All About Minicomputers

Small, low-cost computers with surprisingly high speeds are proliferating as a result of recent advances in semiconductor and magnetic technologies and mass production techniques. This report describes the characteristics, applications, features, and drawbacks of the current minicomputers. Comparision charts summarize the capabilities of 93 computers from 43 manufacturers.

Minicomputers constitute one of the most widely discussed and written-about subjects in the EDP world today. The steadily decreasing costs and increasing capabilities of these compact, versatile computers are leading nearly every wide-awake businessman and scientist to wonder whether a minicomputer might represent the key to solving some or all of his information processing problems.

But what, exactly, is a minicomputer? Where are they being used? What are the significant features and drawbacks of these machines? How can you tell whether a minicomputer will fit into your own data processing plans? And, if so, which if the many available models represents the best overall choice for you? This report is designed to answer these questions and bring you up to date on the rapidly advancing state of the art in minicomputers. The current offerings of 43 manufacturers are summarized in the accompanying minicomputer comparison charts.

WHAT MAKES A MINI A MINI?

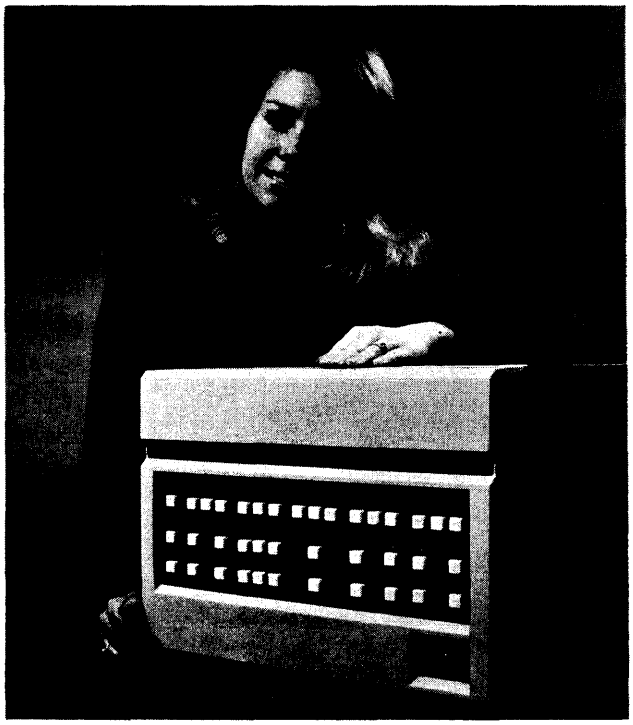
There is some disagreement within the industry as to just what constitutes a minicomputer. Some insiders reserve the minicomputer designation for machines whose mainframes sell for less than $20,000 (or some other arbitrary figure), and—in keeping with the current fashion terminology—use "midicomputer" for the machines that range from $20,000 on up to about $50,000 in purchase price.

Throughout this report, we'll simplify the picture by using the single term "minicomputers" for the whole class of stored-program digital computers which are suitable for general-purpose applications and are priced below $50,000. Excluded from this survey are the general-purpose data processing systems which are described in detailed reports in the Computer section of DATAPRO 70, as well as the electronic accounting machines which are described in our Feature Report 70F-420-01, *All About Small Accounting Computers*.

Although the currently available minicomputers exhibit a wide variety of characteristics and capabilities, there are enough similarities and common traits to make it possible to define a "typical minicomputer" whose characteristics are reasonably representative of most of the machines on the market today.

The typical minicomputer is a parallel, binary processor with a 16-bit word length (though 8-bit machines are also appearing in ever-expanding numbers). It uses integrated circuits and is housed in a compact cabinet suitable for either tabletop use or mounting in a standard 19-inch rack. It weighs less than 50 pounds, consumes less than 500 watts of standard 115-volt electric power, and requires no special air conditioning. It offers from 4,096 to 32,768 words of magnetic core storage with a cycle time of 0.8 to 1.5 microseconds. Parity checking and storage protection are available as extra-cost options.

Today's typical minicomputer uses a one-address instruction format and has two accumulators, a single index register, and a multi-level indirect addressing facility. The add time for 16-bit operands is 1 to 3 microseconds. Hardware multiply/divide instructions are optional, as are power-failure protection and a real-time clock or timer. Floating-point arithmetic requires the use of software subroutines.



The Hewlett-Packard 2100A, introduced at the 1971 SJCC, typifies the current state of the art in minicomputer technology while maintaining full compatibility with earlier Hewlett-Packard models.

Input/output operations in the typical minicomputer are facilitated by an optional direct memory access (DMA) channel, which accommodates I/O data rates of up to about 1,000,000 words per second. The typical complement of standard peripheral equipment consists of a disk storage unit, magnetic tape drive, card reader, paper tape reader and punch, line printer, and an assortment of interfaces for communication and control applications.

Software support for today's typical minicomputer is limited to a symbolic assembler, a Basic FORTRAN compiler, a simple batch-mode operating system or real-time monitor, and a modest assortment of utility routines. And the purchase price of the basic system, including 4,096 words of core storage and a Teletype Model 33 ASR unit, is around $10,000. By all previous standards of value in the computer field, it's a truly impressive little package of computing power for the price.

THE MINICOMPUTER INDUSTRY

The current minicomputer market volume in the U.S. is estimated to be about $300 million a year. (Precise figures are nearly impossible to obtain because of the widespread differences of opinion as to what constitutes a minicomputer.) Over 20,000 minicomputers are already in use around the world, with the great majority in the United States. International Data Corporation estimates that over 11,000 minicomputers were shipped worldwide during 1970 alone, and looks for this figure to increase to 16,500 in 1971. Even so, minicomputers still represent only a small slice of the $12 billion total U.S. market for computer-related products and services – but the minicomputer segment is currently the fastest-growing of all, with estimates of the annual growth rate ranging from 30 to 50 percent. Thus, by 1975 U.S. minicomputer shipments should top $700 million a year, and may well reach the billion-dollar mark.

Digital Equipment Corporation, the company that started the minicomputer boom in the mid-sixties with its highly successful PDP-8 line, is still the undisputed king of the minicomputer field. DEC has installed more than 10,000 computers to date and still commands roughly a 50 percent share of the minicomputer market. DEC's profits have dwindled in recent months as a result of the economic slowdown and increasing competition, but the company is fighting back by dramatically expanding both its product line and its sales and service staffs.

Rounding out the "big five" among minicomputer builders are Data General, Hewlett-Packard, Honeywell, and Varian. Each of these companies has already delivered more than 1000 minicomputers – and Data General managed the unprecedented feat of delivering its 1000th computer just two years after shipping its first computer, the Nova, in February 1969.

In the second echelon of minicomputer makers are aggressive, innovative young companies such as Computer Automation, General Automation, Interdata, and Microdata. Minicomputers are also being built by divisions of large, well-established companies such as Bendix, General Electric, Motorola, Raytheon, and Texas Instruments. And then there are dozens of comparatively small, unproven companies whose survival will depend upon their ability to back up their imaginative hardware ideas with effective marketing, production, software, and customer support.

In all, approximately 50 U.S. companies are now building minicomputers. The current offerings of 43 of these manufacturers are summarized in the accompanying comparison charts.

The difficult economic climate of the past year inevitably led to a shakeout within the minicomputer field. Numerous companies dropped out of the race, while others strengthened their positions through mergers. Atron Corporation became a wholly owned subsidiary of Mohawk Data Sciences; Omnitec Corporation acquired BIT, Inc.; Monitor Data Corporation was acquired by Microdata, another minicomputer builder; Tempo Computers became a part of GTE Information Systems; and Harris-Intertype is about to obtain control of Datacraft Corporation.

But perhaps the most significant development within the minicomputer industry during the past year was IBM's long-awaited entry into the field. The IBM System/7, announced in October 1970, is a fast 16-bit machine that features a semiconductor main memory. Although the System/7 has the hardware capabilities of typical general-purpose minicomputers, IBM is currently marketing it only for "sensor-based" applications in data acquisition, process control, and laboratory and plant automation. The System/7's price is rather high by current minicomputer standards, but computer buyers have long been accustomed to paying more for the privilege of dealing with IBM. Thus, for the first time, IBM – backed by its vast marketing and technical resources – will be slugging it out in direct competition with DEC and all the other minicomputer builders. It should be interesting to watch.

MINICOMPUTER TRENDS

The aggressive competition for the minicomputer buyer's dollar continued to drive prices downward during the past year. DEC, Data General, Hewlett-Packard, Varian, and Computer Automation all introduced new minicomputers which are fully compatible with their earlier models and feature substantially lower price-tags. Many other minicomputer builders, including General Automation, General Electric, Honeywell, Interdata, Raytheon, and Texas Instruments, took an even more direct approach by slashing the prices of their current models. As this report

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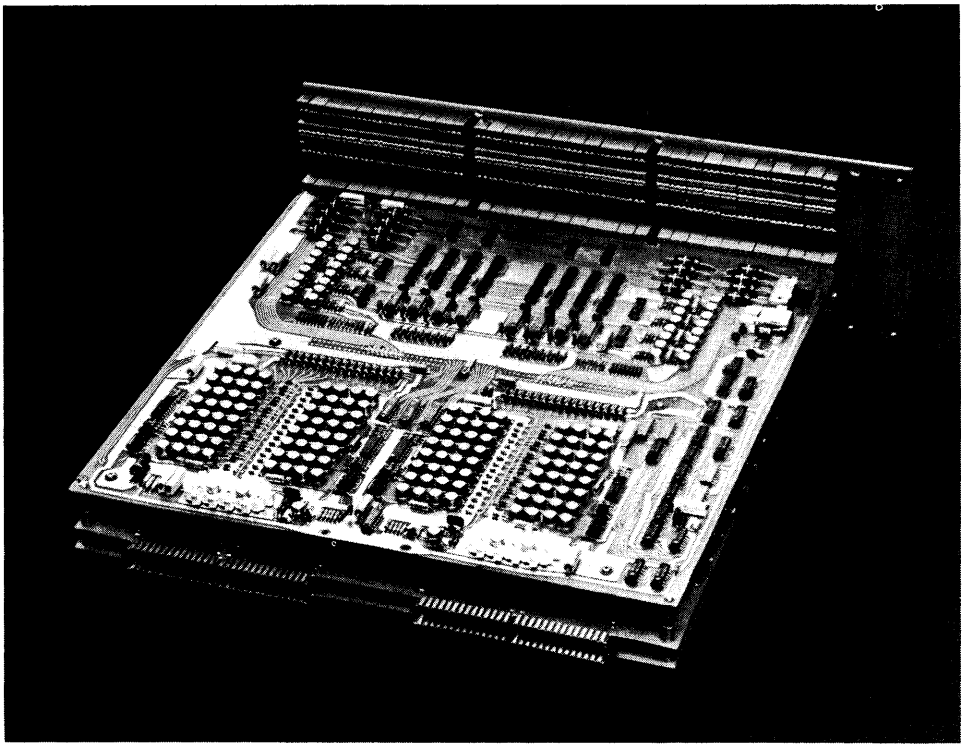

Computer Automation's Naked-Mini is a fully operational 8-bit or 16-bit computer, stripped of power supply, console, and chassis in order to minimize its cost for OEM applications. The 8-bit model with 4K words of core storage currently sells for just $1700 in quantities of 200 or more.

went to press, there was no indication that the industry-wide price war has ended. Thus, the careful minicomputer shopper will almost certainly continue to get steadily increasing computer power per dollar.

Another result of the highly competitive market, particularly within the OEM (original equipment manufacturers) segment, was the recent announcement of "stripped-down" minicomputers from Computer Automation, DEC, and SYS Computer Corporation – with others sure to follow.

Computer Automation's Naked-Mini 8 and 16 are low-cost OEM versions of the firm's general-purpose Alpha-8 and Alpha-16 minicomputers, respectively. The Naked-Minis are supplied without chassis, power supply, or console, and are designed to be "buried" within and powered by equipment produced and sold by other companies. They are offered in minimum quantities of 10 units, at a price (including 4K words of 1.6-microsecond core memory) of only $1,975 for the 8-bit model and $2,500 for the 16-bit model.

DEC's PDP-16 and the SYS 1000 microprocessor are custom-designed to each buyer's specifications through the use of specialized computer programs. Thus, DEC and SYS can produce programmed controllers that give each buyer exactly the hardware he needs to handle his particular application, without forcing him to pay for components he may not need. The PDP-16 can be built with a word length of 8, 12, or 16 bits, features add times in the 400 to 500 nanosecond range, and offers several types of read-only or read/write memory – or no memory at all. The minimum PDP-16 order is 10 units, and prices range from about $800 to $3,000, depending upon complexity and volume.

The long-anticipated semiconductor memories made their initial appearance in commercial minicomputers during the past year. Minicomputer builders have shown an understandable reluctance to turn away from the traditional (and highly reliable) core memories and plunge into the extremely promising but as yet unproven semiconductor memory technology. The turning point came in October 1970, when IBM gave its full endorsement to semiconductor memories by employing them in both its medium-scale System/370 Model 145 computer and its System/7 minicomputer. It now appears to be only a matter of time before the continuing demand for higher performance at lower cost will cause most minicomputer builders to make the switch from core to semiconductor memories. And the industry-wide trend toward the use of LSI (large-scale integration) technology for logic circuits is certain to continue for the same reasons.

Peripheral equipment designed specifically for minicomputers continued to proliferate during the past year. DEC reinforced its position as the industry leader by adding a wide variety of new terminals, disk drives, tape units, and other devices to its growing product line, and the other major minicomputer builders followed suit. In

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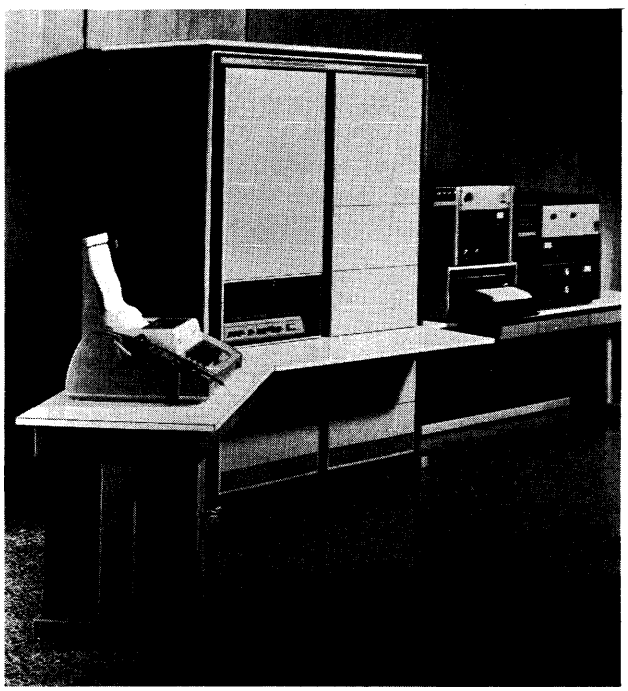

This Varian Chromatography Data System employs a Varian 620/i minicomputer (left center) to automate the acquisition and processing of data from various types of analytical laboratory instruments.

addition, dozens of small independent firms announced disks, drums, cassette tape units, card readers, CRT displays, and many other products whose capabilities and prices are oriented toward the minicomputer buyer's needs and budget. Here again, the careful buyer can get more for his money than ever before.

The developers of proprietary software and systems are increasingly designing their wares around minicomputers. As a result, minicomputer-based systems are now available to handle a wide range of specialized applications in both the scientific and business fields. DEC, for example, currently offers computer-based systems to handle real-time data acquisition, message switching, line concentration, signal averaging, typesetting, chromatography, numerical control, pulse-height analysis, clinical laboratory analysis, graphic displays, vocational training, accounting for office-products distributors, etc. Other minicomputer builders and independent software firms offer other "packaged" systems designed to handle these applications and many more.

Among the most popular minicomputer-based systems are the in-house time-sharing systems. Hewlett-Packard has long been the leader in this area, but now DEC, Data General, Wang Laboratories, and other suppliers are also offering economical systems designed to distribute the problem-solving capabilities of a minicomputer among a number of simultaneous users seated at individual teletypewriter or CRT terminals. Many companies are discovering that these in-house time-sharing systems can satisy their computational needs at a substantially lower cost than the commercial time-sharing services.

MINICOMPUTER APPLICATIONS

Most of the currently installed minicomputers are being used in industrial control and laboratory instrumentation. These are the areas where it all began. The minicomputer boom started when it became apparent that the impressive recent advances in semiconductor and magnetic technologies had made it possible to construct general-purpose computers at a lower cost than the single-purpose, hard-wired controllers which were formerly used in these specialized applications. The added flexibility of stored-program computer control was a welcome bonus that helped to ensure the rapid acceptance of the minicomputers.

During the past five years, the capabilities of the minicomputers have been steadily increasing, while their costs have been decreasing in equally rapid fashion. The proliferation of these small, economical, and surprisingly fast computers has led to an ever-widening range of applications for them.

Among the largest current markets for minicomputers are industrial control, research, data communications, and education. Specific applications in which minicomputers are already being widely and successfully used include:

- Process control
- Numerical control of machine tools
- Direct control of machines and production lines
- Automated testing and inspection
- Telemetry
- Data acquisition and logging
- Control and analysis of laboratory experiments
- Analysis and interpretation of medical tests
- Traffic control
- Shipboard navigation control
- Message switching
- Communications controllers for larger computers
- Communications line concentrators

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- Programmable communications terminals
- Peripheral controllers for larger computers
- Control of multistation key-to-tape/disk systems
- Display control
- Computer-aided design
- Typesetting and photocomposition
- Computer-assisted instruction
- Engineering and scientific computations
- Time-sharing computational services
- Business data processing

MINICOMPUTERS FOR THE BUSINESSMAN

Conventional business data processing applications, which represent by far the largest potential market for the minicomputers, have thus far proved to be an elusive target. Theoretically, the minicomputer's capabilities and economy should make it an ideal solution to the information processing needs of nearly every small business. In retail stores of all kinds, a minicomputer could handle the bookkeeping, inventory control, labeling, billing, payroll, and a variety of other useful functions—and it could do all this at roughly the cost of a single clerk. Yet minicomputers have barely begun to make a significant impact in the business world.

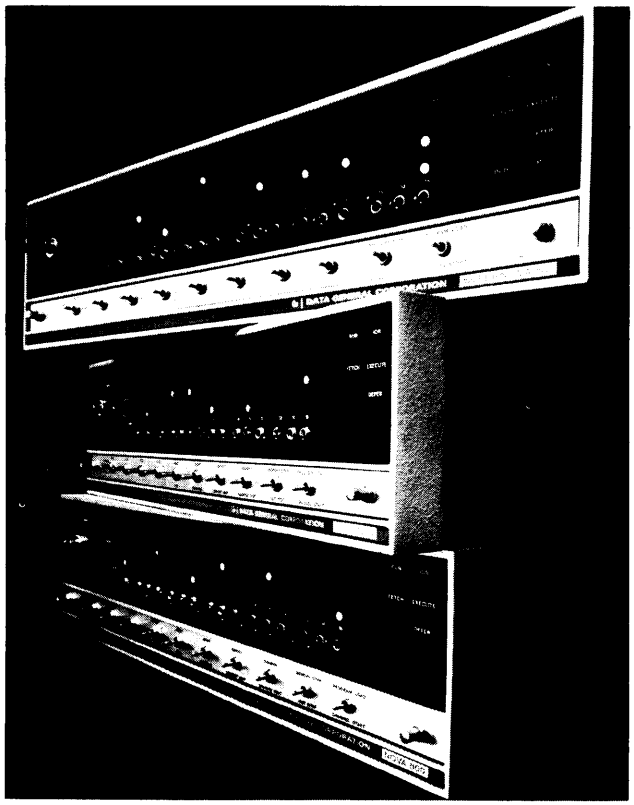
The problem, of course, is software. Despite claims to the contrary, programming for the minicomputers is no easier than programming for the larger, general-purpose data processing systems. In fact, the minicomputers' short word lengths, limited storage capacities, and lack of sophisticated software aids tend to make the programmer's job even more difficult. As a result, it is common in minicomputer applications for programming costs to far exceed the cost of the hardware itself.

Even if small businessmen were willing to pay the price of the software required to solve their problems, they would find it hard to get from most of the current minicomputer builders. In general, the manufacturers have oriented their marketing efforts toward the comparatively sophisticated engineering and scientific markets, which are equipped to design the systems and write the programs required to accomplish their goals with a minimum of assistance from the manufacturer. In fact, the great majority of minicomputers are still being sold in quantity, on an OEM (original equipment manufacturer) basis, to other companies which incorporate them into a wide variety of devices and systems for various end-user markets. It's no secret that mass production is the key to success for the minicomputer builders, and OEM sales represent the quickest route to maximum volume with a minimal investment in marketing, software development, and customer support. As a result, the businessman who is interested in buying a single minicomputer won't receive much encouragement or aid from many of the manufacturers.

But help for the poor businessman is definitely on the way, in the form of three significant recent trends.

First, several manufacturers have introduced minicomputer systems designed primarily for business data processing applications. The Atron 501 Datamanager, the Cascade 80, and the Clary Datacomp 404 are all capable of performing arithmetic on variable-length operands and feature business-oriented software. It is likely that more of the minicomputer builders will recognize the great potential of the business data processing market and develop systems with a similar design orientation.

Second, the larger minicomputer builders are directing an increasing proportion of their marketing efforts toward the end-user market. It has become clear that their potential for growth and profitability will be severely limited



The three latest minicomputer models from fast-growing Data General Corporation are the Supernova SC (top), the Nova 1200 (middle), and the Nova 800 (bottom). The Supernova SC features an optional all-semiconductor memory with a 300-nanosecond cycle time.

until they can supply the peripheral equipment, software, and service required to support individual user installations in the same manner as IBM and the other major computer makers. Therefore, DEC, Varian, Hewlett-Packard, Data General, and other manufacturers are strengthening their support staffs and developing peripheral devices and software facilities that equip their computers to serve in a variety of specific applications, including business-oriented ones.

Third, the availability of the minicomputers had led to the emergence of a new group of computer entrepreneurs: "middlemen" who use the minicomputers as the central components of integrated hardware/software systems designed to handle specific applications. Dozens of companies have entered this business within the past three years; most of them, unfortunately, are quite small, young, and unproven. They offer packaged systems to handle a wide range of applications, such as general accounting, billing, order processing, inventory control, payroll, text editing, hospital data processing, credit authorization, stock brokerage accounting, and many more. These middlemen are accelerating the minicomputer boom by penetrating new markets and making it easier for unsophisticated users to get started in EDP.

These trends, together with the steadily decreasing price-tags of the minicomputers themselves, make it clear that the minicomputers will soon be making their presence felt in the business data processing world. At the same time, enough problems remain to be solved to make it safe to predict that the widely-discussed day when there will be a computer in every store—and perhaps in every household as well—is still quite a few years away.

MINICOMPUTER CHARACTERISTICS

The key functional characteristics of 93 commercially available minicomputers from 43 manufacturers are presented in the accompanying comparison charts. All information in the charts was supplied and/or verified by the 43 manufacturers during April and May of 1971; their close cooperation with the Datapro Research staff in the preparation of these charts is greatly appreciated.

The chart entries and their significance to potential minicomputer users are explained in the following paragraphs, together with some useful guidelines for selecting the most suitable minicomputer for your application.

Data Formats

Probably the single most important distinguishing characteristic of a minicomputer is its *word length;* i.e., the number of bits (binary digits) that can be stored in or retrieved from main storage during a single cycle. In general, the longer the word length, the greater the efficiency and accuracy of a computer's internal operations—and the higher its price tag. Most of the minicomputers currently on the market have a 16-bit word length; this size neatly accommodates two 8-bit characters and has been shown to yield an attractive balance between economy and performance for many applications. Other widely used models have word lengths of 12, 18, or 24 bits, and 8-bit machines are now proliferating rapidly. The 8-bit minicomputers are suitable for many functions where low cost is more important then high precision or sophisticated instruction repertoires—and they can be particularly effective when extensive manipulation of 8-bit bytes must be performed.

For most minicomputers, the *fixed-point operand length* is the same as the word length. Some machines, however, have "extended precision" facilities which enable them to handle arithmetic operands two or more words in length. For many applications, extended precision arithmetic is a valuable feature that helps to overcome the limitations upon number range and accuracy which are otherwise imposed by the short word lengths used in most minicomputers. Some of the 8-bit minicomputers are really byte-oriented machines, designed for efficient processing of variable-length operands composed of one or more 8-bit bytes.

Instruction length is one word in most computers, but some are capable of using instructions which are two or more words in length. In most two-word instruction formats, the first word defines the operation to be performed and the second word contains the address of the required operand. The use of two-word instructions greatly increases the number of storage locations that can be directly addressed. This in turn simplifies programming—but the simplification is usually gained at the expense of two words of storage space to hold each instruction and two memory cycles for each instruction retrieved for processing.

Main Storage

The storage type used in the great majority of the current minicomputers is magnetic cores. Though semiconductor memories began to appear in commercially available minicomputers late in 1970, most minicomputer designers are continuing to choose core storage because of its demonstrated ability to satisfy all reasonable requirements for performance, reliability, and economy. It is likely, however, that the demand for higher performance at lower cost, together with forthcoming improvements in semiconductor technology, will accelerate the trend toward the use of semiconductor memories.

In addition to, or in place of, their standard, alterable main storage units, some minicomputers use read-only memories for one of two functions: to provide fast-access, indestructible storage for vital programs, or to hold the microprograms which define the instruction repertoires of

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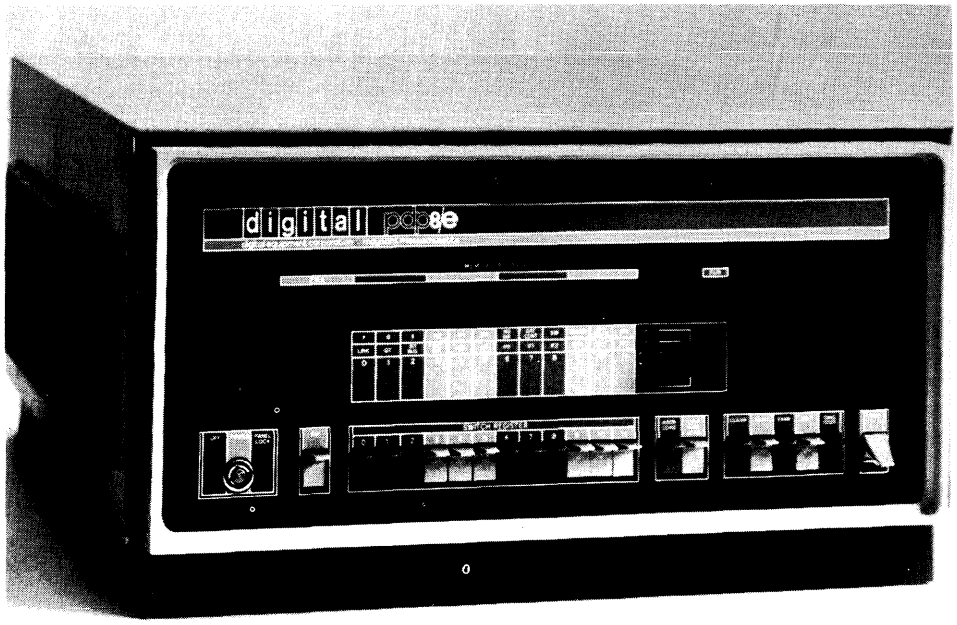

The PDP-8/E is the latest in a long and incomparably popular line of 12-bit minicomputers from Digital Equipment Corporation. It features an improved internal bus system called "Omnibus." DEC also offers a lower-priced, modular version called the PDP-8/OEM, which offers combinations of read-only and read/write memory and is priced as low as $2,800 in lots of 100.

some machines. Where read-only memories are used, their characteristics and functions are described in the "Comments" entries at the bottom of the comparison charts.

The *cycle time* for a storage device is the minimum time interval that must elapse between the starts of two successive accesses to any one storage location. Main storage cycle times for the minicomputers shown in our charts span the range from approximately 0.3 to 8 microseconds. Though cycle time ranks with word length as one of the most significant individual indicators of a computer's performance potential, it is definitely *not* safe to assume that the computer with the fastest cycle time will be the best overall performer in a particular application. Other parameters that have an important effect on a minicomputer's performance include the flexibility and power of its instruction repertoire, the number of storage cycles it requires to execute each instruction, its input/output capabilities, etc.

Our comparison charts show the amount of main storage available for each computer in terms of the *minimum capacity* and *maximum capacity,* expressed in words. In the great majority of cases, storage is available in all the usual binary increments of capacity. Thus, if a computer has minimum and maximum storage capacities of 4,096 and 32,768 words, respectively, it's safe to assume that capacities of 8,192 and 16,384 words are also available.

The indicated price differentials between similar computers equipped with 4K and 8K words of storage make it clear that core storage is one of the costliest elements of the current minicomputers. Therefore, it's important to choose the right storage capacity: enough to hold your largest program and all associated subroutines and data, but not too much more than that. It's also wise to make sure that your computer's main storage capacity can be expanded if necessary, preferably by simply plugging in an additional storage module.

Parity checking is a standard feature of some minicomputers and an extra-cost option for others. In still other cases, the manufacturers maintain—with some justification—that the reliability of modern magnetic core memories is so high that parity checking is an unnecessary luxury unless absolute accuracy is a must. Parity checking requires the addition of one more bit to each main storage location. This added bit is set to the appropriate value (0 or 1) whenever a word is written into main storage and checked each time the word is read out; the technique permits detection of most, though not all, read and write errors.

Storage protection is a feature that prevents unauthorized writing in certain areas of main storage. The protection can be accomplished by hardware means, software means, or a combination of both. Though unnecessary in simple dedicated systems, an effective storage protection scheme is an essential element in multiprogramming and time-sharing environments.

Central Processor

Although there are many variations in their internal architecture, the great majority of currently available minicomputers use parallel, binary processors with single-address instructions and fixed word lengths of 8, 12, 16, 18, or 24 bits.

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In single-address computers, *the number of accumulators* can have a significant effect upon internal flexibility and processing power. An accumulator is a register that holds one operand and permits various arithmetic and logical operations to be performed upon it (e.g., a second operand might be added to the operand contained in the accumulator, with the sum replacing the first operand in the accumulator). In computers with multiple accumulators, instructions involving operands in two of the accumulators can often be executed more rapidly than instructions which require the retrieval of an operand from main storage.

Indexing is an important form of address modification in which the contents of a special register called an index register are added to the machine address contained in an instruction prior to its execution. An effective indexing scheme is particularly desirable in minicomputers, since it can help to compensate for their limited direct addressing capabilities. The *number of index registers* serves as an indication of a computer's programming flexibility and efficiency. Prospective buyers should note, however, that there are wide variations in the indexing schemes used in current minicomputers. It is important to determine whether the index registers are separate hardware registers or simply reserved locations in main storage, whether special instructions are provided for loading, incrementing, and testing the index registers, and how much additional time (if any) indexing adds to the instruction execution times. It should also be noted that many of the current computers use "general registers" which can serve as either accumulators or index registers.

The *number of directly addressable words* of main storage is an important characteristic that may require some explanation if you're investigating minicomputers for the first time. The problem is that the short word lengths impose serious limitations upon the number of bits that can be assigned to hold the address part of each instruction. A typical 16-bit minicomputer instruction might consist of three parts: operation code, address mode field, and the address itself. If 6 bits are assigned to hold the operation code (permitting up to 64 distinct operations) and 2 bits are used to designate the addressing mode (permitting specification of indexing and/or indirect addressing), then only 8 bits are left to hold the address field. Since these 8 bits permit direct addressing of only 256 distinct memory locations, it is clear that other means will need to be employed to access most regions of the computer's main storage. The most common solutions to the problem are the use of multi-word instructions, indexing, and/or indirect addressing.

Indirect addressing is an address modification technique in which the address part of an instruction specifies a storage location that contains another address rather than the desired operand itself. This second address may in turn be either the address of the desired operand or another indirect address; the latter case is called multi-level indirect addressing. Indirect addressing permits the use of an entire word to hold an operand address. It can also simplify programming and speed up execution times in some applications by making it possible to change the effective addresses of numerous instructions by altering the indirect address in a single storage location. Each level of indirect addressing, however, usually requires one additional storage cycle of execution time.

Although it is undeniably dangerous to make inferences about a computer's overall performance capability on the basis of instruction execution times, our charts show the basic *add time* to give a first-level indication of fixed-point arithmetic speeds. In general, the indicated add times are the times required to retrieve a one-word operand from main storage and add it to another operand already contained in an accumulator, with no indexing or indirect addressing. Comparisons based on add times can easily be misleading, however, because of differences in word lengths and instruction repertoires.

Hardware multiply/divide facilities are standard in some minicomputers and optional in others. When no hardware facilities are present, multiplication and division must be performed by means of programmed subroutines at a significant reduction in execution speeds. Many minicomputer applications, however, impose little or no need for multiplication or division operations, and in these cases the hardware facilities would be superfluous.

Hardware floating point facilities are quite rare in the currently available minicomputers, despite the fact that floating point arithmetic is highly desirable, if not essential, in many scientific applications. Where available, these facilities can dramatically reduce the execution times for certain programs by eliminating the need for time-consuming floating point subroutines.

Hardware byte manipulation is the ability to conveniently process information expressed in the 8-bit character codes which are rapidly becoming an industry standard. Obviously, most of the 8-bit minicomputers are effective byte manipulators, and many of the 16-bit machines offer special instructions that permit either half of a word to be addressed and processed as an 8-bit byte.

Immediate (literal) instructions in some minicomputers permit savings in both storage requirements and execution times. An immediate instruction uses its address field to hold the operand itself rather than the address of the operand, thereby saving both the storage space that would normally be required to hold the operand and the time required to access it.

Power failure protection is a vital feature in many real-time applications. This facility provides for a safe

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shut-down of the computer, without destruction of the contents of its main storage or hardware registers, whenever a power failure occurs. Power failure protection is often combined with an automatic restart capability that enables the computer to get back into operation without human intervention when the power supply is restored.

A *real-time clock or timer* is another essential element in most "time-conscious" systems. A real-time clock enables the program to determine the time of day, while an interval timer usually indicates the amount of time that has elapsed since the occurrence of some significant event. In many cases the timer can trigger an interrupt signal when a predetermined interval of time has elapsed.

Input/Output Control

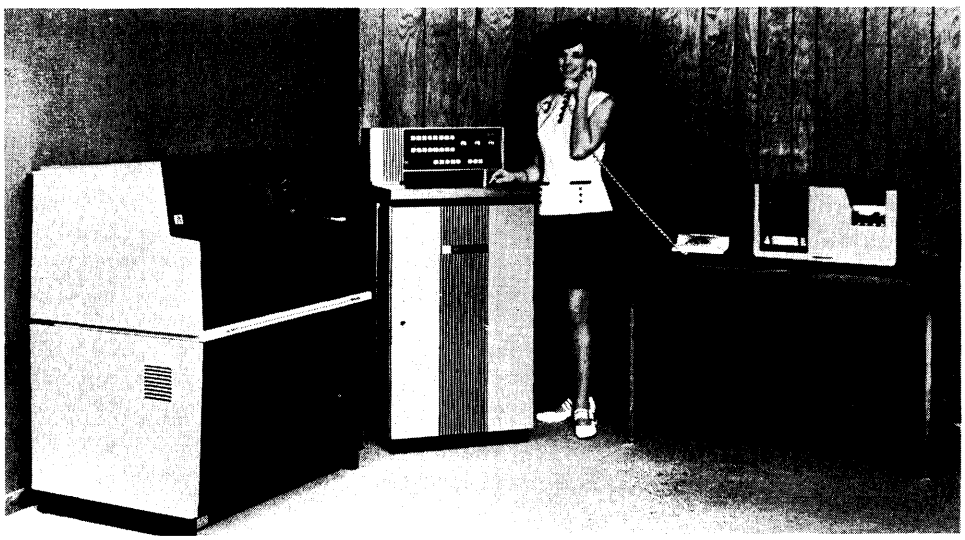
I/O word size is the "width" of a computer's input/output data channels in terms of the number of bits of data which are transferred in parallel. In most cases this is the same as the machine's basic word length. I/O word size can have an important effect upon the cost and complexity of interfacing non-standard peripheral devices to a minicomputer. The machines with an 8-bit I/O word size can interface conveniently with most of the input and output devices on the market today.

A *direct memory access channel* (DMA) permits direct transfers of I/O data between main storage and a peripheral controller. When a DMA channel is used, the I/O data bypasses the computer's main hardware registers, and the I/O operation proceeds independently of program control once it has been initiated by the program. In minicomputers that lack a DMA channel, I/O data transfers are generally carried out under direct program control, with each word being transferred by way of the processor's registers. Generally speaking, the DMA channel has two significant advantages over program-controlled I/O: it can accommodate higher I/O data rates, and it causes far less interference with internal processing operations. Regardless of the type of I/O control they employ, most minicomputers can accommodate multiple I/O devices and include appropriate facilities for addressing the desired device.

Maximum I/O data rate, expressed in words per second, is a measure of each computer's potential ability to transfer data to and from peripheral devices or other external sources. In machines equipped with a DMA channel, the maximum I/O rate frequently equals the cycling rate of the main storage unit. These maximum I/O rates, however, can be quite deceptive in the case of minicomputers. In general, their storage capacities are limited, their capabilities for simultaneous input/output operations are restricted, and fairly complex programming is associated with I/O operations. For all these reasons, I/O data rates approaching the indicated maximum rates can usually be handled only in short bursts, if at all.

An effective *program interrupt* facility is a requirement for virtually all applications of a real-time nature. An interrupt is a signal that causes a temporary suspension of normal program execution so that the particular condition that caused the interrupt can be dealt with. Interrupts fall into two basic categories: internal and external. Internal interrupts are usually triggered by conditions such as a memory parity error, an illegal instruction, or a power failure. External interrupts usually indicate that a particular peripheral device requires attention or has completed an I/O operation. An interrupt usually results in automatic storage of the current contents of the instruction counter, followed by a transfer of control to a software routine that determines the cause of the interrupt and initiates the appropriate action.

The *number of external interrupt levels* provides a reasonable indication of the power of a minicomputer's



This Atron Terminal System, built around the 8-bit 501 Datamanager (center) blends local business data processing power with data communications capabilities. The system includes a 300-lpm chain printer, a 400-cpm card reader, and a communications interface.

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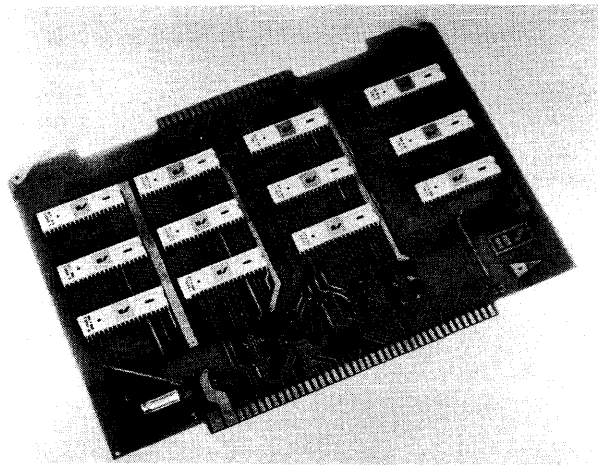

The much-discussed "computer on a chip" concept is rapidly nearing reality. The single circuit card shown here contains the entire central processing unit for the Four-Phase System IV/70 computer. The 12 MOS/LSI semiconductor packages contain the equivalent of 75,000 discrete components.

interrupt system. It shows the number of different external devices whose interrupt signals can be identified by the processor—though it should be noted that this identification process may require a fairly complex and time-consuming sequence of instructions. Many of the minicomputers offer additional external interrupt levels as extra-cost options, and in these cases our charts show the available range, from minimum to maximum.

Peripheral Equipment

The comparison charts summarize the standard peripheral devices that are available for each minicomputer.

Users who are accustomed to larger general-purpose computer systems will find that the term "standard peripheral device" often has a somewhat different meaning when used by a minicomputer manufacturer. Since few of the minicomputer makers produce their own peripheral equipment, the indicated availability of a given type of device may simply mean that an appropriate interface is available to couple the computer with a peripheral unit supplied by some other manufacturer. Therefore, prospective buyers should ask these questions about each item of peripheral equipment they will need:

- Has it actually been installed and used with the computer of interest?
- If so, what has the users' experience been?
- What software support is available?
- Who will provide service for the device, and under what conditions?

The charts indicate the availability of three different types of disk and drum storage units. *Disk pack storage* is now the most popular type of random-access storage in larger computer systems; the interchangeable disk packs are suitable for either random or sequential processing. *Non-interchangeable disk storage* frequently provides larger on-line storage capacities at a lower cost per bit, though it lacks the operational flexibility of the interchangeable disk packs. *Drum storage* tends to provide faster access times and data transfer rates than the disk units, usually at a higher cost per bit.

Disk and drum storage units can greatly expand the scope of practical applications for the minicomputers by compensating for their limited main storage capacities. Cost, however, is likely to be a serious problem, since most of the currently available disk and drum units cost more than the minicomputers themselves. What's more, software support for the available disk and drum units is still fairly rare.

Magnetic tape speed is expressed in characters per second for those minicomputers that offer magnetic tape I/O. Most of the available tape units use standard 1/2-inch tape in IBM-compatible 9-track and/or 7-track formats, though there is also a growing trend toward inexpensive cassette units.

Punched card input and output speeds for standard 80-column cards are expressed in cards per minute. (Readers and punches for IBM's compact new 96-column cards are just beginning to appear on the market, and it seems likely that they will find rapid acceptance among minicomputer builders and buyers.)

Where paper tape I/O devices faster than the ever-present Teletype ASR units are available, these *high-speed paper tape input and output speeds* are expressed in characters per second.

Other standard peripheral devices, such as line printers, plotters, and display units, are briefly identified on the charts. Space does not permit listings of the extensive lines of communications interfaces, real-time interfaces, and analog/digital and digital/analog converters offered by many of the minicomputer builders.

Software

This section of the comparison charts summarizes the major software items offered by the manufacturer of each minicomputer. In addition to the items listed in the charts, most manufacturers also offer utility routines to handle input/output operations, mathematical functions, program loading, and diagnostic operations. Software packages for specific applications, however, are still quite rare. Prospective buyers should carefully note whether the software they will require is included in the basic price of the computer or offered at extra cost.

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An *assembler* is the one essential software item that is available for nearly every minicomputer. The assembler simplifies machine-language programming by permitting the use of mnemonic operation codes and symbolic addresses. Most assemblers also provide pseudo-instructions which control the assembly process and allocate storage space for constants and data.

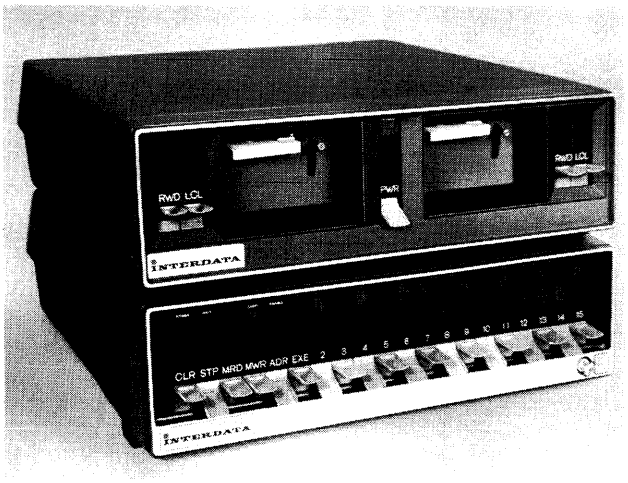
One-pass and two-pass assemblers each offer certain advantages. A "pass" generally means a scan of the full source program during the assembly process. A one-pass assembler saves assembly time, but certain programming restrictions are imposed by the fact that all storage must be allocated at the beginning of the assembly process. A two-pass assembler builds a symbol table during the first pass and generates the machine-language object program during the second pass; this technique tends to be slower but more powerful. Both one- and two-pass assemblers are available for some machines.

A *macro assembler* is an assembler with the added capability to substitute a predetermined sequence of machine instructions for each "macro instruction" that appears in the source program. Macro facilities can simplify programming by making it easy to include subroutines to handle input/output, evaluation of functions, and other frequently encountered operations.

A *compiler* converts source programs written in a procedure-oriented language such as FORTRAN into machine-language object programs. Although compilers can greatly reduce programming time requirements for many applications, they have not been widely used with minicomputers to date for two principal reasons. First, most minicomputers have been used in specialized applications where relatively few programs are required but where high operational efficiency (which is difficult to achieve with compilers) is important. Second, the compilation process itself requires more storage space than many of the minicomputers provide. The trend toward ever more diversified applications for the minicomputers, however, is leading to steadily increasing use of compilers. Most of the available compilers are batch-oriented, but a few are designed for interactive, conversational-mode operation.

FORTRAN is by far the most widely implemented compiler language for the current minicomputers. FORTRAN has been the most popular scientific programming language for more than a decade, and it has been successfully used for many business applications as well. There are many different versions of the FORTRAN language, but conversions of FORTRAN programs from one version to another are usually comparatively simple.

Other compilers, for programs written in languages such as ALGOL, BASIC, and COBOL, are listed on the charts where available.



This Interdata Model 1 minicomputer is equipped with Interdata's Cassette Tape System (top), which can serve as a low-cost replacement for paper tape I/O equipment. Each of the dual tape drives accommodates a removable Phillips-type cassette that holds up to 250,000 bytes of data. Transfer rate is 300 bytes per second.

An *operating system* facilitates the operation of a computer by handling functions such as:

- Scheduling, loading, and supervising the execution of programs;
- Allocating storage and I/O devices;
- Initiating and controlling I/O operations;
- Analyzing interrupt signals and dealing with errors;
- Handling communications between the system and its human operator; and
- Controlling multiprogramming or time-sharing operations.

Most of the current minicomputer operating systems are real-time monitors, designed primarily for use in a dedicated real-time environment. Facilities for multiprogramming and time-sharing are rarely provided.

Pricing and Availability

The comparison charts show the *prices of basic systems* equipped with 4,096 and 8,192 words of main storage. A Teletype Model 33 Automatic Send/Receive unit, which serves as the basic I/O device for most minicomputers, is included wherever available. The indicated prices for each machine include all of the features listed as "standard," but none of the "optional" features. Because of the wide variations in availability and pricing of optional features and peripheral equipment, comparisons such as these can provide only a first-level indication of the overall pricing

relationships among competitive minicomputers. And, of course, prices have been falling steadily during the past year and are likely to continue to do so. Therefore, the only reliable source of detailed, up-to-date pricing information is the manufacturers themselves.

If you'll need two or more minicomputers, it's also worth noting that most of the manufacturers offer sizeable discounts from their list prices on orders for multiple computers. Discounts of up to 40 percent are not unusual on large orders.

Date of first delivery indicates when the first production model of each minicomputer was delivered (or is scheduled to be delivered) to a customer.

Number installed to date shows how many computers of each type had been delivered to customers as of May 1, 1971. All figures were supplied by the manufacturers themselves, and the entry "NA" (Not Available) appears in all cases where the manufacturers chose not to release this information.

Comments at the bottom of the charts describe significant or unusual features, capabilities, or applications which are not reflected in the standard entries.

MINICOMPUTER MANUFACTURERS

Listed below, for your convenience in obtaining additional information, are the full names and addresses of the 43 manufacturers whose products are summarized in the comparison charts.

Atron Corporation (a subsidiary of Mohawk Data Sciences Corporation), 1256 Trapp Road, St. Paul, Minnesota 55118.

Bendix Corporation, Navigation & Control Division, Tererboro, New Jersey 07608

Cascade Data Computer Systems Inc., 3000 Kraft Avenue S.E., Grand Rapids, Michigan 49508.

Cincinnati Milacron Company, Process Controls Division, Lebanon, Ohio 45036.

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

Computer Automation Incorporated, 895 West Sixteenth Street, Newport Beach, California 92660.

Computer Logic Systems, Inc., 225 Crescent Street, Waltham, Massachusetts 02154.

Control Data Corporation, 8100 34th Avenue South, Minneapolis, Minnesota 55440.

Data General Corporation, Southboro, Massachusetts 01772.

Datacraft Corporation, 1200 N.W. 70th Street, P.O. Box 23550, Fort Lauderdale, Florida 33307.

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

Digital Computer Controls, Inc., 23 Just Road, Fairfield, New Jersey 07006.

Digital Equipment Corporation, Maynard, Massachusetts 01754.

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

Electronic Associates, Inc., West Long Branch, New Jersey 07764.

Electronic Processors Incorporated (a subsidiary of the Samsonite Corporation), 5050 South Federal Boulevard, Englewood, Colorado 80110.

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

General Automation, Inc., 1055 S. East Street, Anaheim, California 92805.

General Electric Company, Manufacturing Automation Products Department, 40 Federal Street, Lynn, Massachusetts 01910.

Hewlett-Packard Company, Cupertino Division, 11000 Wolfe Road, Cupertino, California 95014.

Honeywell Information Systems Inc. (a subsidiary of Honeywell Inc.), 200 Smith Street, Waltham, Massachusetts 02154.

IBM Corporation, Data Processing Division, 1133 Westchester Avenue, White Plains, New York 10604.

Interdata, Inc., 2 Crescent Place, Oceanport, New Jersey 07757.

Lockheed Electronics Company (a division of Lockheed Aircraft Corporation), Data Products Division, 6201 E. Randolph Street, Los Angeles, California 90022.

Microdata Corporation, 644 East Young Street, Santa Ana, California 92705.

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

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Motorola Instrumentation and Control Inc. (a subsidiary of Motorola Inc.), P.O. Box 5409, Phoenix, Arizona 85010.

Nuclear Data Inc., P.O. Box 451, Palatine, Illinois 60067.

Omnicomp Computer Corporation, 1580 E. Edinger Avenue, Santa Ana, California 92705.

Omnitec Corporation (a subsidiary of Nytronics Corporation), 903 N. Second Street, Phoenix, Arizona 85004.

Raytheon Data Systems Company (a subsidiary of Raytheon Company), Norwood, Massachusetts.

Redcor Corporation, 21200 Victory Boulevard, P.O. Box 1100, Woodland Hills, California 93164.

Rolm Corporation, 10300 N. Tantau Avenue, Cupertino, California 95014.

SYS Computer Corp., 17-25 Di Carolis Court, Hackensack, New Jersey 07601.

SYSTEMS Engineering Laboratories, Inc., 6901 West Sunrise Boulevard, Fort Lauderdale, Florida 33313.

Tempo Computers, Inc. (a subsidiary of GTE Information Systems), 4005 W. Artesia Avenue, Fullerton, California 92633.

Texas Instruments Inc., Digital Systems Division, P.O. Box 1444, Houston, Texas 77001.

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

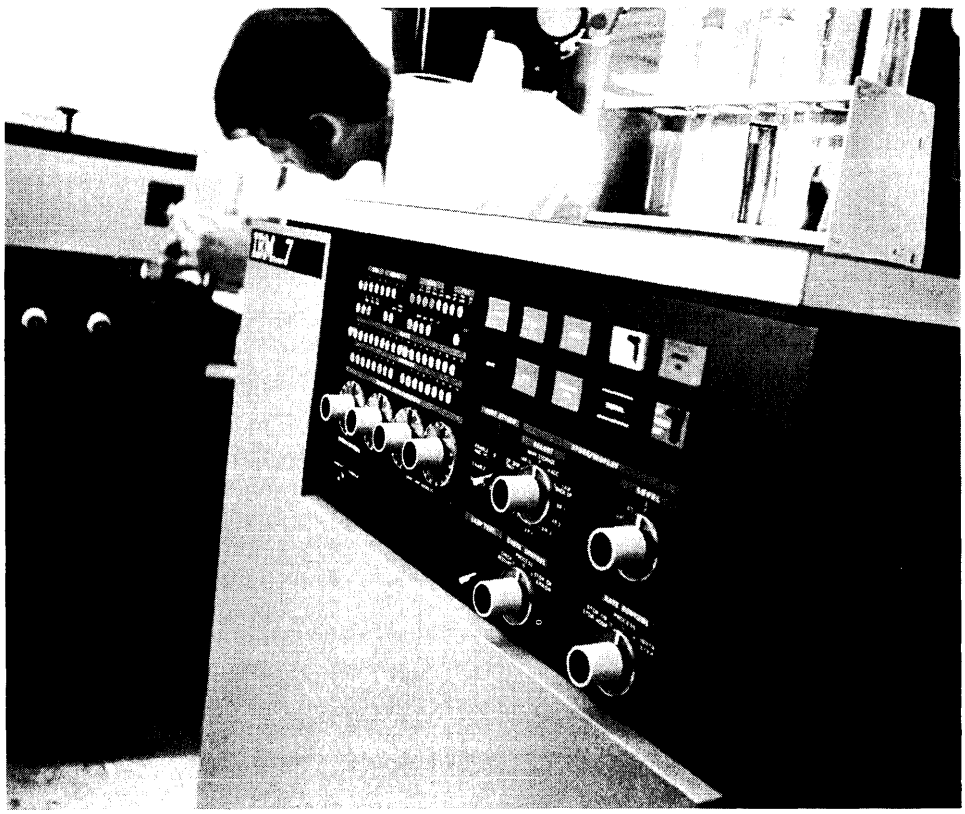
UniComp, Inc., 18219 Parthenia Street, Northridge, California 93124.

Varian Data Machines (a subsidiary of Varian Associates), 2722 Michelson Drive, Irvine, California 92664.

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

Westinghouse Electric Corporation, Computer Department, 1200 W. Colonial Drive, Orlando, Florida 32804.

Xerox Data Systems (a subsidiary of Xerox Corporation), 701 South Aviation Boulevard, El Segundo, California 90245. □



The IBM System/7, introduced in October 1970, is a fast 16-bit minicomputer that features a 400-nanosecond semiconductor main memory.

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MANUFACTURER & MODEL	Atron 501 Datamanager	Bendix BDX6200	Bendix BDX9000	Cascade Data Cascade 80	Cincinnati Milacron CIP/2100
DATA FORMATS					
Word length, bits	8-bit byte	20	16	16 (2 bytes)	8
Fixed-point operand length, bits	1-256 bytes	20/40	16	16-32	8/16/24/32
Instruction length, bits	1-5 bytes	20	16	16-40	8/16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	2.0	2.0	2.0	0.9	1.1
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	16,384	32,768	32,768	32,768
Parity checking	Optional	Optional	Optional	Optional	Optional
Storage protection	Optional	Optional	Optional	No	Optional
CENTRAL PROCESSOR					
No. of accumulators	Variable	3	16	16	2
No. of index registers	Variable	3	2	3	1
No. of directly addressable words	32,768	4,096	256	1,024	32,768
Indirect addressing	Multi-level	Multi-level	Multi-level	One-level	One-level
Add time, microseconds (full word)	Variable	4.0	4.0	8.8	6.38
Hardware multiply/divide	No	Standard	Standard	Standard	Standard
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	No	No	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Optional	No	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8 + parity	20	16	16	8/16
Direct memory access channel	Optional	Optional	Optional	Standard	Standard
Maximum I/O rate, words/sec	500,000	500,000	500,000	416,000	909,000
No. of external interrupt levels	Variable	1-64	1-64	0	8-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	No
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	37.5 in/sec	Not specified	Not specified	2,250	—
Punched card input speed, cpm	300-1000	200	200	300	400
Punched card output speed, cpm	100	—	—	120	—
High-speed paper tape input, cps	—	300	300	300	300
High-speed paper tape output, cps	—	120	120	120	240
Other standard peripheral units	Line printer, Selectric typewriter, communications	A/D and D/A interfaces	A/D and D/A interfaces	Line printers, mark readers, communications, displays, etc.	CRT display, communications interface
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	Yes	No	No	Yes	No
FORTRAN compiler	No	No	No	No	No
Other compilers	RPG	ATLAS	No	RPG	No
Operating system	No	No	No	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$6,000 range in quantity	On request	On request	On request	$5,580
Price of basic system with 8K words & Teletype Model 33 ASR	$8,000 range in quantity	On request	On request	On request	$7,580
Date of first delivery	Sept. 1969	May 1970	Not specified	Jan. 1970	1969
Number installed to date	300	17	0	NA	NA
COMMENTS	Designed for business data processing; macros handle variable-length operands. Also widely used as a batch terminal.	Features 10 hardware registers and 131 register change instructions.		Byte-oriented; designed for business applications. Supported by extensive applications software.	Controlled by 768 to 1024 words of 220-nsec read-only memory. Software is separately priced.

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MANUFACTURER & MODEL	Clary Datacomp 404	Computer Automation Alpha-8	Computer Automation Model 108	Computer Automation Model 208	Computer Automation Model 808
DATA FORMATS					
Word length, bits	16	8	8	8	8
Fixed-point operand length, bits	16/32/48/64	8	8	8	8
Instruction length, bits	16/32	8/16	8/16	8/16	8/16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	2.2	1.6	1.6	2.7	8.0
Minimum capacity, words	1,024	4,096	4,096	4,096	4,096
Maximum capacity, words	65,536	16,384	16,384	16,384	16,384
Parity checking	No	Optional	No	No	No
Storage protection	Optional	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	4	1	1	1	1
No. of index registers	2	0	0	0	0
No. of directly addressable words	1,024	512	512	512	512
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	98 (15 digits)	3.2	3.2	5.3	24
Hardware multiply/divide	Standard	No	No	No	No
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	No	No	No	No
Power failure protection	Optional	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	8	8	8	8
Direct memory access channel	Optional	3 standard	3 standard	3 standard	3 standard
Maximum I/O rate, words/sec	250,000	120,000	120,000	67,000	25,000
No. of external interrupt levels	16-256	3-unlimited	3-unlimited	3-unlimited	3-unlimited
PERIPHERAL EQUIPMENT					
Disk pack storage	No	No	No	No	No
Non-interchangeable disk storage	No	No	No	No	No
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	—	10K-25K	10K-25K	10K-25K	8K-10K
Punched card input speed, cps	—	300	300	300	300
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	150/300	400	400	400	400
High-speed paper tape output, cps	—	60/120	60/120	60/120	60/120
Other standard peripheral units	Line printer, CRT display, magnetic card unit	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.
SOFTWARE					
Assembler	1-pass	3-pass	3-pass	3-pass	3-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	No	No	No	No	No
Other compilers	RPG II, BASIC	No	No	No	No
Operating system	Yes	No	No	No	No
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$11,255	$4,350	$7,500	$7,200	$7,000
Price of basic system with 8K words & Teletype Model 33 ASR	$15,250	$6,050	$10,100	$9,800	$9,700
Date of first delivery	Oct. 1969	Nov. 1971	Dec. 1970	Aug. 1969	April 1968
Number installed to date	NA	0	4	36	145
COMMENTS	Performs both decimal and binary arithmetic. Can be used as an "intelligent terminal."	Naked-Mini 8 is low-cost OEM version of Alpha-8, less chassis, power supply, and console.	Program compatible with Alpha-8, 208, and 808.		

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MANUFACTURER & MODEL	Computer Automation Alpha-16	Computer Automation Model 116	Computer Automation Model 216	Computer Logic Systems CLS-18	Computer Logic Systems CLS-76
DATA FORMATS					
Word length, bits	16	16	16	18	18
Fixed-point operand length, bits	16	16	16	18	18
Instruction length, bits	16	16	16	18	18
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	1.6	2.6	0.96	0.96
Minimum capacity, words	2,048	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	32,768	32,768	262,144	262,144
Parity checking	Optional	No	No	No	No
Storage protection	Optional	Optional	Optional	Standard	Standard
CENTRAL PROCESSOR					
No. of accumulators	2	2	2	4	32
No. of index registers	1	1	1	4	16
No. of directly addressable words	1,024	1,024	1,024	512	512
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	3.2	3.2	5.3	1.92	1.92
Hardware multiply/divide	Standard	Standard	Standard	Optional	Standard
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	No	No	No	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Optional	Optional	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Standard
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	18	18
Direct memory access channel	3 standard	3 standard	3 standard	Standard	Standard
Maximum I/O rate, words/sec	625,000	625,000	375,000	1,040,000	1,040,000
No. of external interrupt levels	3-unlimited	3-unlimited	3-unlimited	8-512	8-512
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Not specified	Not specified
Non-interchangeable disk storage	Yes	Yes	Yes	—	—
Drum storage	Yes	Yes	Yes	—	—
Magnetic tape speed, cps	10K-30K	10K-30K	10K-30K	—	—
Punched card input speed, cpm	300	300	300	—	—
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	400	400	400	—	—
High-speed paper tape output, cps	60/120	60/120	60/120	—	—
Other standard peripheral units	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.	Line printer, A/D converter, data sets, etc.	—	—
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	Yes	Yes
FORTRAN compiler	Yes	Yes	Yes	No	No
Other compilers	BASIC	BASIC	BASIC	No	No
Operating system	No	No	No	No	No
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$5,100	$10,000	$10,000	$11,770	$16,900
Price of basic system with 8K words & Teletype Model 33 ASR	$7,300	$13,800	$13,800	$14,970	$20,100
Date of first delivery	Nov. 1971	Sept. 1970	July 1969	April 1971	Not specified
Number installed to date	0	18	188	NA	NA
COMMENTS	Naked-Mini 16 is low-cost OEM version of Alpha-16, less chassis, power supply, and console.	Program compatible with Alpha-16 and 216.		Features 2 "sub-processors" for foreground-background processing.	Features 8 "sub-processors" for foreground-background processing.

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MANUFACTURER & MODEL	Control Data 1700	Control Data SC-1700	Datacraft 6024/1	Datacraft 6024/3	Datacraft 6024/5
DATA FORMATS					
Word length, bits	16 + 2	16 + 2	24 + 1	24 + 1	24 + 1
Fixed-point operand length, bits	16	16	24/48	24/48	24/48
Instruction length, bits	16/32	16/32	24	24	24
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.1	1.5	0.6	1.0	1.2
Minimum capacity, words	4,096	4,096	8,192	8,192	4,096
Maximum capacity, words	32,768	32,768	65,536	65,536	32,768
Parity checking	Standard	Standard	Standard	Standard	Standard
Storage protection	Standard	Standard	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	2	2	5 or 6	5 or 6	5 or 6
No. of index registers	2	2	3	3	3
No. of directly addressable words	256	256	65,536	65,536	32,768
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	2.2	3.0	1.2	2.0	2.4
Hardware multiply/divide	Standard	Standard	Standard	Standard	Standard
Hardware floating point	No	No	Optional	Optional	No
Hardware byte manipulation	No	Optional	Standard	Standard	Standard
Immediate (literal) instructions	No	No	Standard	Standard	Standard
Power failure protection	Standard	Standard	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	24	24	24
Direct memory access channel	Optional	Optional	Optional	Optional	Optional
Maximum I/O rate, words/sec	900,000	650,000	1,667,000	1,000,000	833,000
No. of external interrupt levels	2-16	2-16	4-72	4-24	16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	No	No	Yes	Yes	Yes
Drum storage	Yes	Yes	No	No	No
Magnetic tape speed, cps	30K max.	30K max.	120K max.	120K max.	120K max.
Punched card input speed, cpm	330-1200	330-1200	400/1000	400/1000	400/1000
Punched card output speed, cpm	100-460	100-460	205	205	205
High-speed paper tape input, cps	400	400	300/600	300/600	300/600
High-speed paper tape output, cps	120/150	120/150	110	110	110
Other standard peripheral units	Line printer, CRT displays, OCR, A/D converters, etc.	Line printer, CRT displays, OCR, A/D converters, etc.	CRT display, plotter, A/D converter, communications	CRT display, plotter, A/D converter, communications	CRT display, plotter, A/D converter, communications
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	Yes	Yes	No	No	No
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	No	No	CAL	CAL	CAL
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$37,420	$22,580	Not available	Not available	$18,750
Price of basic system with 8K words & Teletype Model 33 ASR	$45,900	$27,080	$53,900	$35,300	$23,550
Date of first delivery	April 1966	July 1970	May 1969	Feb. 1970	Nov. 1971
Number installed to date	NA	NA	12	45	0
COMMENTS	18-bit word includes parity and storage protection bits; prices include Model 35 (heavy duty) ASR.		The three Datacraft models are program-compatible. The quoted prices include a basic software package; other software is available at extra cost. Model 6024/5 fits into a standard 19" rack.		

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MANUFACTURER & MODEL	Data General Nova	Data General Nova 1200	Data General Nova 800	Data General Supernova	Data General Supernova SC
DATA FORMATS					
Word length, bits	16	16	16	16	16
Fixed-point operand length, bits	16	16	16	16	16
Instruction length, bits	16	16	16	16	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Semicond./core
Cycle time, microseconds/word	2.6	1.2	0.8	0.8	0.3/0.8
Minimum capacity, words	2,048	2,048	2,048	2,048	1,024
Maximum capacity, words	32,768	32,768	32,768	32,768	32,768
Parity checking	No	No	No	No	No
Storage protection	No	No	No	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	4	4	4	4	4
No. of index registers	2	2	2	2	2
No. of directly addressable words	1,024	1,024	1,024	1,024	1,024
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	5.9	1.35	0.8	0.8	0.3/0.8
Hardware multiply/divide	Optional	Optional	Optional	Optional	Optional
Hardware floating point	No	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	No	No	No	No
Power failure protection	Standard	Standard	Standard	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	285,500	833,000	1,250,000	1,250,000	1,250,000
No. of external interrupt levels	16	16	16	16	16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	No	No	No	No
Magnetic tape speed, cps	30K max.	30K max.	30K max.	30K max.	30K max.
Punched card input speed, cpm	225/400	225/400	225/400	225/400	225/400
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	63	63	63	63	63
Other standard peripheral units	Line printer, A/D converters, communications, plotters, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.	Line printer, A/D converters, communications, plotter, etc.
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC	ALGOL, BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$9,200	$6,700	$8,200	$12,950	$13,150
Price of basic system with 8K words & Teletype Model 33 ASR	$12,850	$9,400	$11,200	$17,450	$19,100
Date of first delivery	Feb. 1969	Dec. 1970	March 1971	April 1970	June 1971
Number installed to date	874	180	8	137	0
COMMENTS	First member of the Nova line. Read-only memory is interchangeable with standard core storage.	Employs LSI circuits. Optional jumbo chassis allows economical expansion.	Compatible with all other Nova-line computers. Jumbo chassis is optional.	300-nsec read-only memory is interchangeable with standard core storage.	800-nsec core and 300-nsec semiconductor memory modules can be interchanged and mixed.

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MANUFACTURER & MODEL	Datamate-16	Datamate-70	Digital Computer Control D-112	Digital Computer Control D-112H	Digital Computer Control D-216
DATA FORMATS					
Word length, bits	16	16	12	12	16
Fixed-point operand length, bits	16/32	16	12	12	16
Instruction length, bits	16	16	12/24	12/24	16/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core/semicond.	Core
Cycle time, microseconds/word	1.0	1.0	1.2	1.0/0.3	1.2
Minimum capacity, words	8,192	4,096	4,096	256	4,096
Maximum capacity, words	32,768	32,768	32,768	32,768	32,768
Parity checking	No	No	Optional	Optional	Optional
Storage protection	No	No	Standard	Standard	Optional
CENTRAL PROCESSOR					
No. of accumulators	1	4	1	1	8
No. of index registers	1	2	8	8	Up to 8
No. of directly addressable words	512	1,024	256	256	32,768
Indirect addressing	Multi-level	Multi-level	One-level	One-level	One-level
Add time, microseconds (full word)	2.0	1.0	2.4	2.4	2.4
Hardware multiply/divide	Standard	Optional	Optional	Optional	Optional
Hardware floating point	No	No	Optional	Optional	Optional
Hardware byte manipulation	Standard	Standard	Optional	Standard	Standard
Immediate (literal) instructions	Standard	Standard	No	No	Standard
Power failure protection	Standard	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	12	12	16
Direct memory access channel	Standard	Standard	Optional	Optional	Standard
Maximum I/O rate, words/sec	1,000,000	1,000,000	833,000	833,000	833,000
No. of external interrupt levels	8-64	0-62	1-64	1-64	Variable
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	96K max.	96K max.	30K	30K	30K
Punched card input speed, cpm	300	300	200	200	200
Punched card output speed, cpm	120	120	100	100	100
High-speed paper tape input, cps	500	500	300	300	300
High-speed paper tape output, cps	75	75	110	110	110
Other standard peripheral units	Line printer, CRT display, analog subsystems	Line printer, etc.	Line printer	Line printer	Line printer
SOFTWARE					
Assembler	2-pass	2-pass	1 & 2-pass	1 & 2-pass	2-pass
Macro assembler	Yes	Yes	Yes	Yes	Yes
FORTRAN compiler	Yes	No	Yes	Yes	Yes
Other compilers	No	No	ALGOL, BASIC	ALGOL, BASIC	BASIC
Operating system	No	No	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	Not available	$10,200	$5,240	$6,850	$6,550
Price of basic system with 8K words & Teletype Model 33 ASR	$16,600	$12,900	$7,940	$8,550	$8,250
Date of first delivery	Nov. 1969	Aug. 1970	Aug. 1970	April 1971	Aug. 1970
Number installed to date	NA	NA	50	NA	0
COMMENTS	Multiply time is 5 to 7 microseconds; divide time is 9 microseconds.	Measures only 1-3/4 by 19 by 20 inches; fast semiconductor memory is an option.	Designed to be fully compatible with the DEC PDP-8 computers.	Offers either core or 300-nsec semiconductor memory. Has expanded PDP-8 series instruction set.	Designed to be fully compatible with the DEC PDP-11 computers.

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MANUFACTURER & MODEL	Digital Equipment PDP-8/I	Digital Equipment PDP-8/L	Digital Equipment PDP-8/E	Digital Equipment PDP-11/20	Digital Equipment PDP-11/15
DATA FORMATS					
Word length, bits	12	12	12	16	16
Fixed-point operand length, bits	12	12	12	16	16
Instruction length, bits	12/24	12/24	12/24	16/32/48	16/32/48
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.5	1.6	1.2	1.2	1.2
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	8,192	32,768	124K	32,768
Parity checking	Optional	Optional	Optional	Optional	Optional
Storage protection	No	Optional	Optional	No	No
CENTRAL PROCESSOR					
No. of accumulators	1	1	1	8	8
No. of index registers	8	8	8	Up to 8	Up to 8
No. of directly addressable words	256	256	256	32,768	32,768
Indirect addressing	One-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	3.0	3.2	2.6	2.3	2.3
Hardware multiply/divide	Optional	No	Optional	Optional	Optional
Hardware floating point	Optional	Optional	Optional	No	No
Hardware byte manipulation	No	No	Yes	Standard	Standard
Immediate (literal) instructions	No	No	No	Standard	Standard
Power failure protection	Optional	Optional	Optional	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	12	12	12	16	16
Direct memory access channel	Standard	Standard	Standard	Standard	Standard
Maximum I/O rate, words/sec	666,000	625,000	833,000	833,000	833,000
No. of external interrupt levels	1-64	1-64	1-64	Variable	Variable
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Special order	Special order	Special order	No	No
Magnetic tape speed, cps	36K max.	36K max.	36K max.	36K max.	36K max.
Punched card input speed, cpm	200	200	200	200	200
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	50	50	50	50	50
Other standard peripheral units	DECtape, plotter, CRT displays, printers, etc.	DECtape, plotter, CRT displays, printers, etc.	DECtape, plotter, CRT displays, printers, etc.	DECtape, CRT displays, A/D converters, printers, etc.	DECtape, CRT displays, A/D converters, printers, etc.
SOFTWARE					
Assembler	1 & 2-pass	1 & 2-pass	1 & 2-pass	2-pass	2-pass
Macro assembler	Yes	Yes	Yes	Runs on PDP-10	Runs on PDP-10
FORTRAN compiler	Yes	Yes	Yes	Yes	Yes
Other compilers	ALGOL, BASIC, DIBOL, FOCAL	ALGOL, BASIC, DIBOL, FOCAL	ALGOL, BASIC, DIBOL, FOCAL	BASIC	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$12,800	$8,500	$6,490	$10,800	$6,200
Price of basic system with 8K words & Teletype Model 33 ASR	$16,800	$12,500	$9,490	$14,300	$9,700
Date of first delivery	March 1968	Oct. 1968	Dec. 1970	March 1970	April 1971
Number installed to date	See Comment	See Comment	See Comment	Over 1000	NA
COMMENTS	Over 10,000 PDP-8 systems have been delivered since 1965. All models are program-compatible. Extensive software is available, as well as integrated systems for specific applications. The PDP-8/I and 8/E are designed to allow plug-in expansion, while the 8/L is not.			"Unibus" permits flexibility in I/O and memory units. 500-nsec read-only core memory is available in 1024-word increments. PDP-11/15 is designed for OEM use.	

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MANUFACTURER & MODEL	Digital Equipment PDP-12	Digital Equipment PDP-15	Digital Scientific META 4	Electronic Associates EAI 640	Electronic Processors EPI-118
DATA FORMATS					
Word length, bits	12	18	16	16	18
Fixed-point operand length, bits	12	18	16	16	18
Instruction length, bits	12/24	18	32	16	18
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	0.8	0.90	1.65	0.9
Minimum capacity, words	4,096	4,096	4,096	8,192	4,096
Maximum capacity, words	32,768	131,072	65,536	32,768	32,768
Parity checking	Optional	Optional	Standard	No	No
Storage protection	Optional	Optional	Standard	Standard	Standard
CENTRAL PROCESSOR					
No. of accumulators	1	1	32	2	2
No. of index registers	8	1	Variable	1	Any no. (opt.)
No. of directly addressable words	1,024	4,096	65,536	512	32,768
Indirect addressing	One-level	One-level	One-level	Multi-level	One-level (opt.)
Add time, microseconds (full word)	3.2	1.6	2.14	3.3	See Comments
Hardware multiply/divide	Optional	Optional	Standard	Standard	Optional
Hardware floating point	Optional	No	Optional	Optional	No
Hardware byte manipulation	No	No	Standard	No	Standard
Immediate (literal) instructions	No	No	Standard	Standard	No
Power failure protection	Optional	Optional	Optional	Standard	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	12	18	16	16	18
Direct memory access channel	Standard	Standard	9 standard	Standard	Optional
Maximum I/O rate, words/sec	625,000	1,000,000	1,000,000	600,000	900,000
No. of external interrupt levels	1-64	28-64	16	7-64	18
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	No	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	No
Drum storage	Special order	Yes	Yes	No	No
Magnetic tape speed, cps	36K max.	60K max.	—	36K	—
Punched card input speed, cpm	200	200	200/300	400	—
Punched card output speed, cpm	—	—	200	—	—
High-speed paper tape input, cps	300	300	300	300	Not specified
High-speed paper tape output, cps	50	50	50	120	Not specified
Other standard peripheral units	DECtape, plotters, A/D converters, printers, etc.	DECtape, A/D converters, real-time interfaces	Line printer, plotter, communications	Line printer, communications, A/D converters, display, etc.	CRT display, cassette tape, A/D and D/A interfaces
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	Yes	Yes	No	Yes
FORTRAN compiler	Yes	Yes	Yes	Yes	No
Other compilers	BASIC	FOCAL	Yes	Op. Interpreter	BASIC
Operating system	Yes	Yes	Yes	Yes	No
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$14,900	$16,500	$25,000	Not available	$7,150
Price of basic system with 8K words & Teletype Model 33 ASR	$18,900	$22,500	$30,500	$24,500	$9,800
Date of first delivery	April 1969	Fall 1969	Jan. 1970	Feb. 1967	Nov. 1970
Number installed to date	NA	NA	NA	160	NA
COMMENTS	Designed for laboratory applications; can execute PDP-8 programs; built-in CRT display.	Program compatible with the PDP-9, and has 17 new instructions.	Controlled by 1K to 4K words of 90-nsec read-only memory. Can emulate the IBM 1130 and 1800.	Can serve as the digital portion of a hybrid computer system.	Basic add time is 2.0 microseconds per octal digit. Faster, 18-bit arithmetic unit is optional.

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MANUFACTURER & MODEL	Four-Phase Systems, Inc. System IV/70	General Automation SPC-12	General Automation SPC-16	General Automation System 18/30	General Electric GE-PAC 30-1
DATA FORMATS					
Word length, bits	24	8	16	16	16
Fixed-point operand length, bits	24	8/12	16	16/32	16
Instruction length, bits	24	8/16	16	16/32	16/32
MAIN STORAGE					
Storage type	Semiconductor	Core	Core	Core	Core
Cycle time, microseconds/word	1.9	2.16	0.96	0.96	1.5
Minimum capacity, words	4,096	4,096	4,096	4,096	4,096
Maximum capacity, words	8,192	16,384	32,768	32,768	32,768
Parity checking	Standard	Optional	No	Standard	Optional
Storage protection	No	No	No	Standard	Optional
CENTRAL PROCESSOR					
No. of accumulators	5	4	16	2	16
No. of index registers	3	3	6	3	15
No. of directly addressable words	8,192	4,096	32,768	32,768	32,768
Indirect addressing	One-level	One-level	One-level	One-level	No
Add time, microseconds (full word)	15.2	6.48	0.96	2.4	28
Hardware multiply/divide	Standard	No	Optional	Standard	Standard
Hardware floating point	Standard	No	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	No	Standard
Immediate (literal) instructions	No	Standard	Standard	Standard	Standard
Power failure protection	No	Optional	Standard	Standard	Optional
Real-time clock or timer	Standard	Standard	Standard	Standard	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	24	8/12	16	16	8
Direct memory access channel	Standard	Optional	Standard	5 standard	Optional
Maximum I/O rate, words/sec	131,000	460,000	1,040,000	960,000	500,000
No. of external interrupt levels	8	2-256	8-unlimited	6	256
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	No
Non-interchangeable disk storage	No	Yes	Yes	Yes	No
Drum storage	No	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	20K	60K max.	60K max.	60K max.	20K
Punched card input speed, cpm	300	400/1000	400/1000	400/100	200
Punched card output speed, cpm	—	100	100	100	—
High-speed paper tape input, cps	—	400	400	400	300
High-speed paper tape output, cps	—	75	75	75	60
Other standard peripheral units	CRT displays, line printer, Data-Phone interface	A/D converters, communications interfaces	A/D converters, communications interfaces	A/D converters, communications interfaces	TermiNet 300, real-time interfaces
SOFTWARE					
Assembler	2-pass	1-pass	2-pass	1-pass	1 & 2-pass
Macro assembler	No	No	Yes	No	No
FORTRAN compiler	No	No	Yes	Yes	No
Other compilers	No	No	No	No	No
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$17,150	$4,850	$10,150	$18,950	$9,600
Price of basic system with 8K words & Teletype Model 33 ASR	$23,750	$6,650	$13,350	$22,950	$13,200
Date of first delivery	Feb. 1971	Jan. 1968	May 1970	July 1969	May 1969
Number installed to date	NA	NA	NA	NA	40
COMMENTS	Specifically designed to support up to 32 interactive CRT terminals. MOS/LSI CP consists of 12 chips on 1 card.	Off-the-shelf "minicontrollers" facilitate analog, digital, and communications interfacing.	480-nsec read-only memory modules are interchangeable with standard core modules.	Instruction set is fully compatible with the IBM 1130 and 1800.	Read-only memory (an array of pulse transformers) holds prewired microprogram.

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MANUFACTURER & MODEL	General Electric GE-PAC 30-2	General Electric GE-PAC 30-2E	General Electric GE-PAC 30-CS	Hewlett-Packard 2100A	Hewlett-Packard 2114B
DATA FORMATS					
Word length, bits	16	16	8	16	16
Fixed-point operand length, bits	16	16	8	16	16
Instruction length, bits	16/32	16/32	8/16	16	16
MAIN STORAGE					
Storage type	Core	Core	Core or ROM	Core	Core
Cycle time, microseconds/word	1.0	1.0	1.0	0.98	2.0
Minimum capacity, words	4,096	4,096	2,048	4,096	4,096
Maximum capacity, words	32,768	32,768	16,384	32,768	8,192
Parity checking	Optional	Optional	Optional	Standard	Optional
Storage protection	Optional	Optional	No	Standard	No
CENTRAL PROCESSOR					
No. of accumulators	16	16	1	2	2
No. of index registers	15	15	Up to 8,192	0	0
No. of directly addressable words	32,768	32,768	512	2,048	2,048
Indirect addressing	No	No	One-level	Multi-level	Multi-level
Add time, microseconds (full word)	3.2	5.6	2.0	1.96	4.0
Hardware multiply/divide	Optional	Standard	No	Standard	No
Hardware floating point	Optional	Standard	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	No	No
Immediate (literal) instructions	Standard	Standard	Standard	No	No
Power failure protection	Optional	Standard	Optional	Standard	Optional
Real-time clock or timer	Optional	Optional	Standard	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8	8/16	8	16	16
Direct memory access channel	Optional	Optional	Optional	Optional (2)	Optional
Maximum I/O rate, words/sec	500,000	500,000	500,000	1,000,000	500,000
No. of external interrupt levels	256	256	8	Up to 56	7-24
PERIPHERAL EQUIPMENT					
Disk pack storage	No	No	No	Yes	Yes
Non-interchangeable disk storage	No	No	Yes	Yes	Yes
Drum storage	Yes	Yes	Yes	Yes	Yes
Magnetic tape speed, cps	20K	20K	20K	7,500	2,500
Punched card input speed, cpm	200	200	200	200/1,000	200/1,000
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	500	500
High-speed paper tape output, cps	60	60	60	120	120
Other standard peripheral units	TermiNet 300, real-time interfaces	TermiNet 300, real-time interfaces	TermiNet 300, casette tape	Line printers, plotters, DataPhone interface	Line printers, plotters, DataPhone interface
SOFTWARE					
Assembler	1 & 2-pass	1 & 2-pass	1 & 2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	Yes	Yes	No	Yes	Yes
Other compilers	No	No	No	ALGOL, BASIC	ALGOL, BASIC
Operating system	Yes	Yes	No	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$10,100	$12,400	$5,550	$9,250	$9,000
Price of basic system with 8K words & Teletype Model 33 ASR	$14,200	$15,900	$7,350	$12,750	$12,500
Date of first delivery	June 1969	June 1970	Feb. 1971	Not specified	Oct. 1968
Number installed to date	40	20	10	0	Over 600
COMMENTS	Read-only memory (an array of pulse transformers) holds prewired microprogram.	Flexible interrupt-driven I/O function is controlled by read-only memory.	2048-byte read-only memory modules can be intermixed with read/write core modules.	Controlled by semiconductor read-only memory. Fully compatible with 2114B and 2116C.	FORTRAN operates in 4K; ALGOL and BASIC require 8K.

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MANUFACTURER & MODEL	Hewlett-Packard 2116C	Honeywell 112	Honeywell 316	Honeywell 516	IBM System/7
DATA FORMATS					
Word length, bits	16	12	16	16	16
Fixed-point operand length, bits	16	12	16/32	16/32	16
Instruction length, bits	16	12	16	16	16/32
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Semiconductor
Cycle time, microseconds/word	1.6	1.69	1.6	0.96	0.4
Minimum capacity, words	8,192	4,096	4,096	4,096	2,048
Maximum capacity, words	32,768	8,192	32,768	32,768	16,384
Parity checking	Optional	No	Optional	Optional	Standard
Storage protection	Optional	No	Optional	Optional	No
CENTRAL PROCESSOR					
No. of accumulators	2	1	1	1	1
No. of index registers	0	0	1	1	7
No. of directly addressable words	2,048	128	1,024	1,024	16,384
Indirect addressing	Multi-level	One-level	Multi-level	Multi-level	No
Add time, microseconds (full word)	3.2	7.63	3.2	1.92	0.8
Hardware multiply/divide	Optional	No	Optional	Optional	No
Hardware floating point	No	No	Special order	Special order	No
Hardware byte manipulation	No	No	Standard	Standard	No
Immediate (literal) instructions	No	No	No	No	Standard
Power failure protection	Standard	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Standard (2)
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	12	16	16	16
Direct memory access channel	2 optional	Optional	Optional	Optional	Standard
Maximum I/O rate, words/sec	263,000	295,000	313,000	1,040,000	500,000
No. of external interrupt levels	16-48	1	1-65	1-65	64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	No	Yes	Yes	No
Non-interchangeable disk storage	Yes	No	Yes	Yes	No
Drum storage	Yes	No	Yes	Yes	No
Magnetic tape speed, cps	7,500	—	64K max.	64K max.	—
Punched card input speed, cpm	200/1,000	—	800	800	—
Punched card output speed, cpm	—	—	100	100	—
High-speed paper tape input, cps	500	400	300	300	—
High-speed paper tape output, cps	120	110	110	110	—
Other standard peripheral units	Line printers, plotters, Data-Phone interface	Analog and digital I/O interfaces	Line printers, communications interfaces, displays, etc.	Line printers, communications interfaces, displays, etc.	Analog and digital I/O interfaces
SOFTWARE					
Assembler	2-pass	2-pass	1 & 2-pass	1 & 2-pass	1-pass
Macro assembler	No	No	Yes	Yes	Yes
FORTRAN compiler	Yes	No	Yes	Yes	No
Other compilers	ALGOL, BASIC	No	BASIC	BASIC	No
Operating system	Yes	No	Yes	Yes	Limited
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	Not available	$7,200	$10,100	$25,000	$19,035
Price of basic system with 8K words & Teletype Model 33 ASR	$16,000	$9,880	$13,600	$33,000	$26,385
Date of first delivery	Sept. 1967	Nov. 1969	June 1969	Oct. 1966	Nov. 1971
Number installed to date	Over 700	130	700	650	0
COMMENTS	Software allows multi-programming and time-shared access by up to 16 users in 16K disc systems.	Plug-in control panel can be detached, enabling one panel to serve two or more 112's.	The 316 and 516 are logically identical. They form the basis of Honeywell's Series 1600 data acquisition and data communications systems. Ruggedized models, 316R and 516R, are also available.		Designed for sensor-based applications. Can be used on-line with IBM 1130, 1800, 360, and 370 computers.

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MANUFACTURER & MODEL	Interdata Model 1	Interdata Model 4	Interdata Model 5	Lockheed Electronics MAC 16	Lockheed Electronics MAC Jr.
DATA FORMATS					
Word length, bits	8	16	16	16	16
Fixed-point operand length, bits	8	16 (32 opt.)	16	16	16
Instruction length, bits	8/16	16/32	16/32	16	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.0	1.0	1.0	1.0	1.0
Minimum capacity, words	2,048	2,048	4,096	4,096	4,096
Maximum capacity, words	16,384	32,768	32,768	65,536	65,536
Parity checking	Optional	Optional	Optional	Optional	Optional
Storage protection	No	Optional	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	1	16	16	1	1
No. of index registers	8,192	15	15	8-64	4-16
No. of directly addressable words	512	32,768	32,768	1,024	1,024
Indirect addressing	One-level	No	No	Multi-level	Multi-level
Add time, microseconds (full word)	2.0	3.2	3.2	2.0	2.0
Hardware multiply/divide	No	Optional	Standard	Optional	Optional
Hardware floating point	No	Optional	Standard	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Optional	Standard	Optional
Real-time clock or timer	Standard	Optional	Optional	Standard	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8	8	8/16	8/16	8/16
Direct memory access channel	4 optional	Optional	Optional	Standard	Standard
Maximum I/O rate, words/sec	1,000,000	500,000	500,000	1,000,000	1,000,000
No. of external interrupt levels	8	2-256	2-256	8-64	4-16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	No	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	Yes	No	Yes	Yes	Yes
Magnetic tape speed, cps	20K max.	20K max	20K max.	30K max.	30K max.
Punched card input speed, cpm	200	200	200	300	300
Punched card output speed, cpm	100	100	100	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	60	60	60	75	75
Other standard peripheral units	Tape cassettes, line printer, digital multiplexer	Plotter, A/D converters	Line printer, Tape cassette, A/D converters	Line printer, cassette tape, communications, displays, etc.	Line printer, cassette tape, communications, displays, etc.
SOFTWARE					
Assembler	1 & 2-pass	1 & 2-pass	1 & 2-pass	2-pass	2-pass
Macro assembler	No	No	No	Yes	Yes
FORTRAN compiler	No	Yes	Yes	Yes	Yes
Other compilers	No	No	No	No	No
Operating system	Yes	No	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$5,850	$10,100	$12,100	$12,800	$9,500
Price of basic system with 8K words & Teletype Model 33 ASR	$7,650	$13,300	$15,300	$16,750	$12,600
Date of first delivery	Feb. 1972	Aug. 1968	July 1970	Feb. 1969	Jan. 1971
Number installed to date	0	408	30	203	68
COMMENTS	2,048-byte read-only memory modules can be intermixed with standard core modules.	16 hardware general registers; read-only memory holds prewired microprogram.	Software is designed to coordinate multitask operations.	Optional Multiplex Data Channel handles up to 16 concurrent I/O operations.	Program-compatible with MAC 16. Optional channel handles up to 16 concurrent I/O operations.

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MANUFACTURER & MODEL	Microdata Micro 400	Microdata Micro 800	Microdata Micro 810	Microdata Micro 820	Microdata Micro 1600
DATA FORMATS					
Word length, bits	8	8 or 9	8	8	8
Fixed-point operand length, bits	8	Variable	8/16/24/32	8/16/24/32	Variable
Instruction length, bits	8/16	16	8/16/24/32	8/16/24/32	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	1.1	1.1	1.1	1.0
Minimum capacity, words	1,024	0	4,096	4,096	0
Maximum capacity, words	65,536	32,768	32,768	32,768	65,536
Parity checking	No	Optional	Optional	Optional	No
Storage protection	No	No	No	No	No
CENTRAL PROCESSOR					
No. of accumulators	2	15	2	2	30
No. of index registers	1 or 2	0	1	1	Up to 30
No. of directly addressable words	4,096	32,768	32,768	32,768	65,536
Indirect addressing	No	No	One-level	One-level	No
Add time, microseconds (full word)	1.6	0.22	11	11	0.20
Hardware multiply/divide	No	No	No	Optional	No
Hardware floating point	No	No	No	Optional	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Optional	Optional	Standard
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8	8	8	8	8
Direct memory access channel	Optional	Optional	Optional	Optional	Standard
Maximum I/O rate, words/sec	625,000	910,000	910,000	910,000	1,000,000
No. of external interrupt levels	1-64	1-64	2-32	2-32	1-64
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes	Yes
Drum storage	No	Yes	Yes	Yes	No
Magnetic tape speed, cps	20K	20K	20K	20K	20K
Punched card input speed, cpm	300	400	400	400	300
Punched card output speed, cpm	—	—	—	—	—
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	75	75	75	75	75
Other standard peripheral units	Communications interfaces	Line printers, CRT displays, communications interfaces	Line printers, CRT displays, communications interfaces	Line printers, CRT displays, communications interfaces	Line printers, CRT displays
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No	No
FORTRAN compiler	No	No	No	No	No
Other compilers	No	No	BASIC	BASIC	No
Operating system	No	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$4,695	$6,000	$7,540	$7,650	On request
Price of basic system with 8K words & Teletype Model 33 ASR	$5,195	$7,000	$8,540	$8,650	On request
Date of first delivery	Jan. 1970	Jan. 1969	Jan. 1969	Dec. 1969	July 1971
Number installed to date	20	400	250	75	0
COMMENTS	Only 3.5" high by 17.5" wide by 21" deep; weighs 23 pounds.	A micro-programmable computer built around a file of 16 registers and a 220-nsec read-only control memory.	A micro-programmed adaptation of the Micro 800.	Features stack processing and character and string manipulation.	A micro-programmable computer built around a file of 31 registers and a 200-nsec read-only control memory.

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MANUFACTURER & MODEL	Modular Comp. Systems Modcomp I	Modular Comp. Systems Modcomp II	Modular Comp. Systems Modcomp III	Motorola MDP-1000	Nuclear Data ND812
DATA FORMATS					
Word length, bits	16	16	16	8	12
Fixed-point operand length, bits	16	16/32	16/32/48	8	12
Instruction length, bits	16/32	16/32	16/32	8/12	12/24
MAIN STORAGE					
Storage type	Core, semicond.	Core	Core	Core	Core
Cycle time, microseconds/word	0.8	0.8	0.8	2.16	2.0
Minimum capacity, words	512	4,096	4,096	4,096	4,096
Maximum capacity, words	16,384	32,768	65,536	16,384	16,384
Parity checking	Optional	Optional	Standard	No	No
Storage protection	No	No	Optional	No	No
CENTRAL PROCESSOR					
No. of accumulators	3	15 (8 in core)	15	4	2
No. of index registers	3	7	7	3	2 (core)
No. of directly addressable words	16,384	32,768	32,768	4.096	16,384
Indirect addressing	One-level	One-level	One-level	One-level	One-level
Add time, microseconds (full word)	0.8	0.8	0.8	4.32	2/4
Hardware multiply/divide	No	Optional	Optional	No	Standard
Hardware floating point	No	No	Optional	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	No
Immediate (literal) instructions	Standard	Standard	Standard	Standard	Standard
Power failure protection	Optional	Optional	Standard	Optional	Standard
Real-time clock or timer	Optional	Optional	Optional	Standard	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	16	8/12	12/24
Direct memory access channel	Optional	Optional	Optional	No	Standard
Maximum I/O rate, words/sec	1,250,000	1,250,000	1,250,000	46,000	500,000
No. of external interrupt levels	1-5	3-8	4-32	1-128	256-4,096
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	No	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	No	Yes
Drum storage	No	No	No	Yes	No
Magnetic tape speed, cps	10K/36K	10K/36K	10K/36K	12K	36K
Punched card input speed, cpm	300/1000	300/1000	300/1000	60	—
Punched card output speed, cpm	100	100	100	—	—
High-speed paper tape input, cps	625	625	625	300	125/300
High-speed paper tape output, cps	110	110	110	120	50/110
Other standard peripheral units	Line printers, A/D converters	Line printers, A/D converters	Line printers, A/D converters	Line printer, mark reader, CRT display, communications	Line printer, cassette tape, A/D converters
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	Yes	Yes	No	Limited
FORTRAN compiler	No	Yes	Yes	No	No
Other compilers	No	No	No	No	NUTRAN
Operating system	No	Yes (3)	Yes (3)	Yes	Limited
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$6,700	$11,100	$15,000	$8,300	$8,400
Price of basic system with 8K words & Teletype Model 33 ASR	$9,300	$15,100	$19,000	$11,300	$11,050
Date of first delivery	4th Q 1971	March 1971	Dec. 1970	June 1968	Nov. 1970
Number installed to date	0	1	4	NA	45
COMMENTS		200-nsec read-only control memory consists of 256 to 512 40-bit words.	200-nsec read-only control memory consists of 256 to 1024 40-bit words.	"Shared byte" instructions can conserve memory space.	Integrated circuits can be easily replaced without re-soldering.

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MANUFACTURER & MODEL	Omnicomp Omnus-1	Omnitec BIT 483	Raytheon 703	Raytheon 704	Raytheon 706
DATA FORMATS					
Word length, bits	16	8-bit byte	16	16	16
Fixed-point operand length, bits	8/16	1-64 bytes	16	16	16
Instruction length, bits	16/32	16/32	16	16	16
MAIN STORAGE					
Storage type	Core	Core	Core	Core	Core
Cycle time, microseconds/word	1.2	0.98	1.75	1.0	0.9
Minimum capacity, words	2,048	1,024	4,096	4,096	4,096
Maximum capacity, words	32,768	65,536	32,768	32,768	32,768
Parity checking	No	Optional	No	Optional	Optional
Storage protection	Optional	Standard	No	No	Optional
CENTRAL PROCESSOR					
No. of accumulators	2,049	1	1	1	1
No. of index registers	2,049	0	1	1	1
No. of directly addressable words	32,768	512	2,048	2,048	2,048
Indirect addressing	No	One-level	No	No	No
Add time, microseconds (full word)	2.4	2.3	3.5	2.0	1.8
Hardware multiply/divide	Optional	Optional	Optional	Optional	Optional
Hardware floating point	Optional	Optional	No	No	No
Hardware byte manipulation	Standard	Standard	Standard	Standard	Standard
Immediate (literal) instructions	Standard	No	Standard	Standard	Standard
Power failure protection	Standard	Standard	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	8/16	8	16	16	16
Direct memory access channel	Standard	Standard	Optional	Optional	Optional
Maximum I/O rate, words/sec	833,000	1,020,000	571,000	1,000,000	1,100,000
No. of external interrupt levels	32-256	8-32	1-16	1-16	1-16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	No	No	Yes	Yes	Yes
Drum storage	No	Yes	No	No	No
Magnetic tape speed, cps	20K	20K-30K	60K max.	60K max.	60K max.
Punched card input speed, cpm	300	225	1100	1100	1100
Punched card output speed, cpm	–	150	100-400	100-400	100-400
High-speed paper tape input, cps	300	300	300	300	300
High-speed paper tape output, cps	72	60	110	110	110
Other standard peripheral units	Line printer	CRT display, Tape cassette, Line printer, Plotter	Line printers, tape cassette, plotter, A/D converters	Line printers, tape cassette, plotter, A/D converters	Line printers, tape cassette, plotter, A/D converters
SOFTWARE					
Assembler	1-pass	2-pass	1 & 2-pass	1 & 2-pass	1 & 2-pass
Macro assembler	Yes	Yes	Yes	Yes	Yes
FORTRAN compiler	No	Yes	Yes	Yes	Yes
Other compilers	No	No	Conversational FORTRAN	Conversational FORTRAN	Conversational FORTRAN
Operating system	No	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$9,450	$9,010	$12,750	$9,200	$19,000
Price of basic system with 8K words & Teletype Model 33 ASR	$12,900	$10,950	$17,500	$12,700	$24,600
Date of first delivery	May 1971	Jan. 1970	Oct. 1967	March 1970	May 1969
Number installed to date	NA	55	250	150	100
COMMENTS	Features 2,048 general registers in core memory and single-bus architecture. Read-only memory is optional.	Performs both decimal and binary arithmetic on variable-length operands.	All three Raytheon computers are program-compatible; a software library of over 600 routines includes a Real-Time Operating System capable of controlling foreground/background multiprogramming in 8K disk systems. An Array Transform Processor facilitates signal processing.		

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MANUFACTURER & MODEL	Redcor RC 70	Rolm Corp. 1601 Ruggednova	SYS Computer Corp. SYS 1000	SYSTEMS 72	Tempo Computers TEMPO I
DATA FORMATS					
Word length, bits	16	16	8	16	16
Fixed-point operand length, bits	16	16	8	16/32	16
Instruction length, bits	16/32	16	24	16	16/32
MAIN STORAGE					
Storage type	Core	Core/semicond.	Semiconductor	Core/disk	Core
Cycle time, microseconds/word	0.86	2.6	1.0	0.88	0.9
Minimum capacity, words	4,096	256	128	4,096/32,768	4,096
Maximum capacity, words	32,768	32,768	32,768	65,536/524.288	65,536
Parity checking	Standard	No	Optional	Optional	No
Storage protection	Standard	No	Standard	Standard	Optional
CENTRAL PROCESSOR					
No. of accumulators	2	4	32	2	16
No. of index registers	1	2	32	2	16
No. of directly addressable words	32,768	1,024	32	512	65,536
Indirect addressing	One-level	Multi-level	No	One-level	One-level
Add time, microseconds (full word)	1.9	5.9	2.0	3	1.8
Hardware multiply/divide	Standard	Optional	Optional	Optional	Optional
Hardware floating point	No	No	Optional	Optional	No
Hardware byte manipulation	No	Standard	Standard	Standard	Standard
Immediate (literal) instructions	No	No	Standard	Optional	Standard
Power failure protection	Standard	Standard	Standard	Optional	Optional
Real-time clock or timer	Standard	Optional	Standard	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	16	16	8	8/16	16/8
Direct memory access channel	Standard	Standard	Standard	Optional	Optional
Maximum I/O rate, words/sec	1,100,000	285,500	2,000,000	1,000,000	640,000
No. of external interrupt levels	0-32	16	0	0-384	4-16
PERIPHERAL EQUIPMENT					
Disk pack storage	Yes	No	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Standard	No
Drum storage	No	No	Yes	Yes	Yes
Magnetic tape speed, cps	20/60/120K	150 ips max.	Not specified	20K max.	30/60K
Punched card input speed, cpm	300	400	Not specified	300/600	400
Punched card output speed, cpm	—	—	Not specified	80	—
High-speed paper tape input, cps	300	300	Not specified	300	400
High-speed paper tape output, cps	60	63	Not specified	120	120
Other standard peripheral units	Line printers, CRT displays, communications controllers	Line printer, cassette tape, plotters	Line printers, CRT displays	Line printers, communications, analog interfaces	Line printer, 360 interface, communications multiplexer
SOFTWARE					
Assembler	1-pass	2-pass	None	1-pass	1 & 2-pass
Macro assembler	No	No	No	No	Yes
FORTRAN compiler	Yes	Yes	No	Yes	Yes
Other compilers	No	ALGOL, BASIC	No	BASIC	No
Operating system	Yes	Yes	No	Yes (2)	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$17,600	$21,250	On request	$18,995	$15,600
Price of basic system with 8K words & Teletype Model 33 ASR	$22,500	Not specified	On request	$24,495	$21,500
Date of first delivery	April 1969	March 1970	Jan. 1971	Aug. 1970	Sept. 1969
Number installed to date	150	NA	10	6	50
COMMENTS	Single-pass FORTRAN IV compiler requires 8K words.	Ruggedized version of the Data General Nova, designed for severe environments.	Highly modular programmed controller. MOS/LSI read-only memory is wired to customer's specifications.	Features virtual memory; quoted prices include memory map and 32K memory extension disk.	Usable as a multi-processor system or as a front-end communications processor handling up to 480 lines.

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MANUFACTURER & MODEL	Texas Instruments Model 960	Texas Instruments Model 980	Unicom CP-8	UniComp COMP-16	UniComp COMP-18
DATA FORMATS					
Word length, bits	16 + 1	16 + 1	8	16	18
Fixed-point operand length, bits	16	16	8	16	18
Instruction length, bits	32	16/32	8/16	16	18
MAIN STORAGE					
Storage type	Core	Core	Core or ROM	Core	Core
Cycle time, microseconds/word	1.0	1.0	1.75	0.88	0.88
Minimum capacity, words	4,096	4,096	512	4,096	4,096
Maximum capacity, words	65,536	65,536	32,768	65,536	262,144
Parity checking	Standard	Standard	Standard	No	No
Storage protection	Standard	No	Optional	Optional	Optional
CENTRAL PROCESSOR					
No. of accumulators	16	2	1	1	1
No. of index registers	16	1	1	6	6
No. of directly addressable words	65,536	65,536	4,096	256	1,024
Indirect addressing	One-level	One-level	32,768	One-level	One-level
Add time, microseconds (full word)	6.0	2.0	3.5	2.25	2.25
Hardware multiply/divide	Optional	Standard	Optional	Optional	Optional
Hardware floating point	No	No	No	Optional	Optional
Hardware byte manipulation	Standard	No	No	Optional	Optional
Immediate (literal) instructions	Standard	Standard	Yes	Standard	Standard
Power failure protection	Standard	Standard	Optional	Standard	Standard
Real-time clock or timer	Optional	No	Optional	Optional	Optional
INPUT/OUTPUT CONTROL					
I/O word size, bits	1 to 16	16	8	16	18
Direct memory access channel	Standard	Standard	Optional	Standard	Standard
Maximum I/O rate, words/sec	1,000,000	1,000,000	45,000	1,100,000	1,100,000
No. of external interrupt levels	2	3-4,097	4	1-128+	1-128+
PERIPHERAL EQUIPMENT					
Disk pack storage	No	No	No	Yes	Yes
Non-interchangeable disk storage	No	Yes	No	Yes	Yes
Drum storage	No	No	No	Yes	Yes
Magnetic tape speed, cps	60K max.	60K max.	2 ips	20K	20K
Punched card input speed, cpm	300	300	—	300	300
Punched card output speed, cpm	100	100	—	120	120
High-speed paper tape input, cps	300	300	500	625	625
High-speed paper tape output, cps	60	60	500	60/120	60/120
Other standard peripheral units	Line printer, A/D converters, communications processor	Line printer, A/D converters, communications processor	CRT display, page printer, cassette tape	Line printer, A/D converters, communications interfaces	Line printer, A/D converters, communications interfaces
SOFTWARE					
Assembler	2-pass	2-pass	2-pass	1 & 2-pass	1 & 2-pass
Macro assembler	Yes	No	Yes	Yes	Yes
FORTRAN compiler	Yes	Yes	No	Yes	Yes
Other compilers	No	No	No	BASIC	BASIC
Operating system	Yes	Yes	Yes	Yes	Yes
PRICING & AVAILABILITY					
Price of basic system with 4K words & Teletype Model 33 ASR	$10,250	$11,380	$5,695	$9,300	$10,000
Price of basic system with 8K words & Teletype Model 33 ASR	$13,250	$14,380	$7,395	$12,450	$13,150
Date of first delivery	June 1970	May 1968	March 1970	Aug. 1970	Aug. 1970
Number installed to date	15	30	189	NA	NA
COMMENTS	Designed for efficient manipulation of individual bits and bit fields; has 16 general registers.	Real-Time Monitor can handle foreground/background multiprogramming.	Available with either read-only or read/write memory; prices are for Model CP-8C with read/write core memory.	48-word read-only memory holds bootstrap loader. Prewired read-only memory modules of 512, 1024, or 2048 words are available, as well as hardware square root, Fourier transform, and coordinate converter.	

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MANUFACTURER & MODEL	Varian 520/i	Varian 620/i	Varian 620/f	Varian 620/L
DATA FORMATS				
Word length, bits	8	16 (18 opt.)	16	16
Fixed-point operand length, bits	8/16/24/32	16 (18 opt.)	16	16
Instruction length, bits	8/16/24	16/32	16/32	16/32
MAIN STORAGE				
Storage time	Core	Core	Core	Core
Cycle time, microseconds/word	1.5	1.8	0.75	1.8
Minimum capacity, words	4,096	4,096	4,096	4,096
Maximum capacity, words	32,768	32,768	32,768	32,768
Parity checking	Optional	Optional	Optional	No
Storage protection	No	Optional	Optional	Optional
CENTRAL PROCESSOR				
No. of accumulators	2	2	2	2
No. of index registers	2	2	2	2
No. of directly addressable words	4,096	2,048	2,048	2,048
Indirect addressing	Multi-level	Multi-level	Multi-level	Multi-level
Add time, microseconds (full word)	4.5	3.6	1.5	3.6
Hardware multiply/divide	No	Optional	Optional	Optional
Hardware floating point	No	No	No	No
Hardware byte manipulation	Standard	No	No	No
Immediate (literal) instructions	No	Standard	Standard	Standard
Power failure protection	Optional	Optional	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL				
I/O word size, bits	8	16 (18 opt.)	16	16
Direct memory access channel	Optional	Standard	Standard	Standard
Maximum I/O rate, words/sec	660,000	200,000	1,330,000	200,000
No. of external interrupt levels	4	0-64	0-64	0-64
PERIPHERAL EQUIPMENT				
Disk pack storage	Yes	Yes	Yes	Yes
Non-interchangeable disk storage	Yes	Yes	Yes	Yes
Drum storage	No	Yes	Yes	Yes
Magnetic tape speed, cps	20K max.	20K max.	20K max.	20K max.
Punched card input speed, cpm	300	300/1000	300/1000	300/1000
Punched card output speed, cpm	200	200/300	200/300	200/300
High-speed paper tape input, cps	300	150/300	150/300	150/300
High-speed paper tape output, cps	60	75	75	75
Other standard peripheral units	Line printer, Plotter, Data set coupler	Line printer, CRT display, A/D converters, Plotters, etc.	Line printer, CRT display, A/D converters, Plotters, etc.	Line printer, CRT display, A/D converters, Plotters, etc.
SOFTWARE				
Assembler	2-pass	2-pass	2-pass	2-pass
Macro assembler	No	No	No	No
FORTRAN compiler	No	Yes	Yes	Yes
Other compilers	No	BASIC, RPG	BASIC, RPG	BASIC, RPG
Operating system	No	Yes	Yes	Yes
PRICING & AVAILABILITY				
Price of basic system with 4K words & Teletype Model 33 ASR	$7,400	$11,750	$12,300	$7,200
Price of basic system with 8K words & Teletype Model 33 ASR	$9,400	$16,500	$14,800	$9,500
Date of first delivery	Sept. 1968	Sept. 1967	June 1970	May 1971
Number installed to date	90	1300	10	1
COMMENTS	Two full sets of registers facilitate inter-program switching.	A ruggedized version, Model R-620/i, costs $18,700 with 4K words & ASR.	Upward compatible with 620/i; optional 300-nsec read-only memory uses braided cores.	Repackaged, lower-priced version of the popular 620/i. Fully program compatible.

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MANUFACTURER & MODEL	Wang Laboratories WANG 3300	Westinghouse 2500	Xerox Data Systems CF16	Xerox Data Systems CF16A
DATA FORMATS				
Word length, bits	8	16	16	16
Fixed-point operand length, bits	16/32	16	16	16
Instruction length, bits	16	16	16	16
MAIN STORAGE				
Storage type	Core	Core	Core	Core
Cycle time, microseconds/word	1.6	0.75	2.67	1.6
Minimum capacity, words	4,096	4,096	4,096	1,024
Maximum capacity, words	65,536	65,536	32,768	32,768
Parity checking	No	Optional	No	No
Storage protection	No	Optional	Optional	Optional
CENTRAL PROCESSOR				
No. of accumulators	2	2	1	1
No. of index registers	0	2	1	1
No. of directly addressable words	768	256	768	768
Indirect addressing	One-level	One-level	Multi-level	Multi-level
Add time, microseconds (full word)	4.8	1.7	5.33	3.2
Hardware multiply/divide	Optional	Standard	No	No
Hardware floating point	No	Optional	No	No
Hardware byte manipulation	Standard	No	Standard	Standard
Immediate (literal) instructions	Standard	No	Standard	Standard
Power failure protection	Standard	Standard	Optional	Optional
Real-time clock or timer	Optional	Optional	Optional	Optional
INPUT/OUTPUT CONTROL				
I/O word size, bits	8	16	16/8	16
Direct memory access channel	Standard	Optional	Standard	Optional
Maximum I/O rate, words/sec	500,000	Not specified	250,000	666,000
No. of external interrupt levels	8	Up to 120	3-64	3-64
PERIPHERAL EQUIPMENT				
Disk pack storage	No	Yes	No	No
Non-interchangeable disk storage	No	Yes	Yes	Yes
Drum storage	No	No	No	No
Magnetic tape speed, cps	—	Not specified	20K	20K
Punched card input speed, cpm	—	300/600	300	300
Punched card output speed, cpm	—	—	—	—
High-speed paper tape input, cps	30	300	300	300
High-speed paper tape output, cps	—	110	60	60
Other standard peripheral units	Selectric I/O writers, cassette tape, plotter	Line printer, CRT display, communications, A/D converters	A/D converters, Communications interfaces	A/D converters, Communications Interfaces
SOFTWARE				
Assembler	2-pass	1 & 2-pass	1 & 2-pass	1 & 2-pass
Macro assembler	No	Yes	No	No
FORTRAN compiler	Yes	Yes	Yes	Yes
Other compilers	BASIC	BASIC, RPG	No	No
Operating system	Yes	Yes	No	No
PRICING & AVAILABILITY				
Price of basic system with 4K words & Teletype Model 33 ASR	$6,900	$11,850	$10,000	$10,000
Price of basic system with 8K words & Teletype Model 33 ASR	$8,400	$14,450	$13,800	$13,800
Date of first delivery	April 1971	April 1971	Dec. 1969	Nov. 1970
Number installed to date	30	NA	45	NA
COMMENTS	Time-sharing system; can handle up to 16 BASIC users simultaneously; software is separately priced.	Features 16-high speed IC registers. Used in Westinghouse 2550 programmable terminal system.	Basic FORTRAN compiler operates in 4K memory; fully compatible with CF16A.	Can be equipped with read/only memory and/or 400-nsec IC "scratchpad" memory.