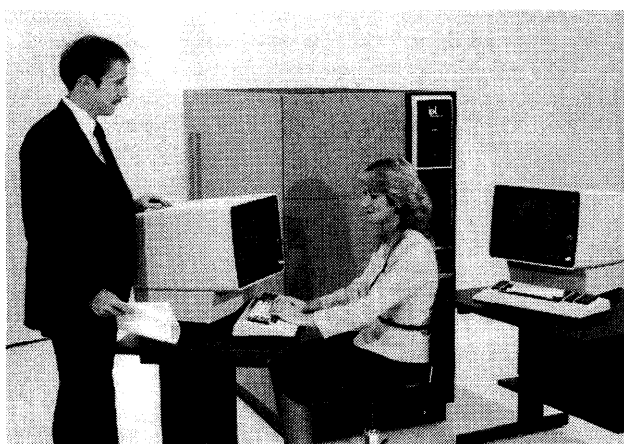# IPL Systems 4400 Series

MANAGEMENT SUMMARY

UPDATE: *IPL Systems has made no hardware or software enhancements to the 4400 Series during the past year. Monthly maintenance prices remain unchanged but purchase prices have been lowered. Also IPL no longer leases or rents its processors.*

The primary objective in designing an IBM plug-compatible system is to make it literally transparent to IBM operating systems, systems software, applications, and IBM-compatible peripherals. IPL set out to not only achieve this objective, but also to develop a system that 1) provides fault-tolerant architecture in the PCM marketplace, 2) is easily field upgradable, 3) provides high reliability and maintainability, and 4) provides better price/performance than the competition.

IPL has about 400 systems installed worldwide, of which over 120 have been sold directly to end users in the U.S. With its expertise in microcode emulation, the company has been able to successfully counter IBM's 4300 Series with products of its own.

The IPL Series consists of the 4460 single-processor model, and the 4480 dual-processor model. Both systems use microcoding extensively to emulate IBM System/370 and 4300 Series operating features. The systems are composed of several distinct elements, such as the CPU, memory modules, input/output control units, and a service processor, which are connected to a high-speed internal link called the ExpandaBus. All data transfers occur over the ExpandaBus, resulting in higher overall throughput. The ExpandaBus architecture actually is made up of three buses: the central data transfer bus, a main storage bus, and a control storage bus. The 4460 is field-upgradable to the 4480 and typically requires nothing more than changing a few plug-in modules in the system backplane. ▷

The IPL 4400 Series systems have from 4 to 16 megabytes of main memory, support 5 to 10 I/O channels, are field-upgradable, and feature better price/performance than comparable IBM 4300 Series processors.

The IPL 4400 Series consists of two models that are compatible with IBM's 4300 Series. The two IPL systems are functionally compatible with IBM software, firmware, and peripheral equipment. The IPL 4400 Series features ECL circuitry and 64K-bit chip technology.

MODELS: IPL 4460 and 4480.
CONFIGURATION: One to two CPUs with from four to sixteen megabytes of main memory, and five to ten I/O channels.
COMPETITION: IBM 4361-5 and 4381-2; NAS AS/6620, AS/6630, AS/6650, and AS/6660.
PRICES: Purchase prices range from $190,800 for a four-megabyte 4460 to $503,400 for a 16-megabyte 4480.

CHARACTERISTICS

MANUFACTURER: IPL Systems, Inc., 360 Second Avenue, Waltham, Massachusetts 02154. Telephone (617) 890-6620.

MODELS: IPL 4460 and 4480.

DATA FORMATS

BASIC UNIT: 8-bit byte. Each byte can represent 1 alphanumeric character, 2 BCD digits, or 8 binary bits. Two consecutive bytes form a "halfword" of 16 bits, while 4 consecutive bytes form a 32-bit "word."

FIXED-POINT OPERANDS: Can range from 1 to 16 bytes (1 to 31 digits plus sign) in decimal mode; 1 halfword (16 bits) or 1 word (32 bits) in binary mode.

FLOATING-POINT OPERANDS: 1 word, consisting of 24-bit fraction and 7-bit hexadecimal exponent, in "short" format; 2 words, consisting of 56-bit fraction and 7-bit hexadecimal exponents, in "long" format; or 4 words in "extended precision" format.

INSTRUCTIONS: 2, 4, or 6 bytes in length, specifying 0, 1, or 2 memory addresses, respectively.

INTERNAL CODE: EBCDIC.

MAIN MEMORY

Main storage for the 4400 Series consists of 4, 8, 12, or 16 one-megabyte modules, each module has two ports. Either port can fail without affecting the other port and any storage module can fail without affecting the others. Also included is a one-megabyte module which can be operator configured in place of a failing storage module.

Each 4400 Series model has a cache buffer to provide improved system throughput. The buffer stores selected areas of main storage that might be used next by the CPU. If the requested data is contained in the cache, the CPU request can be handled rapidly. The 4460 has up to 24K bytes of cache and the 4480 can have up to 48K bytes. The ▶

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▷ The central processors in both models use emitter-coupled logic (ECL) circuitry, which affords greater component packaging densities, resulting in reduced floor space requirements and less power consumption. To improve system performance an optional high-speed multiply/divide is available.

Main storage is based on 64K-bit chip technology. All memory is error-correcting and corrects all single-bit errors and detects most multiple-bit errors. Memory cycle time is 500 nanoseconds for both read and write operations. The systems can have from four to sixteen megabytes of memory with buffer storage, or cache, for improving execution speeds. Model 4460 has 24K bytes and Model 4480 has 48K bytes of cache memory. The system's operating features are implemented in microcode, which is contained in control storage. Model 4460 is equipped with 64K bytes of control storage while Model 4480 has 128K bytes.

The Model 4480 consists of two independent processing units which share main storage. The 4480 can be configured either in a multiprocessor complex or as two uniprocessors. Main storage for the 4480 consists of 8, 12, or 16 one-megabyte modules which each have two ports. A spare one-megabyte module is also included, which can be operator-configured in the place of a failing storage module without a system break.

IPL 4400 Series processors will operate with all IBM and IBM-compatible terminals and peripheral devices that are supported on System/370 and 4300 Series systems, except those devices requiring direct control or integrated controllers and adapters. The 4460 comes equipped with one byte and five block multiplexer channels. A channel set with one byte and four block multiplexer channels comes standard with each processor within the 4480. Byte multiplexer channels transfer data at 50K bytes per second in byte mode and 180K bytes per second in burst mode. Block multiplexer channels 1 and 2 can transfer data at up to 3 megabytes per second, and channels 3, 4, and 5 can transfer data at up to 2 megabytes per second. Data streaming, which is required with the high-performance IBM 3375 and 3380 (and equivalent) disk drives, is supported on channels 1 and 2.

The byte multiplexer channel can support up to 256 unshared subchannels, and each block multiplexer channel can support up to 256 subchannels.

COMPETITIVE POSITION

If the objective of a plug-compatible vendor is to offer better price/performance than comparable IBM 4300 Series products, then the IPL 4400 Series certainly fills the bill. The 4460 is the only plug-compatible competition for the IBM 4361-5, while the 4480 competes with the IBM 4381-2 and the NAS AS/6650 and AS/6660. The IPL 4460 with four megabytes of main memory and an estimated 1.6 MIPS (millions of instructions per second) rating is priced at $190,800. The IBM 4361-5 with an estimated MIPS rating of 1.14 and four megabytes of memory has a price tag of $195,000. Both the IPL 4480 and the IBM 4381-2 are ▷

▶ 4460 has 16K bytes of operand cache memory when using 4K-byte pages in addition to the 8K-byte instruction cache.

The Store and Fetch Protection features, which guard against inadvertent overwriting and/or unauthorized reading of data in specified 2048-byte blocks of storage, are standard.

STORAGE TYPE: See Table 1.

CAPACITY: See Table 1.

CYCLE TIME: See Table 1.

CHECKING: All data paths between the central processor and main memory are parity-checked by byte. When data is stored, an error-correcting code is substituted for the parity bits. When the data is retrieved, single-bit errors are detected and corrected automatically, and most multiple-bit errors are detected and flagged for appropriate action.

RESERVED STORAGE: Not supplied by vendor.

CENTRAL PROCESSORS

The IPL 4400 Series processors are designed to execute the IBM System/370 instruction set, as well as special control functions associated with the IBM 4300 Series. The CPUs are modular in construction, and are built around a high-speed internal bus, called the ExpandaBus.

The processors are microcoded and have an internal cycle time of 50 nanoseconds. Extensive use of emitter-coupled logic (ECL) circuitry produces high internal speeds, while requiring less power and floor space and generating less heat than comparable systems.

The system architecture is modular, with the CPU, main memory, input/output channels, and console functioning as independent subsystems interconnected by the ExpandaBus. System expansion and upgrading is easily accomplished by removing/replacing the required boards from the system. Maintenance is also made simpler since faulty components can be replaced in the field, once the specific problem has been determined. The 4460 is field-upgradable to the 4480.

The system's operational characteristics are provided by microcode, a reloadable control program that is loaded into the system at power-up. Microcoding has made it possible for IPL, as well as its competitors, to quickly emulate architectural and functional changes in 4300 Series processors.

IPL's processors are equipped with dynamic address translation (DAT) which allows programs to be written using up to 16 megabytes of virtual storage in page sizes of 4096 or 2048 bytes. The conversion of a virtual address to a real address is done by a translation process using a set associative memory called Translation Lookaside Buffer (TLB).

The standard timing features of the System/370 architecture are included in the central processors. These include a CPU Timer and a Clock Comparator; the latter provides a means for causing an interrupt when the standard Time-of-Day Clock reaches a program-specified value. Additional instructions are provided to set and store the Time-of-Day Clock, Clock Comparator, and CPU Timer.

Additional features of the System/370 found in the IPL processors include control registers, a System/370 Commercial Instruction Set, a byte-oriented operand, conditional swapping, dynamic address translation, microprogrammed instruction retry, a double word buffer, an interval timer, machine check handling, a time-of-day clock, channel com- ▶

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TABLE 1. SYSTEM COMPARISON

MODEL	4460	4480
SYSTEM CHARACTERISTICS		
Date announced	October 1982	February 1983
Date first delivered	2nd quarter 1983	3rd quarter 1983
Field upgradable to	4480	—
Relative performance	—	—
Number of processors	1	2
Cycle time, nanoseconds	50	50
Word size, bits	32	32
Operating systems	DOS/VS, DOS/VSE, OS/VS1, OS/VS2, VM/370, SSX/VSE	DOS/VS, DOS/VSE, OS/VS1, OS/VS2, VM/370, SSX/VSE OS/MVS 3.8, OS/MVS SP 1.1, VM/SP1
MAIN MEMORY		
Type	64K RAM	64K RAM
Minimum capacity, bytes	4M	8M
Maximum capacity, bytes	16M	16M
Increment size	4M	4M
Cycle time, nanoseconds	500	500
BUFFER STORAGE		
Minimum capacity	16K	24K
Maximum capacity	24K	24K
Increment size	—	—
INPUT/OUTPUT CONTROL		
Number of channels:		
Byte multiplexer	1	1
Block multiplexer	5	5
Word	—	—
Other	—	—

▷ rated at an estimated 2.7 MIPS and the NAS AS/6660 has an estimated MIPS rating of 2.8. With the same amount of main memory (16 megabytes) the IBM 4361-5 is priced at $620,000, and the NAS AS/6660 is priced at $539,000, compared to the purchase price of $503,400 for the IPL 4480. The 4480, according to IPL, competes with systems manufactured by Tandem and Stratus in regard to fault tolerance; however, the 4480 is reported to have a greater processing capacity than either the Tandem or Stratus machines, and has the advantage of IBM program compatibility.

ADVANTAGES AND RESTRICTIONS

The big advantage of the IPL 4400 Series in the IBM plug-compatible market is its low purchase price. The 4460 and the 4480 support all the operating systems offered on the IBM 4300 Series except VM/XA and IX/370 which were added by IBM to the 4300 Series last year.

The disadvantage of any plug-compatible mainframe is that the vendor usually does not market peripherals to sell with the CPU. In the case of the IPL machines, no integrated peripheral controllers are available. The IPL systems can utilize all IBM System/370 and 4300 Series input/output and mass storage subsystems, except those that require integrated controllers or adapters. Data streaming is required for high-speed disk drives.

IPL calls the Model 4480 the "Continuous Compatible Computer." The company says that this system can "survive the vast majority of hardware failures and continue to function even while the failing component is being identified and replaced." While the 4480 employs the tightly coupled approach to continuous, nonstop processing, one possible drawback that should be considered is that shared ▷

▶ mand retry, channel indirect addressing, a console audible alarm, a console file, advanced control program support, an extended control mode, and program event recording. Control registers are used for operating system control of relocation, priority interruptions, program event recording, error recovery, and masking operations. A double-word buffer consists of a 64-bit area temporarily reserved for data used in performing an I/O operation. Each channel attached to the CPU has a fixed amount of channel buffer dedicated to its use.

The interval timer is a 32-bit decremental counter that is reduced by one several hundred times per second. The timer generates an interrupt when the contained value is decremented from a positive to a negative number. Machine check handling analyzes errors and attempts recovery by retrying the failed instruction if possible. If retry is unsuccessful, it attempts to correct the malfunction or to isolate the affected task. The time-of-day clock is incremented once every microsecond and provides a consistent measure of elapsed time suitable for the indication of date and time. Some channels have the capability to perform channel command retry, a channel and control-unit procedure that causes a command to be retried without requiring an I/O interruption. Channel Indirect Addressing (CIA) is a companion feature of dynamic address translation, providing data addresses for I/O operations. CIA permits a single channel command word to control the transmission of data that crosses noncontiguous pages in real main storage. If CIA is not indicated, then channel one level (direct) addressing is employed.

The console audible alarm is a device activated when predetermined events occur that require operator attention or intervention for system operation. The console file is the basic microprogram loading device for the system, containing a read-only file device. The media read by this device contains all the microcode for field engineering device diagnostics, basis system features, and any optional system features. The extended control mode (EC) is a mode in which all features of the System/370 computing system, including dynamic address translation, are operational. Program event recording is a hardware feature used to assist in debugging programs by detaching and recording program events. ▶

▷ main storage can be a single failure point for both processors. IPL claims that this potential problem is minimized through the use of dual port independent access to each storage module and the unique partitioning of main storage into one-megabyte module field replaceable units. Until recently IBM did not offer a nonstop system, but with the announcement of the System/88 IBM now has a fault-tolerant system. Compared to the shared memory of the IPL 4480 the duplexed memory of the IBM System/88 is a definite advantage.

USER REACTION

The 1985 Datapro Computer Users Survey yielded no responses from IPL 4400 Series users. Datapro contacted four users selected from a list supplied by the vendor. This represents a very small, but quite diverse group of users: a government agency which has one Model 4480 installed with 200 remote and local terminals on-line; a manufacturer with a Model 4460 performing system testing; a communications facility with two 4460 systems and 23 local and remote terminals on-line; and a research company which has one Model 4460 installed and plans to purchase a Model 4480 later this year. Just as varied as the businesses are the applications for the 4400 Series. They range from interactive and batch processing, to CAD/CAM and raster processing, and testing networking programs. All four respondents had purchased their systems. Two users had converted from IBM systems and one had upgraded from a smaller IPL system. Operating systems software included MVS and VM/SP, and Cobol was the prefered language. Two respondents performed their own maintenance service, and two used Sorbus service.

Three users said that the system had performed as expected and they would recommend the system to another user. The same three respondents experienced very little downtime and rated the reliability of the mainframe and the ease of operation from good to excellent. Troubleshooting, education, and documentation also received a rating from good to excellent. The fourth user experienced excessive CPU failure, and rated the reliability of the mainframe and the ease of operation from poor to fair. He also rated troubleshooting, education, and documentation as fair or poor. The respondent stated that he was not satisfied with the system and would not recommend it to another user. Peripherals are not provided by IPL; therefore, we did not ask the users to rate these devices. StorageTek and Masstor disk drives were used by three of the respondents, and no problems were reported. □

▶ The 4480 consists of two completely independent processing units sharing a partitioned, dual-ported main storage. Each processing unit has its own instruction execution unit, control storage, channel set cache buffers, storage control unit, service processor, operator console, and power supplies. When operating in a tightly coupled, dual-processor configuration, a simplified image of the system is presented to the user in terms of peripherals, input and output queues, and system control. In contrast, the system may also be configured as two separate uniprocessor systems, providing continuous availability of a production system on one of the uniprocessors while software or hardware maintenance is running on the other.

All 4400 Series processor operations are controlled by microprograms that reside in high-speed control storage. The standard control storage capacity is 64K bytes in Model 4460 and 128K bytes in Model 4480. Control storage can be increased to 128K bytes or 256K (4480) if required. This is sufficient to hold the microcode required for the System/370 Universal Instruction Set and all of the standard software assist features. The microprograms are loaded into control storage by means of a diskette unit called the Console File.

Model 4460 has sixteen 32-bit general-purpose registers and eight 64-bit registers. Model 4480 has two-by-sixteen bit general-purpose and two-by-eight 64-bit floating point registers. These registers can be used for indexing, base addressing, and as accumulators.

The Extended Control (EC) and Extended Control Program Support (ECPS) features are standard on the 4400 Series processors. As a result, both models can operate in any of the following modes: Basic Control (for System/360 programs); Extended Control (for programs that require dynamic address translation); ECPS:VS1 (which uses microcoding to improve system performance under the VS1 operating system); ECPS:VM/370 (which provides improved system performance under VM/370); ECPS:VSE mode, which uses microcoding to reduce overhead and improve system throughput under DOS/VSE; and ECPS:MVS, which provides improved performance when operating under MVS. In addition, all releases of MVS/SP can operate in native mode or concurrently with ECPS:VM.

A system console is supplied with the 4400 Series central processor models. It consists of a control panel, keyboard, CRT display, the Console File (a pair of diskette drives used to load the 4400 microcode and system diagnostics into control storage), and an optional console printer. The system console can operate in either of two modes, as selected during the initial microprogram load (IMPL) procedure.

- Display mode, in which the CRT and keyboard appear to the operating system as an IBM 3277 Model 2 Display Station with keyboard. This mode requires the Device Independent Display Operator Console Support (DIDOCS) software or its equivalent. If the optional console printer is included, it requires the Multiple Console Support (MCS) software or its equivalent and must be addressed separately as an IBM Console Printer.

- Printer-keyboard mode, in which the CRT, keyboard, and optional console printer appear to the operating system as an IBM 3215 Console Printer-Keyboard. This mode is supported by DOS, DOS/VS, OS, OS/VS, and VM/370.

The system console also contains the Service Processor, a microprocessor for diagnostic functions, and a remote data link facility that provides on-line communications for remote diagnostics.

The CRT(s) associated with the console can be located up to 30 feet from the CPU. IPL supports up to three additional CRTs and printers at the console on Model 4460 and up to six additional CRTs and printers on Model 4480. IPL also supports IBM 3278 2A, 3279 2C, and compatible terminals.

SPECIAL FEATURES: The 4400 Series features a high-speed multiply/divide unit to improve system performance.

PHYSICAL SPECIFICATIONS: The 4460 and 4480 are housed in identical cabinets, which also contain the maximum of 16 megabytes of main memory. The cabinet is 31.5 inches (80 cm) wide, 63 inches (160 cm) deep, 60 inches (153 cm) high, and weighs 2,000 pounds (907 kg). Central system components require 208 VAC ±10 percent, 3 phase at 60 Hz ±0.5 percent. Heat dissipation is 10,000 Btu per hour for the 4460, and 17,000 Btu per hour for the 4480. A ▶

IPL Systems 4400 Series

▶ temperature between 60 to 90 degrees Fahrenheit (15 to 32 degrees Centigrade) with a relative humidity between 20 and 80 percent noncondensing is an acceptable range.

CONFIGURATION RULES

IPL 4400 systems can be configured in essentially the same manner as IBM System/370 and 4300 Series computer systems, except that no integrated peripheral controllers are available for the IPL computers.

The IPL 4400 can utilize all IBM System/370 and 4300 Series input/output and mass storage subsystems, except those that require integrated controllers or adapters, as well as the plug-compatible counterparts of these IBM subsystems offered by other vendors. Detailed coverage of many of these peripherals can be found in Volume 2 of DATAPRO 70.

INPUT/OUTPUT CONTROL

The IPL 4400 systems support one byte multiplexer channel and up to five block multiplexer channels. Each byte multiplexer channel has 256 unshared subchannels and can address up to 256 devices. Similarly, each block multiplexer channel can have up to 256 subchannels. Unit control words (UCWs) can be dynamically assigned from a pool of 432 unshared and 16 shared UCWs.

The maximum byte multiplexer channel data rate is 50,000 bytes per second in normal operating mode and 180,000 bytes per second in burst mode. Any block multiplexer activity reduces the byte multiplexer data rate.

Block multiplexer channels 1 and 2 have a maximum data rate of 3.0 million bytes per second (Data Streaming), and block multiplexer channels 3 through 5 have a maximum rate of 2.0 million bytes per second. The aggregate data rate for all block multiplexer channels in a 4460 system is 11 million bytes per second. For Model 4480, the aggregate block multiplexer data rate is 18 million bytes per second. Block multiplexer channels can operate as selector channels where they control one operation at a time.

A unique double-word buffer that provides greater levels of throughput is included with each block multiplexer channel.

Each of the processors within the 4480 comes equipped with its own independent channel set with one byte multiplexer channel and four block multiplexer channels. These dual independent channel sets allow for one of the processors to be taken off-line and used to isolate and repair a failing path while the system continues to run as a uniprocessor.

Concurrently with computing, a 4400 Series processor can control a maximum of one high-speed I/O data transfer operation on each block multiplexer channel and one low-speed I/O data transfer operation on each subchannel of each byte multiplexer channel, subject to the maximum channel and aggregate data rates specified above. Alternatively, a byte multiplexer channel can operate in burst mode and handle a single high-speed I/O operation instead of multiple low-speed operations.

MASS STORAGE

Not supplied by vendor.

INPUT/OUTPUT UNITS

Not supplied by vendor.

TERMINALS

Not supplied by vendor.

COMMUNICATIONS

Not supplied by vendor.

SOFTWARE

OPERATING SYSTEM: The Model 4460 fully supports the following IBM operating systems: DOS/VS, DOS/VSE, OS/VS1, OS/VS2 (SVS and MVS), VM/370, and SSX/VSE. Detailed descriptions of these operating systems can be found in the IBM 4300 Series report (70C-504MK-301). Extended Control Program Support (ECPS) for VS1, DOS/VSE, MVS, and VM/370 is standard in both models. Concurrent operation of ECPS:VM and ECPS:VS1 or ECPS:MVS is also standard.

When Model 4480 is operated in a tightly coupled, multiprocessor complex, it is supported by OS/MVS 3.8, OS/MVS SP 1.1 or higher, or VM/SP Release 1 or higher. When it is run as two uniprocessors, it is supported by all operating systems supported on Model 4460.

PROGRAMMING LANGUAGES: The IPL 4400 Series supports all languages depending on applications software.

DATA BASE MANAGEMENT: All DBMS products from IBM and other vendors are supported.

DATA MANAGEMENT: Not supplied by vendor.

DATA COMMUNICATIONS: *CICS* from IBM, and Communications Monitors from third-party vendors are supported.

PROGRAM DEVELOPMENT: Not supplied by vendor.

UTILITIES: All utilities available for the IBM 4300 are supported on the IPL 4400.

OTHER SOFTWARE: IPL is a plug-compatible vendor, therfore does not supply its own software.

PRICING & SUPPORT

POLICY: IPL 4400 Series systems are available on a direct purchase basis only.

Since Model 4480 is considered a single processing complex, only a single license fee is needed for each IBM licensed program whether the 4480 is operated as a tightly coupled dual processor or as two separate uniprocessor systems.

SUPPORT: IPL provides support through 114 Sorbus offices throughout the country. Sorbus' hardware/software specialists are trained by IPL to handle problems that arise at a local level. IPL's Technical Support Center, located in Waltham, MA, can also be contacted, and a communications link is established in order to isolate and correct system malfunctions.

With IBM providing System Installation Productivity Options (SIPOs) for non-IBM users, IPL and other plug-compatible vendors can function as a user's agent in dealing with IBM for specific SCP and other licensed IBM program products.

The minimum monthly maintenance charges, as shown in the following price list, include support for both hardware and SCPs for one shift per day, five days per week. Full ▶

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➤ maintenance coverage for 24 hours per day, seven days per week is available.

EDUCATION: Not offered by vendor.

TYPICAL CONFIGURATION: IPL Systems is an IBM plug-compatible vendor and does not provide mass storage units, terminals or other peripherals for its systems. For central processor configuration prices refer to the price list at the end of this report.

EQUIPMENT PRICES

		Purchase Price ($)	Monthly Maint. ($)
PROCESSORS			
	Model 4460 Processor; includes CPU with 50-nanosecond cycle time, 500-nanosecond main memory, one byte multiplexer and five block multiplexer channels, 16K byte or 24K byte high-speed buffer storage, 64K bytes of control storage, and system console		
4460-4	4,096,000 bytes of memory	190,800	964
4460-8	8,192,000 bytes of memory	223,800	1,084
4460-12	12,228,000 bytes of memory	256,800	1,204
4460-16	16,384,000 bytes of memory	289,800	1,324
	Model 4480 Processor Complex; includes two tightly coupled CPUs, each with 50-nanosecond cycle time, 500-nanosecond dual ported main memory, one byte multiplexer and four block multiplexer channels, 24K byte high-speed buffer storage, 64K bytes of control storage, and system console		
4480-8	8,192,000 bytes of memory plus 1,096,000 bytes active spare memory	433,000	1,084
4480-12	12,288,000 bytes of memory plus 1,096,000 bytes active spare memory	468,200	1,204
4480-16	16,384,000 bytes of memory plus 1,096,000 bytes active spare memory	503,400	1,324
SYSTEM OPTIONS			
4460	High-speed multiply divide	5,000	—
4480	High-speed multiply divide	10,000	— ■