k memory, 900-nsec cycle time, 14 hardware registers (8 general-purpose), register-to-register operation, four hardware priority interrupts, 14 addressing modes, more than 100 hardware instructions, an ASR-33 Teletype, and software packages, including USA Standard FORTRAN IV and a macroassembler. Word size is 16 bits. Add time is 1.8 microsec, and maximum word transfer rate is 1.33 MHz. The machine is available in a console or in a 60-in. rack with room for 12 or more peripheral controllers.

Options include: memory growth to 65k, parity, up to 25 hardware registers, multiprogram feature, program flags, additional interrupts, and others. The Tempo-1 has been available since 1969.

Texas Instruments, Inc.
12203 Southwest Freeway
Stafford, Texas 77006

TI-960

Using plug-in printed circuit cards, the 960 process-control computer can interface with a wide variety of devices. As many as 4,096 I/O lines can be handled and each line can be addressed in groups of 16 or independently. The machine is expandable to 65k words (16-bit word size) from the minimum 4k of memory capacity. Memory cycle time is 1.0 microsec, and add time is 6 microsec. Instructions: 57. The 960

software package includes a process automation monitor. The 4k version of the 960 is priced beginning at \$14,500.

TI-980

The TI-980 is a general-purpose stored-program digital computer with a 16-bit word, 1-microsec memory cycle time, and 400-nsec memory access time. Add time is 2 microsec; multiply time is 6.5 microsec. Basic memory is 4,096 words expandable to 65,536. The machine has eight 16-bit registers and 85 instructions, including multiply and divide. There are three priority interrupts: internal, DMAP, and I/O bus. Software includes a real-time monitor, a symbolic assembly program implemented for the 980 and IBM System/360 computers, FORTRAN IV, a link editor, and others. Basic price of the unit with 4k memory is \$16,700.

Unicom, Inc.
1275 Bloomfield Avenue
Fairfield, New Jersey 07006

CP-8A and CP-8D

Unicom is marketing a family of new small computers which can operate as peripheral device controllers, data concentrators, or mass storage devices. The smallest is the CP-8A, a machine with 512 8-bit bytes of read-only memory (ROM), four hard-wired scratch-pad registers, and 40 byte-oriented instructions. The CP-8A is priced at \$1,800.

For mass storage, the CP-8D has a magnetic tape cassette system that stores up to one million bytes per cassette. This computer also has 1k bytes of ROM, high-speed search, four priority interrupts, and an index register. Cost: \$4,900.

Read-write memory is 1,024 to 32k bytes; memory cycle time for the CP series is 1.75 microsec. Read-only memory is 512 to 32k bytes; cycle time is 350 nsec. Add time is 3.5 microsec. Addressing is direct and indirect, with 50 instructions.

UniComp, Inc.
18758 Bryant Street
Northridge, California 91324

Comp-16 and Comp-18

Built especially for use in a rugged environment, the Comp-16 includes a 0.9-microsec full memory cycle time, a 2.2-microsec add time, and a core diode memory expandable from the basic 4k to 65k (16 bits). The computer has six memory index registers, simple command structure, parallel I/O bussing, octal readout on the front panel, and DMA interface. Available software includes

Basic, conversational FORTRAN, a relocatable assembler, multiple precision floating-point routines, and special real-time packages. ROM and/or scratch-pad memory is optional. Basic unit, with 4,096 words and DMA, is slightly less than \$10,000.

The Comp-18 costs about \$700 more and has a maximum memory size of 262k. Both machines were first delivered this year.

Varian Data Machines
2722 Michelson Drive
Irvine, California 92664

520/i

The Varian 520/i features a dual environment (a dual set of program counter, index register, and accumulator registers in the central processor) within which the computer can operate interchangeably. When the interrupt occurs, the program can switch to the registers of the second environment without any delay for saving the contents of the registers of the first environment. At the end of the interrupt, the program returns to the undisturbed data.

Memory cycle time is 1.5 microsec, with the memory expandable from 4,096 bytes (8 bits) to 32,768 bytes, direct addressing to 4,096 bytes. Add time for a full word is 4.5 microsec. The machine has seven accumulators, seven hardware registers, and one hardware index register. The maximum number of external interrupts is 11.

The main frame is 8½ in. high, 19 in. wide, and 20 in. deep, with a weight of 48 lbs. Basic cost of the 520/i system equipped with 4,096 bytes of core memory, console, programmed parity line I/O system, four priority interrupts, and power supply is now listed as \$6,000. The machine had been listed at \$7,500.

Recent software innovations have been integrated into a single Master Operating System (MOS), which includes I/O control, system executive, system loader, a two-pass assembler, FORTRAN IV, and maintenance and debugging packages.

With 8k words, the price is \$8,000; with ASR-33 and controller, the total cost is \$9,400. Adding a magnetic tape unit increases the amount by \$8,900. A disk memory costs \$7,200. The 520/i was first delivered in late 1968.

620/f

The Varian 620/i was designed for on-line data systems and has magnetic core memory, word length of 16 or 18 bits, 1.8-microsec full cycle time, 700-nsec access time, and 4,096 words expandable to 32,768. Add and subtract time is

3.6 microsec, multiply is 18.0 microsec, and input/output from memory is 5.4 microsec. The machine has nine hardware registers, over 100 basic commands, six addressing modes, and direct addressing to 2,048 or 32,768. The maximum number of external interrupts is 64. The 620/i was originally priced at \$12,100, and the first machines were delivered about 3 years ago. The basic system with 4,096 16-bit words of storage has been reduced in price to \$9,950.

The Varian 622/i is an 18-bit computer, with 4,096 18-bit words of storage, which has been reduced in price from \$14,100 to \$11,995. The Varian R-620/i is merely a more rugged version of the 620/i and is designed for operation in severe environments.

620/f

The Varian 620/f is the latest of the line and is listed at \$13,000, with 8k words. The 4k version is priced at \$10,005. An ASR-33 and controller increases the price by \$1,800. A complete 620/f system with magnetic tape totals \$23,700; the system price with disk is \$24,700.

The basic memory cycle time of the 620/f is 750 nsec. The machine can be equipped with an optional braided core ROM. Access time to the read-only memory is 300 nsec. Processing of ROM data and programs requires 500 nsec per machine cycle. Word length is 16 bits, with 4,096 words basic expandable to 32,768. Add or subtract time is 1.5 microsec, multiply (optional) is 3.1-7.0 microsec. Input/output times from A or B register is 4.1 microsec; from memory it is 4.9 microsec. There are 148 standard instructions, 10 optional.

The 620/f is compatible with all programs written for earlier models in the Varian 620 line. New programs written specifically for the 620/f take advantage of the computer's expanded instruction set.

Up to 32 peripheral controllers can be connected to the basic I/O bus. These include all standard input/output devices. The machine features three different I/O operations: a basic I/O bus party line transfers data rates up to 30,000 characters/second; a direct memory access mode interlaces program steps with I/O to and from memory to produce data rates up to 276,000 words/second; and a direct port to memory is provided by the priority memory access for high-speed transfer rates up to 1.3 million words/second.

Varisystems Corporation
257 Newton Road
Plainview, New York 11803

PAC-16/2

The basic 4k (expandable to 8k) unit costs \$3,850 and includes 16-bit word length, 1.75-microsec memory cycle time, and 2.0-microsec add time. Maximum I/O is 666 kbytes/second. The machine has 16 instructions with direct addressing and 0 to 2 priority interrupts. An assembler and FORTRAN IV are available as software.

Viatron Computer Systems Corporation
Route 62
Bedford, Massachusetts 01730

Models 2140 and 2150

The Viatron 2140 is a 4k machine with two interrupt levels; the 2150 is a 8,192-word computer with four interrupts. Both have 16-bit word length and one DMA channel. Memory cycle time is 2.0 microsec; add time is 5 microsec. The maximum I/O is 330 kbytes/second. There are 85 instructions. Software includes a two-pass assembler and FORTRAN. Price of the 2140 computer is \$4,752. The 2150 is under \$10,000. Input/output equipment options include teletypewriter, typewriter, card reader, CRT, magnetic tape, and mag tape cassette.

Victor Comptometer Corporation
3900 North Rockwell Street
Chicago, Illinois 60618

820/10

The Victor 820/10 has an average monthly rental cost of \$300 and average purchase price of \$10,000; the basic unit price, however, is \$6,950. Memory cycle time is 2.0 microsec, access time is 5 microsec. Word length is 64 bits, and maximum memory capacity is 6,144 (core + read-only instruction). The machine has four index registers, indirect addressing, but no automatic interrupt. There are four CPU I/O channels.

820/30

The 820/21, 820/25, and 820/30 are all very similar, so the 820/30 will be described here. Word length is 64 bits, access time is 5 microsec, and maximum memory capacity is 16,384. Minimum capacity is 0.064 (core, data) and 1 (+ read only). The 820/30 has five index registers, four CPU I/O channels, editing instructions, indirect addressing, and buffering, but no automatic interrupt. Basic machine cost is approximately \$20,500; the average system purchase cost, however, is about \$29,900, with a \$900 average monthly rental.

Wang Laboratories, Inc.
836 North Street
Tewksbury, Massachusetts 01876

WANG 3300 BASIC Time Sharing System

WANG 3300 BASIC is a compact computer system designed for use as an in-house multiterminal time-sharing system utilizing the Basic language.

Word length is 8 bits with 1.6-microsec memory cycle time (add time, 4.8 microsec) in 4k units up to 65k with 256-byte pages. The machine has a 72-instruction set with 21 memory reference commands, a push-down/pop-up address scheme, and a direct-access channel.

The 3300 is set up with an 8-bit accumulator, an 8-bit accumulator extension, and an 8-bit addressable status register; it is claimed to use every byte of core as an index register.

The system can handle up to 16 users with a mixture of Teletypes and I/O writers. Remote access to the central processor is limited to the Model 3315 Teletype. Model 3310 I/O writers must be located within 75 ft of the central processor.

Minimum system configuration for the BASIC computer and two terminals is 12k of core. This is said to give each user a 1,000-byte partition. Partition size is variable and additional core storage (to 65k) can be added.

Terminals may be standard 33-ASR Teletypes or I/O writers (IBM Selectric typewriters) with magnetic tape cassettes. A low-cost 65,000 disk and 0.5 megabyte disk will be available.

Four available addressing modes include in page, absolute (page 0 on 1), immediate, and indirect. The primary language is Basic. Other software includes an assembler, a source tape editor, a debug package, loader and IOCS modules, and diagnostic routines.

A two-user Teletype system includes a 3300 central processor costing \$4,950, a 3301 memory at \$5,000 (4k memory at \$2,500), 3315 ASR-33 Teletypes, \$3,500 (at \$1,750 each), and a 3316 control for four at \$500. Total price is \$13,950, \$6,975 per station.

For a four-user station the price increases to \$19,950, or \$4,987.50 per station. The \$6,000 added cost for the larger system covers an extra 4k of memory (\$2,500) to bring the configuration to 12k, and two additional Teletypes (\$3,500). There is an additional cost of \$1,500 for BASIC and system setup. But a 12k minimum core is required for BASIC. The four-user I/O Writer

Cassette System is \$24,150 plus the \$1,500 BASIC charge. Sixteen terminals with Teletypes and BASIC is priced at \$55,950; this includes 32k total bytes of memory, 21.5k total bytes left for partition, and 1,344 bytes for each terminal.

Optional typical monthly maintenance contract charges are \$34.65 for the central processor, \$17.50 for 4k modules, \$17.50 for 33-ASR Teletype, and \$14 for cassette drives. The Wang Time-Sharing System is new, 1970.

Westinghouse Electric Company
Hagan Computer Division
Box 868
Pittsburgh, Pennsylvania 15230

P-2000

The Westinghouse P-2000 is a 16-bit-word machine with a minimum capacity of 4k expandable to 65k. Memory cycle time is 0.5/3.0 microsec; add time is 7 microsec. The unit has 32 basic hardware instructions, four direct-memory-access channels, and 128 direct data channels, with 64 buffered. Software includes FORTRAN IV and a two-pass assembler. Although the basic cost is about \$11,000, the system becomes expensive as it is expanded into useful form. And the housing is not small; rack height is about 87 in. Standard I/O devices are available.

Xerox Data Systems
701 South Aviation Boulevard
El Segundo, California 90245

CE-16 and CF-16

The CE-16 and CF-16 computers were designed by Scientific Data Systems engineers before the company became part of Xerox Data Systems. Both machines have 16-bit word lengths and minimum memory capacities of 4k. The CE-16 is expandable to 16k, the CF-16 to 32k. Memory cycle time for the CE model is 8 microsec and add time is 16 microsec; for the CF-16, cycle time is 2.7 microsec and add is 5.3 microsec. Both machines have three priority-interrupt levels with 126 hardware instructions, one direct-memory-access channel, and seven hardware registers. Software includes FORTRAN, loaders, debug, source tape preparation, an assembler, and math library.

The Model CE-16 with 4k sells for approximately \$9,980; the CF-16 is priced at \$7,990. Rack height is approximately 15 in.

Other Small Computers

Phillips Business Systems, Inc. (100 East 42nd Street, New York, New York 10017) recently began making deliveries on a machine which is presently business-oriented, the P-350 computer, priced at \$8,450 for 3.2k basic memory, expandable to 19.2k.

The Friden Division of Singer Company (2350 Washington Avenue, San Leandro, California 94577) has entered the market with System Ten, a 6-bit 10k-expandable-to-110k computer with hard-wired time sharing, priced at \$15,900.

The Electronic Engineering Company of California (P.O. Box 58, Santa Ana, California 92702) markets a real-time engineering EECO-1600 computer with 16-bit word size, 4k memory expandable to 32k, 2.6-microsec cycle time, numerous hardware registers, and 16 priority-interrupt levels. Basic price: \$7,600.

Computer Signal Processors, Inc. (209 Middlesex Turnpike, Burlington, Massachusetts 01803) recently introduced the CSP-30 computer with a 200-nsec add time and 1-microsec multiply. The machine operates at 10 MHz to perform continuous real-time fast Fourier transforms at sampling rates up to about 45 kHz.

The Wilkinson Computer Sciences 881 (Box 350, Sweetwater Avenue, Bedford, Massachusetts 01730) is a 16-bit machine with 2k memory expandable to 32k, priced at \$7,500. Cycle time is 2.0 microsec.

REFERENCES

- HABER, R. N. An on-line computer in a visual perception laboratory. *Behavior Research Methods & Instrumentation*, 1968, 1, 86-93.
- HUESMANN, L. R. Controlling experiments with

a general-purpose time-sharing system. *Behavior Research Methods & Instrumentation*, 1969, 1, 276-280.

MAYZNER, M. S. The research potential of a computer-based cathode-ray tube display system. *Behavior Research Methods & Instrumentation*, 1968, 1, 41-44.

MOISE, S. L., Jr., & JARRARD, L. E. A computer-controlled system for training and testing primates. *Behavior Research Methods & Instrumentation*, 1969, 1, 234-236.

OLLIVIER, R. T. A technique for selecting small computers. *Datamation*, 1970 (January), 16, 141-145.

RESTLE, F., & BROWN, T. V. A computer running several psychological laboratories. *Behavior Research Methods & Instrumentation*, 1969, 1, 312-317.

STADLER, S. J. On the varieties of computer experience. *Behavior Research Methods & Instrumentation*, 1969, 1, 267-269.

UTTAL, W. R. *Real time computers: Technique and applications in the psychological sciences*. New York: Harper & Row, 1968.

NOTE

1. Noted by N. S. Zimbel of Arthur D. Little, Inc.