BTI 8000

MANAGEMENT SUMMARY

UPDATE: *Recent enhancements to the BTI 8000 system have been in the software area. The MARS II relational database management system was designed to take full advantage of the BTI 8000's 32-bit architecture. Also new is the COMP fourth generation programming language, available as part of MARS II. In applications software, BTI has announced that MCBA business software is now being offered for the 8000.*

The BTI 8000 is based on a 32-bit, 67-nanosecond bus serving multiple processors, controllers for main memory modules, a System Services Unit, and peripheral processors which in turn control I/O device controllers, an approach which BTI calls "Variable Resource Architecture." Computational Processing Units (CPUs), Memory Control Units (MCUs), Peripheral Processing Units (PPUs), and System Services Units (SSUs) can be plugged into the bus in any mix to match the requirements of the application. A minimum configuration requires at least one of each. The system's computational power, memory, and I/O resources are automatically pooled for efficient processing of the overall workload. If an application subsequently requires more computational power, memory, or I/O capacity, additional modules can be plugged into the bus. Conventional manual regeneration of the operating system (sysgen) is not required when changing the hardware configuration—the system does it automatically under control of one front-panel switch. The 8000's hardware configuration is totally isolated from the user software, preserving a user's software investment as the system grows.

The BTI 8000 is a 32-bit, multiprocessor, multiuser, and multifunction system. Modular in configuration, the 8000 is designed around a central bus with a 32-bit wide data path and 16 slots for plug-in attachment of system resource modules. The system is capable of supporting as many as 256 interactive users and provides a high level of security for users in a time-sharing environment.

MODEL: 8000.
MEMORY: 1M to 24M bytes.
DISK CAPACITY: Up to 9G bytes.
WORKSTATIONS: Up to 256 (interactive).
PRICE: Basic system package—$79,950.

CHARACTERISTICS

MANUFACTURER: BTI Computer Systems, 870 West Maude Avenue, Sunnyvale, California 94086. Telephone (408) 733-1122.

CANADIAN ADDRESS: BTI does not currently have an office in Canada.

DATA FORMATS

BASIC UNIT: 32-bit word and 8-bit byte.

FIXED-POINT OPERAND: Operands can be single or double words, a character, or a field of from 1 to 32 bits.

The BTI 8000 is a 32-bit multiprocessor packaged system designed to support up to 256 interactive users in a multilanguage, multifunction environment. The system, which is modular in configuration, can also support up to 24MB of main memory and 9GB of disk storage.

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CHART A. SYSTEM COMPARISON

MODEL	BTI 8000
SYSTEM CHARACTERISTICS	
Date of introduction	May 1980
Date of first delivery	June 1981
Operating system	8000-VRM
Upgradable from	Not applicable
Upgradable to	Not applicable
MIPS	1.0 to 3.5
Relative performance	Not applicable
MEMORY	
Minimum capacity, bytes	1M
Maximum capacity, bytes	24M
Type	ECC-MOS
Cache memory	None
Cycle time, nanoseconds	670
Bytes fetched per cycle	4
INPUT/OUTPUT CONTROL	
Number of channels	Max. 32
High-speed buses	32-bit
Low-speed buses	Not applicable
MINIMUM DISK STORAGE	64MB
MAXIMUM DISK STORAGE	9GB
NUMBER OF WORKSTATIONS	256
COMMUNICATIONS PROTOCOLS	RS-232-C asynchronous

The BTI 8000's operating system creates private virtual machine environments for each process, independent of and isolated from the hardware configuration. Users may therefore develop application programs without reference to the specific system's hardware, and reprogramming is unnecessary as a system is expanded or otherwise changed in configuration.

BTI's Variable Resource Architecture also makes the 8000 system "fail-soft." In a multimode configuration, the loss of a processor or memory bank merely reduces the resource pool. The operator removes or replaces the faulty module—identified by built-in diagnostics—and resumes system operation with a one-button restart.

The BTI 8000's bus provides a 32-bit wide data path and uses distributed logic to achieve a data transfer rate between resource modules of 60M bytes per second. Up to 16 resource modules can be plugged into the bus. In addition to the CPU, MCU, and PPU modules, the system requires one SSU, a microprogrammed processor that provides system control.

The SSU includes the system's operator control panel, with pushbuttons for various system operations and a 10-character alphanumeric display. The display informs the operator of normal and exception status conditions and the results of self-test diagnostics. Each resource module automatically runs a self-test at system start-up (bootstrap). On completion of the self-tests, the SSU continues "bootstrap," which, if all modules are operative, configures the operating system. Any module not in working order is identified by the SSU display. The operating system also checks the resource modules present and, if the hardware configuration has been expanded or reduced by the operator since the previous start-up, automatically reconfigures the operating system to match the resources available. The

FLOATING-POINT OPERAND: Sixteen floating-point instructions deal with 64-bit, double-word operands, which include 11-bit biased exponents (10^{-154} to 10^{154}) and 52-bit mantissas (over 15 decimal digits).

INSTRUCTIONS: Machine instructions are all one word in length and reside on memory word boundaries. There are 174 machine instructions available to the user. The lowest 22 bits of most instructions specify an operand, while the next 3 higher bits are sometimes used to specify a register. Different methods of referencing operands are provided by the "address mode" field and 21 addressing modes. Indirect addressing further involves special one-word structures called pointers, which themselves contain address mode fields and parameters for operand specification.

Instructions provided for subroutine-linkage check entry points and provide parameter-type checking for the subroutine. The calling sequence and the entry sequence are executed part by part, passing one parameter at a time with the pass parameter instructions on the calling side and corresponding store parameter instructions on the subprogram side. The instructions specify the parameter type, whether the parameter is being passed by location or value, and whether this is the last parameter in the protocol.

INTERNAL CODE: ASCII.

MAIN STORAGE

TYPE: ECC-MOS RAM.

CYCLE TIME: Read access time is 867 nanoseconds, including two bus transfers (read request and response) and byte parity check. Write time is 667 nanoseconds.

CAPACITY: Minimum memory is 1M bytes and is increased in 1M-byte increments to a maximum of 24M bytes. For cross-vendor comparative information on BTI 8000 system capacities, please refer to Chart A, System Comparison Chart.

CHECKING: The memory incorporates automatic checking of single- and double-bit errors, and correction of single-bit errors.

STORAGE PROTECTION: The memory management logic divides memory present into 4096-byte pages, while treating memory as an entity. Assignment of pages of physical memory to satisfy virtual memory page requests is controlled by the memory manager. Pages of memory exhibiting hard errors are automatically deleted from the pool of memory pages available. Battery backup supports memory for up to two hours.

RESERVED STORAGE: The system reserves approximately 10 to 30 pages (40K- to 120K-byte), depending on the system configuration, for memory management and other system operations.

CENTRAL PROCESSOR

GENERAL: The major resource modules and all peripheral controllers are special-purpose microprogrammed processors, which in turn use microcomputer-based submodules for many service functions. The foundation of the system is the Variable Resource Architecture (VRA) bus, a distributed-logic, passive, synchronous bus with a 32-bit wide data path and 16 slots for the attachment of major modules. All data transfers between major modules take place through the VRA bus at 67 nanoseconds per 32-bit word (15 million words per second or 60 million bytes per second).

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SSU contains a program-accessible system ID, a permanently assigned number which identifies the system in which the SSU is installed, which permits vendors of proprietary software packages control of what systems can run their packages by checking the system ID before executing.

The Computational Processing Unit is a microprogrammed processor which uses 32-bit architecture throughout. Integer arithmetic is 32 or 64 bits; floating-point arithmetic is 64 bits. Twenty-one addressing modes directly support compiler data structures, including stack, queue, array, and linked-list structures, with arbitrary size data elements. System computation is performed by one or more Computational Processing Units, operating concurrently. To gain more computational power, additional CPUs are plugged into the bus. The operating system software assigns tasks equally among available CPUs to achieve true concurrent processing. As an indication of the CPUs' speed, a fully configured, multiple-CPU system performs floating-point multiplication with 64-bit operands in an average time of approximately three microseconds. Hardware address mapping in the CPU converts virtual memory addresses to physical memory addresses in parallel with instruction execution.

The BTI 8000 uses MOS (metal oxide semiconductor) memory with ECC (error-correcting code) and features a 670-nanosecond full cycle time (including Memory Control Unit operation). Read access time is under 900 nanoseconds. Memory is furnished in 1M-byte increments and is interfaced to the system via the MCUs. Minimum memory is 1MB, and the system will support up to 24MB of main memory. All memory present is treated by the system as an entity (even if interfaced through more than one MCU) organized in pages of 4096 bytes. In the event of a memory malfunction, the system eliminates the bad area on a page basis and reconfigures the available memory.

Mass storage for the BTI 8000 is provided by disk drives in formatted capacities from 67 to 279MB. Drives are of both fixed and removable storage types. One disk controller can control up to four drives in any mix and can provide for overlapping seeks to minimize access times. A special error-correction technique substantially reduces the risk of data loss in the event of disk-read problems. Mass storage data transfers take place one page at a time, and each page occupies one "block" of disk capacity. Blocks are stored on disk in a number of segments in such a way that an entire block can be reconstructed even if a segment becomes totally unreadable. The system "remembers" bad areas and dynamically reassigns block placements to work around them.

All system peripherals, including disk drives, are controlled by device controllers. Each Peripheral Processing Unit can support up to four controllers. Peripherals currently available for the BTI 8000 include serial magnetic tape cartridge drives, 9-track open-reel magnetic tape drives, and four line printers with print rates from 300 to 1,200 lines per minute.

The four major modules are the System Services Unit (SSU), the Computational Processing Unit (CPU), the Memory Control Unit (MCU), and the Peripheral Processing Unit (PPU). A system must include at least one of each, but no more than one System Services Unit is required. Additional CPUs, MCUs, and PPUs can be configured to the system to increase throughput and to provide fail-soft operation.

All resource modules automatically carry out self-tests at system start-up. On completion of its self-test, the SSU completes system start-up. If all modules are operative, the operating system is automatically configured to match the resources present. Faulty resource modules are identified with the aid of a front panel display. In multimodule configurations, faulty modules can be removed and the system restarted (one-button bootstrap).

The System Services Unit is internally cabled to the operator's panel. The panel contains a readout of 10 alphanumeric characters for reporting system status and exception conditions, an alarm light, and eight rocker switches. The switches include the main power switch, a switch to disable BTI remote maintenance access, a switch to select between normal start-up and dedicated diagnostic start-up, the run/halt switch, and four switches to select from 16 variations of start-up or diagnostic operation.

CONTROL STORAGE: Although the BTI 8000 CPU is microprogrammed, the user cannot modify control storage.

REGISTERS: Eight 32-bit general-purpose registers, a program counter, and a processor status register are available for machine-language programming.

ADDRESSING: Twenty-one addressing modes reference operands in registers, in memory, and instructions themselves. Addressing modes directly support compiler data structures, including stack, queue, and linked-list, with data elements of arbitrary size. Virtual to physical memory address conversion is performed in a one-bus cycle (67 nanoseconds) in parallel with instruction execution.

INTERRUPTS: Computational Processors present in the system configuration are subject to interrupts and traps, which are tracked by the VRM operating system.

Interrupts are generated primarily by I/O devices and by the System Services Unit. Whichever Computational Processor is free first will pick up an interrupt. Traps (program exceptions) are generated by the user process running on a Processor and direct the Processor to the appropriate trap routine.

OPERATING ENVIRONMENT: The nominal operating environment for the BTI 8000 system is 60 to 80 degrees F (15 to 27 degrees C) at 20 to 80 percent relative humidity, noncondensing.

A 2-bay cabinet minimum configuration is 70.75 inches (179.7 centimeters) high, 48.5 inches (123.2 centimeters) wide, 32.75 inches (83.2 centimeters) deep, and weighs 715 pounds (324 kilograms).

An expanded 3-bay cabinet configuration is 70.75 inches (179.7 centimeters) high, 71.0 inches (180.4 centimeters) wide, and 32.75 inches (83.2 centimeters) deep. A 4-bay system is the same height and depth as the three-bay configuration, but is 22.5 inches wider with a total width 93.5 inches.

Power requirements for the BTI 8000 system are 200 to 250 VAC, 60 Hz, single phase (50 Hz operation optional). For a base system, maximum AC power consumption is 4600 watts, and maximum heat dissipation is 16,000 Btus per hour.

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CHART B. MASS STORAGE

MODEL	8230	8232	8234
Type	8″ fixed	8″ removable	8″ fixed
Controller model	8208	8208	8208
Drives per subsystem/controller	1 to 4	1 to 4	1 to 4
Formatted capacity per drive, megabytes	67	67	135
Number of usable surfaces	5	5	10
Number of sectors or tracks per surface	3292 tracks	3292 tracks	3292 tracks
Bytes per sector or track	4096 per track	4096 per track	4096 per track
Average seek time	35 ms	30 ms	30 ms
Average rotational/relay time	8.3 ms	8.3 ms	8.3 ms
Average access time	43.3 ms	38.3 ms	38.3 ms
Data transfer rate	1.2MB per sec.	1.2MB per sec.	1.2MB per sec.
Supported by system models	8000	8000	8000
Comments			

CHART B. MASS STORAGE (continued)

MODEL	8236	8215	8225
Type	8″ fixed	14″ removable	14″ removable
Controller model	8208	8208	8208
Drives per subsystem/controller	1 to 4	1 to 4	1 to 4
Formatted capacity per drive, megabytes	279	67	254
Number of usable surfaces	—	5	19
Number of sectors or tracks per surface	3292 tracks	3292 tracks	3292 tracks
Bytes per sector or track	4096 per track	4096 per track	4096 per track
Average seek time	20 ms	30 ms	30 ms
Average rotational/relay time	8.3 ms	8.3 ms	8.3 ms
Average access time	28.3 ms	38.3 ms	38.3 ms
Data transfer rate	—	1.2MB per sec.	1.2MB per sec.
Supported by system models	8000	8000	8000
Comments			

Terminals and modems are interfaced to the BTI 8000 through an Asynchronous Communications Controller (ACC), which is in turn controlled through a PPU channel. One PPU can control up to four ACCs, and each ACC can control up to 64 ports in increments of 8 ports. BTI considers a practical maximum for the 8000 system to be 256 ports. Any or all ports can be used at rates up to 19,200 bps. To allow users flexibility in the type of asynchronous terminal or other asynchronous device to be used with the system, user programs have full control over interface pins, selection of terminating characters, and input and output buffers.

Security mechanisms have been designed into the 8000 system, including its hardware, to enable the system to operate in a secure, multiuser, on-line environment. The account structure is closed and secure in that all operations and data remain private within account boundaries, unless explicit action to grant foreign access is taken. All passwords required are stored in encrypted form only, and BTI claims there is no way to decrypt stored passwords. Users can share files on a read-only basis, can limit writing privileges to "append-only," or can grant full access to a file. On-line disk packs are not encrypted. A special recording format is used to provide security.

The BTI 8000's operating system provides private virtual machine environments in which the system manager, operator, and all other users operate. The virtual system shields all users from the actual hardware present in any given configuration. Any program will execute regardless of the number of CPUs, amount of physical memory, or even the

INPUT/OUTPUT CONTROL

Peripheral Processing Units (PPUs) are special-purpose processors which relieve CPUs of channel management overhead. Each PPU manages up to four independent I/O channel activities initiated by the CPUs, handling data transfers between memory and the peripheral devices. PPUs also provide buffering, blocking, and deblocking capabilities. The PPUs' channels can be connected to the controllers of the following peripherals: disk drives, 9-track magnetic tape drives, magnetic tape cartridge drives, line printers with speeds of 300 to 1200 lpm, and user communications facilities.

Up to eight PPUs can be configured to a BTI 8000 system providing an input/output capacity of 32 channels. All peripheral devices interfaced to the respective number of channels provided by the PPUs can be active simultaneously, accommodating multitasking operations.

CONFIGURATION RULES

GENERAL: The 8000 is modular in configuration and is designed around a Variable Resource Architecture bus with a 32-bit wide data path and 16 slots for the attachment of major modules. At least one each of the four major modules (System Services Unit, Computational Processing Unit, Memory Control Unit, and Peripheral Processing Unit) must be included. Only one System Services Unit is necessary, but multiples of the other three may be attached as needed to increase memory size, to add peripherals, or to increase computational power.

Up to 24MB of main memory can be interfaced to the BTI 8000 via Memory Control Units (MCUs) with a single MCU controlling from 1M to 4M bytes of semiconductor memory. Additional memory is available in increments of

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specific peripherals connected to the system. The user can make I/O assignments externally to the program to suit his or her convenience. The operating system is protected to ensure inviolate system operation despite any possibly harmful activities attempted by any user process or by the system operator. Each user program runs in a virtual work space of 512K bytes regardless of the actual amount of physical memory present or the number of other users sharing that memory. The operating system itself uses address space separate from the user's work space for all I/O services associated with the user's process.

Memory is organized in pages of 4096 bytes, all of which is available to the programmer. Real memory is dynamically allocated to users' processes on a demand-paged basis in a manner transparent to users. User processes can generate other concurrent processes to handle heavy work loads in parallel.

BTI has chosen not to develop application software, but reaches end-users requiring such software through an informal alignment of its computer systems with application software furnished by independent vendors. BTI offers a significant advantage to application software suppliers; protection for their software comparable to that of BTI's proprietary operating system. With their software protected by an exclusive "proprietary" screen initially set-up by BTI, vendors are able to install their software on BTI 8000 systems and can support their software over the telephone, much as BTI supports its own software.

Software emphasis is on the commercial DP market stressing data protection and on-line terminal access. Software bundled with the system includes the operating system, Control Mode (the system's command language), and the following utilities: copy, sort/merge, help, loader, spooler, backup/recovery, operator/manager, interactive editor, debugger, plus one programming language. Sequential, relative, and multiple-keyed indexed sequential file-access methods are supported. A file utility package is also provided as part of the bundled software. High level languages offered by BTI include Cobol 74, Fortran 77, Pascal/8000, and BTI Basic (Basic-X). There is also an assembler.

BTI markets application software for its systems from other sources, such as third-party vendors. Recently, a major agreement was reached between BTI and MCBA, where BTI will market MCBA's business software for the BTI 8000 system.

COMPETITIVE POSITION

The major target markets for the BTI 8000 system are data processing departments requiring high processing response and large database applications involving extensive multiuser access.

Major competition for the BTI 8000 is presented by other 32-bit systems, in particular, the Digital Equipment VAX 8600, Hewlett-Packard's HP 3000, the Prime 50 Series

1M bytes. Memory is organized in pages of 4096 bytes. (Each MCU occupies one of the system's 16 basic module slots.)

WORKSTATIONS: Virtually any terminal with a standard RS-232-C interface can be used with the BTI 8000 system. Any modems with facilities for the RS-232-C interface can be used for remote applications. The BTI 8000 is capable of supporting up to 256 interactive users.

DISK STORAGE: The Model 8205 disk controller used in the BTI 8000 supports up to four drives, in any mix of capacities.

MAGNETIC TAPE: Nine-track, 800/1600-bpi, 45- and 75-ips reel-to-reel magnetic tape drives and a high-density cartridge tape unit can be configured to the BTI 8000 for loading and dumping data files and programs.

PRINTERS: One controller is required per printer for each printer configured to the BTI 8000 system.

MASS STORAGE

For information on available mass storage devices for the BTI 8000, please refer to Chart B, Mass Storage Devices.

INPUT/OUTPUT UNITS

As a purchasing convenience to customers, BTI offers, as options, a line of workstations manufactured by other vendors. Descriptive specifications for available workstations are usually presented in Chart C, Workstations, but the latter chart does not appear in this report at the request of the vendor. Readers are requested to contact BTI directly for information on currently available workstations.

For information on available printers please refer to Chart D, Printers. For information on available magnetic tape equipment please refer to Chart E, Magnetic Tape Equipment.

COMMUNICATIONS CONTROL

GENERAL: The BTI 8000, in its largest configuration, can support a practical limit of 256 interactive users.

The *8510 Asynchronous Communications Controller (ACC)* supports up to eight 8515 8-port (RS-232-C) interfaces for a maximum configuration of 64 ports. One Peripheral Processing Unit can control four ACCs (a total of 256 ports per PPU). Data rates can be set individually to any standard rate from 110 to 19,200 bps. The ACC includes internal buffering to accommodate full-screen (1,920 characters), interactive terminals.

SOFTWARE

OPERATING SYSTEM: The BTI 8000 operating system pools and coordinates physical machine resources, including processors, to provide a secure environment for each user of the system. The operating system shields all users from actual hardware configurations, creating a virtual machine for each user process, and is itself protected from violation by user processes. It is also responsible for automating as much of the system operation as possible.

When the system is started, either from the operator's panel or through the remote maintenance facility, the System Services Unit sends a start signal through the bus, causing all units to run self-contained diagnostics. Upon successful completion of this stage of system start, the first Computa-

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Model 9955, and Data General's MV/10000. As a general-purpose superminicomputer system, the Prime 9955 provides a good measure for comparison.

The BTI 8000 supports up to 24MB of main memory; the Prime 9955 can only support up to 16MB. The two systems have similar disk capacities, 9GB for the BTI 8000 and 10GB for the Prime 9955. They also support virtually the same number of workstations—the BTI 8000 supports 256, while the Prime 9955 can support 254. In performance, the Prime system has a slight edge over the BTI 8000, as it can reportedly process 4.0 MIPS, compared to 3.5 MIPS performance on the BTI 8000.

ADVANTAGES AND RESTRICTIONS

One of the major advantages of the BTI 8000 is its fail soft Variable Resource Architecture. The failure of a processor or memory board will not halt the system; rather, the available resource pool is reduced and traffic is routed away from the failed component. This provides the user with a system that will suffer less downtime, and be more reliable in general than a system where a failed component brings the entire system down.

Another advantage of the BTI 8000 system is its modular expandability. The system is designed for flexible exapansion and reconfigurability, enabling a user to start out with a small installation and add memory, processors, and peripherals as needs dictate.

This expansion is limited, however. Since the BTI 8000 is not a member of a compatible family of systems like many of its competitors, there is no clear migration path to follow should a user outgrow the system parameters. While 24MB of main memory, 9GB of disk storage, and support for 256 terminals is quite sufficient for many installations and applications, it is still limited. For example, in DEC's VAX-11 systems, upward migration is stopped at the VAX-11/780 or VAX-11/785 levels, where main memory capacity can be up to 64MB, maximum disk storage is 30GB, and up to 384 users can be supported.

USER REACTION

Datapro contacted 4 BTI 8000 users in May 1985 to obtain the opinions of their computer systems.

The first user we contacted was a food distributor in the south central part of the country. Their BTI 8000 system was installed about a year ago, replacing a BTI 5000 system. A spokesperson for the company said that the conversion from the 5000 to the 8000 had gone very smoothly. The BTI 8000 system is used primarily to perform accounting, inventory control, payroll and sales analysis applications. The system had 1MB of main memory and 600MB of disk storage. There were 12 local terminals and 3 remote terminals attached to the system. The spokesperson said that the company is very pleased with the performance of the BTI system. He also said that they had not encountered any major problems with the system. They were particular-

tional Processing Unit to become ready temporarily takes over the system. It locks out other CPUs so that it can control system initialization, reads resident operating system code from a known location on the system disk volume into the low pages of physical memory, and then executes that code. This is the only circumstance in which one CPU assumes control of the system to the exclusion of other CPUs.

When the other CPUs are unlocked, the system immediately enters its normal run mode. At the start, there are no users on the system (assuming a cold start), and all CPUs run that portion of the operating system code (from a fixed physical memory location) which investigates a task assignment table elsewhere in memory; at this point, there will be no tasks, so all CPUs will go idle. When a device (particularly a communications controller) signals the beginning of what might be a user logon activity, the associated Peripheral Processing Unit places an interrupt signal on the bus. The first CPU to respond will handle the interrupt and post to the appropriate operating system tables.

In the steady state of system operation, when there are more processes than processors, each CPU requests an interrupt from the SSU (in varying intervals) after it "switches in" to any task to see if another task should be executed. Periodic interruption to run the operating system's task dispatching code does not require full context switching.

The memory tables used to direct and coordinate the activities of multiple CPUs are read and updated using software lockout. The lockout algorithms and the CPU instructions used to implement them are the same as those that the nonoperating system software can use to coordinate any set of cooperating simultaneous processes. A given memory location is chosen by mutual agreement to contain a "lock" word. Before proceeding through a critical region of code to be entered and executed completely by only one process at a time, the process executes a noninterruptible instruction that sets a special locked value into the public lock word while simultaneously bringing the previous value of that word into private storage for examination. If the retrieved value is other than locked, the process continues through the critical region, unlocking it when done. If, on the other hand, the retrieved value is locked, then the process waits, since this indicates that some other process has entered the critical region.

Even though memory modules can be physically interfaced through separate Memory Control Units, the system treats all of memory as a single continuous resource. The low n+9 pages ("n" is the number of resident CPUs) are unavailable for paging, since they contain resident operating system code and tables. The rest of memory is used on a page basis for temporary location of code and data transferred in from mass storage, with no preassigned boundaries or regions.

When a routine executing in a CPU instructs a PPU to transfer a page into memory from mass storage, the PPU is given two memory addresses. One is the location of the page itself; the other is the address of an operating system table element for storage of the structural information included in every mass storage block. In this way, programs can make use of the full 1,024 words in every page, since pointers, flags, and other maintenance information are kept externally to the page contents. A similar procedure is used to write to disk.

The operating system keeps track of the logical status of all pages in memory, including their "home" addresses on mass storage. If a user requests execution of a program, the operating system will search its lists before executing a disk-read request and will take advantage of memory residency of any of the program pages to avoid disk access; any number

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CHART D. PRINTERS

MODEL	8420	8422	8425	8427
Type	Band	Band	Band	Band
Speed	300 lpm	220 lpm	600 lpm	440 lpm
Bidirectional printing	Not applicable	Not applicable	Not applicable	Not applicable
Paper size	Up to 15"	Up to 15"	Up to 15"	Up to 15"
Character formation	Full	Full	Full	Full
Horizontal character spacing (char./inch)	10	10	10	10
Vertical line spacing (lines/inch)	6 or 8	6 or 8	6 or 8	6 or 8
Character set	64	96	64	96
Controller/Interface	8415	8415	8415	8415
No. of printers per controller/interface	1	1	1	1
Printer dimensions, in. (h x w x d)	44.5 x 34 x 24	44.5 x 34 x 24	44.5 x 34 x 24	44.5 x 34 x 24
Graphics capability	None	None	None	None
Comments				

CHART D. PRINTERS (continued)

MODEL	8430	8432	8435	8436
Type	Band	Band	Band	Band
Speed	900 lpm	660 lpm	1200 lpm	880 lpm
Bidirectional printing	Not applicable	Not applicable	Not applicable	Not applicable
Paper size	Up to 15"	Up to 15"	Up to 15"	Up to 15"
Character formation	Full	Full	Full	Full
Horizontal character spacing (char./inch)	10	10	10	10
Vertical line spacing (char./inch)	6 or 8	6 or 8	6 or 8	6 or 8
Character set	64	96	64	96
Controller/Interface	8415	8415	8415	8415
No. of printers per controller/interface	1	1	1	1
Printer dimensions, in. (h x w x d)	44.5 x 34 x 24	44.5 x 34 x 24	44.5 x 34 x 24	44.5 x 34 x 24
Graphics capability	None	None	None	None
Comments				

ly pleased with the system's high degree of expandability, and were planning to add another megabyte of main memory, an additional CPU, and more communication ports.

The second user represented a timesharing organization in the Southwest. He said that before settling on the BTI 8000, he had also considered the IBM System/38 and the DEC VAX-11/780; he selected the BTI machine because it seemed to deliver the best performance for the price. He praised the system, saying that he was impressed by its ease of use and by the reliability of the hardware and system software. He said he felt that the system is extremely "growth-oriented," allowing the addition of CPUs and peripherals as computing requirements increase. He also remarked that the BTI 8000 offers excellent Pascal and Cobol compilers, and noted that Fortran programs run extremely fast on the system.

On the negative side, this user cited as a drawback the lack of application software, particularly for manufacturing. He also said that BTI should offer more software development tools, such as a Fortran editor and macro procedures for Fortran compilation; these tools, in his opinion, would create a more user-friendly interface to the system. He said that he would recommend the system to users who had experienced software people in-house, but, due to the lack of tools, would not recommend it for those seeking a turnkey solution.

Overall, the second user rated the BTI 8000 "a super box." He said he felt that BTI was "90 percent there" with its system software; if the aforementioned tools could be added, he said, the BTI 8000 would be that much better.

of users can share any number of pages. This list searching takes place with every page-read request, including those for file data blocks.

Access control flags associated with each page indicate whether the page is read-only or writable, and, if writable, whether it has been altered during its residency. This information allows pages of writable program data or file data to be shared among multiple users. They will share the same physical memory page initially, but the operating system will create a private copy of a shared writable page for any process that issues an instruction that would alter the page contents.

The access control and status flags, including a "page referenced" flag, are carried into the page files of the CPUs, so that the system need not make an extra memory reference merely to update or examine them. The page referenced flag is used to identify the working set of a process as it executes, for scheduling purposes.

The system is disk-based in the sense that structural information and operating parameters are ultimately entrusted to mass storage. Main memory is treated as a temporary area for process operation, with any structured or parameter changes written to disk. System restart presumes no information in memory. Thus the main concern in mass storage management is maintaining the integrity of its structures.

Disk drives, disk modules, and disk volumes (the logical contents of packs) are all identified separately, so that, for example, volumes can be copied from module to module. Files and libraries of files reside on individual mass storage volumes, so that volumes may be dismounted either logically or physically without halting system operation or destroying the integrity of structures. The system volume, containing the operating system's operational tables and routines as well as other data, cannot be dismounted, but can be located on any physical disk drive in the system.

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CHART E. MAGNETIC TAPE EQUIPMENT

MODEL	8310	8330	8340
TYPE	Cartridge	Reel-to-reel	Reel-to-reel
FORMAT			
Number of tracks	4 (independent)	9	9
Recording density, bits per inch	6400	800/1600	800/1600
Recording mode	MFM	PE/NRZI	PE/NRZI
CHARACTERISTICS			
Controller model	Integral	8320	8324
Drives per controller	Max. 4	Max. 4	Max. 4
Storage capacity, bytes	15M	20M/40M	20M/40M
Tape speed, inches per second	30	45	75
Data transfer rate, units per second	192K	36K/72K	60K/120K
Streaming technology	None	None	None
Start/stop mode; speed	Not applicable	Not applicable	Not applicable
Switch selectable	No	Yes	Yes

A third user contacted represented an East coast timesharing company serving the specialty insurance industry. Applications included all insurance functions, as well as handling the indexing and cross referencing of the insurance companys' microfilming libraries. This BTI user had 48 terminals online with 10 terminals inhouse and 38 terminals in the local area using dial up and dedicated phone lines. The user mentioned that his system has 2MB of memory with 600MB of disk storage, uses both Pascal and Basic programming languages, and a third-party database management system. Prior to purchasing the BTI system, the user considered such systems as Burroughs, Hewlett-Packard, and Digital Equipment Corporation, but felt BTI was able to better handle their specialized requirements. The user rated the BTI 8000 system very highly, and actually raved about their system support. He gave an example of the system being burned out by lightning and said that BTI had replaced all the burned out or melted parts and had the system up and running within three days. He was impressed by the fact that they even repaired communications devices and other areas that were not necessarily their domain. The user also stated that they do definitely plan to expand the system as his business is growing rapidly and feels the BTI system will be capable of handling this expansion plan. Planned expansions include upgraded disk storage as well as processing capabilities such as added CPUs. He listed fast response time as an advantage of the system, since all their end users are online and are 89 percent automated with the system. He said he would definitely recommend the system to potential users.

The fourth user represented a community hospital on the Pacific Coast. Overall, the user was very happy with the price/performance of the BTI 8000. He said what he liked best about the system was that it offered, "more cluck for the buck"; he felt as though the BTI 8000 offered more machine for a lower price. He also said since the day it was plugged in the system had never been down. Before deciding on the BTI system he had considered a Data General Eclipse MV/4000. But he decided on the BTI 8000 after analyzing the cost of adding memory and CPU modules. The only drawback of the BTI system was a lack of commercial software, in his opinion. He felt the BTI operating software could be streamlined considerably. The user endorsed the BTI 8000 for anyone who needed a supermini this large. □

Internal system tables that are critical to operation or to the use of an entire volume are recorded redundantly in the interests of protecting operations and data. During a structural update, the more junior table is created first and removed last. Even relatively complex structures are handled in a crash-resistant manner by using the worst-case technique of creating an entirely new structure containing the new information and a copy of any previous information to be retained, updating the block that points to it, and finally freeing the old structure space.

Since the purpose of the BTI 8000 is to support many simultaneous processes, it is properly described as a multitasking system as well as a multiprocessor system. A "process" is the distinct invocation or separate execution of a program. Each process on the system is usually, but not always, associated one-for-one with an on-line interactive user. An interactive user process may generate other concurrent processes. Programs executed from batch queues are processes, and invocations of the operating system's routines are also processes.

The operating system creates a basically private, but identical, virtual machine for each process; one of its aspects is the process address space, or virtual memory. Any and every program on the BTI 8000 may be written to address a continuous virtual memory of 128 pages (512K bytes) as if it were the only program executing on a private computer with that much physical memory. The operating system creates and maintains the correspondence between each page of every process' virtual memory and some page in physical memory; this is what is loaded into a CPU's page file when a CPU runs a process.

Processes on the BTI 8000 may be running in some CPU; runnable, but waiting for a CPU to become available; or waiting for some other resource, including a page of virtual memory which is not yet resident in physical memory. Every process has all of its required virtual pages represented on blocks of a mass storage volume, but normally not all of them will be represented in physical main memory. When a running process references a virtual page that is not resident, as indicated by the page file, the process becomes suspended and the operating system assumes the responsibility of loading the page from mass storage into some page of physical main memory.

Three characteristics of this technique should be noted. First, the pages of a given process may be placed anywhere in paged memory. Second, a memory page that the operating system chooses to overlay with a new page will not first be written back to disk if it has not been altered since it was loaded in from disk. Third, frequently referenced pages, including pages referenced by more than one process, tend to remain resident, since the operating system's replacement algorithm tries to minimize disk access.

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Demand-paging systems normally operate with a least-recently used replacement algorithm; that is, the page chosen for overlaying is that which has "aged" the longest since being referenced by any process. This algorithm is entirely reasonable with a moderate load on a system, but invites "thrashing" when the load grows too large. The pages used by a given process during a specified period of time are its working set for that period. In a demand-paging system, the relationship between the total pages required to hold all active working sets and the total number of memory pages available determines the amount of disk activity on the system. As the page load grows, disk transfers become more frequent until all processes are reduced to their minimum working sets, below which they are incapable of executing any instructions without demanding a new page. Thereafter, any increase in load causes the system to spend almost all of its time in disk transfers. At this point, essentially no work is performed.

The BTI 8000 modifies the conventional demand-paging algorithm to prevent thrashing. When a demand occurs, the operating system selects the "least valuable process," based on a number of criteria, including the distinction between interactive and batch processes, and strips this process of the least recently used page of its working set, overlaying that memory page with the one demanded. As the overall load grows, this procedure is repeated until all processes are reduced to working sets close to minimum. At this stage, *prior to the thrash point*, the operating system identifies the process that is the most critical "troublemaker"—normally the one with the largest current working set. It then suspends this process for a certain period of time, rolling out its entire working set to free up memory for the rest of the load. The BTI 8000 process management algorithm avoids thrashing by making a dynamic transition from demand-paging to a modified multiprogramming technique.

There are no preset, conventional priorities in this scheduling technique, although the system operator can modify certain scheduling parameters (e.g., to favor batch processing). The operating system automatically favors processes that are currently interactive on the assumption that a user at a terminal requires service as soon as possible after entering a message. Processes that are not currently interactive can relinquish their demands for system resources, including CPU's, in favor of interactive processes, although a "fairness" algorithm ensures that batch processes are not totally locked out of execution. Process scheduling operates with dynamic priorities according to the recent behavior and current characteristics of the processes. On a heavily loaded system, with all other considerations equal, the most efficiently written programs—those with compact working sets—will be favored for execution over potential troublemakers.

DATABASE MANAGEMENT SYSTEM: BTI offers the *MARS II* relational database management system and application development system for the BTI 8000 system. The idea of a database management system is to free the designer from concern with the linking of data elements within the database. With MARS II, database creation is reduced to defining the groupings of data, called datasets or tables.

Other features of MARS II include an ad hoc query facility to provide speedy access to information, a flexible screen formatter, a report writer that will produce reports to user specified formats, and a data dictionary. A measure of security is provided by multilevel access control and data encryption facilities.

Provided with MARS II is the *COMP* fourth generation language. COMP can accelerate application and maintenance by a ratio 4 to 1 over high level languages, according to BTI. Precoded modules and command sequences permit rapid prototyping of new applications.

The BTI 8000 *File Management System (FMS)* supports indexed (ISAM) files and relative files. FMS services may be utilized for both indexed and relative files through BTI 8000 Pascal/8000 and BTI 8000 Cobol, and for relative files through BTI 8000 Fortran (Fortran 77). The transaction control features of FMS allow a user to lock a group of files or objects within files during a transaction, to ensure that other on-line users cannot impact or be influenced by a file update.

FMS is complemented by the *Interactive File Manager (IFM)* utility which provides direct access to all services of FMS. IFM is used primarily for specific tasks such as copying and loading files, where the performance of the task programmatically would be less efficient.

LANGUAGES: The BTI 8000 supports four high-level programming languages: Cobol 74, Fortran 77, Pascal/8000, and BTI Basic (Basic-X). All four have the following concepts in common:

- Program development may occur in an interactive mode. Programs may be written, compiled, and linked from a terminal, and test files can be defined, built, and dumped from a terminal. Programs can be tested at a terminal with the aid of an interactive, symbolic level debugging facility.

- All languages support terminals as standard I/O devices. A terminal can be accessed by the operating system without special telecommunications software.

BTI 8000 Cobol is a high-intermediate implementation of the 2 ANSI Cobol X.3.23-1974 standard. An interactive Debug replaces the standard Debug module. It also includes full indexed I/O support, transaction handling, and an extended ACCEPT and DISPLAY for terminal handling.

BTI 8000 Fortran is a full implementation of Fortran 77, ANSI standard Fortran X3.9-78. This language allows the programmer to concentrate on the algorithm instead of its implementation. Support of upper-/lowercase symbolic data names is one of the language's features. Debugging statements (identified by a "D" in column 1) can be included in the compilation or interpreted as remarks, depending upon a selected compiler option. A fully interactive debugging facility aids in program test and verification.

BTI 8000 Fortran places the full power of the operating system in the hands of the programmer through the use of extended I/O facilities. Files may be created, attached, interrogated, and destroyed under program control using the OPEN, CLOSE, and INQUIRE statements. Data transfer to and from files may be formatted, unformatted, or list-directed. Files may be direct access or sequential and may contain variable length records. In addition, data may be transferred to and from character strings by using statements which are similar to regular I/O statements. Character strings may be concatenated and assigned to variables. Strings may be compared with other strings. Substrings may be extracted with a convenient subscript-like notation. Numeric data types (Real, Integer, and Complex) have over 15 digits of significance; Double Precision Real supports 34 digits of significance. Variables of any type may be subscripted, and an array may have up to seven dimensions with no restrictions on upper and lower bounds.

BTI 8000 Fortran extends the ANSI Fortran 77 standard with the following features:

- Debugging statements can be easily eliminated for compilation of production program version.

- Array subscript and computed GO TO expressions of real, double precision, or integer type.

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- Interactive debug support.
- Symbolic names, 1 to 30 characters in length, in upper- and lowercase.
- Subexpression optimization.
- Variable length record I/O support.

BTI 8000 Pascal/8000 includes all the features of standard Pascal, and is a valid superset of standard Pascal. The BTI 8000 Pascal/8000 adds the following features to standard Pascal:

- Full support for string data type.
- Loop state allows the user to accomplish repetition and decision in the same statement.
- Support of multikeyed indexed sequential and relative file access methods.
- Case labels arranged in ranges.
- Compile-time expression evaluation for "CONST" declarations.
- Spawning and management of concurrent processes and generation and control of underprograms.
- An interprocess communication capability.

BTI Basic (Basic-X) is an extended version of Dartmouth Basic with many added features for improved file handling, matrix and string operations, and user interface facilities. Application programs written in Basic-X for BTI 5000 and BTI 6000 systems may be transported directly to the BTI 8000.

In addition to these high level languages, an Assembly language is available.

COMMUNICATIONS: The *EMIBM* utility is an IBM 2780/3780 terminal emulator that provides system-to-system communication between a BTI 8000 and a system using the IBM 2780/3780 communications protocol. Using EMIBM, a BTI 8000 may act as a remote job entry station to an IBM mainframe, or it may serve as a host to an IBM 2780 or 3780 terminal or emulator. In either case, both files and operator messages can be transferred between the two systems.

COMM is the BTI 8000 asynchronous communications utility. It allows a BTI 8000 to communicate with any other system that supports asynchronous ASCII terminals. It can also be used to transfer files between two BTI 8000 systems. COMM has a terminal pass-through mode that enables a user to work at a terminal as if it were connected directly to another computer.

UTILITIES: *EDIT/8000* is a line-oriented editor for the input and editing of programs, data files, and files of Control Mode (system command language) commands to be executed as DO files or batch sessions.

SCREDIT is a versatile screen editor which allows data to be entered and modified in either a screen-oriented or line-oriented mode. It may be used for creating or editing programs, data files, and DO files to be run as batch sessions.

The BTI 8000 *DEBUG* utility permits interactive debugging of Cobol, Fortran, and Pascal programs by specifying execution breakpoints and tracepoints, and displaying the values of memory locations. Execution may be traced either at the source statement level or at the machine instruction level. DEBUG permits single-stepping through a program, executing one source statement or machine instruction each time, or running the program at normal speed and stopping only at breakpoints.

The *HELP* utility allows the user to access the information in on-line HELP files provided for all BTI-supplied programs and commands. HELP information is organized into topics and subtopics, and may be examined by following the outline structure for a given topic, or searched by inputting keywords associated with the desired subject.

The *HELPMAKE* utility enables users to create their own HELP files, which may then be read with the HELP utility.

The *LINK* utility is used to link-edit object modules produced by the compilers into a runnable program. Options are provided to allow the user to include only the modules needed to execute a program. Through LINK, the user may request a memory-allocation map and external symbol table, which are useful in using the high-level language DEBUG utility.

The *SORT/MERGE* utility consists of two programs, SORT and MERGE, which provide the capability to sort and/or merge records from up to 32 input files to produce sorted data on a single output file. Up to 16 sort or merge keys, each with its own collating sequence, may be defined.

The *COPY* utility creates a duplicate of a single random access file, code file, or sequential access file, or concatenates data from up to 32 sequential access files to a single sequential access file. Subfiles within a sequential access file may be copied selectively, and data may be appended to the end of a sequential access file.

With the *VIEW* utility, the user can display all or part of the contents of a sequential access or random access file, or a program compiled-code file.

The *Object Binary Manager* utility permits a user to display the names and compilation dates of object modules produced by the compilers in a binary file, and to rename, update, move, or delete such modules.

The *COMPARE* utility compares the contents of two files of like type.

The *CONVERT* utility is a specialized copy program which permits converting specified fields in the input records from one data format to another. It also allows blocking and deblocking of records, and the use of declared fields to select specific input records to be written to the output file. Format conversions possible are: ASCII to and from EBCDIC; packed decimal with trailing sign to and from leading sign; packed decimal with trailing sign to and from ASCII; and 32-bit integer to and from 8-, 16-, and 24-bit integer formats.

OFFICE AUTOMATION: The *MAIL* utility provides a vehicle for users of a BTI 8000 to send messages to and receive messages from other users of the system. Messages are sent and received through personal "mail boxes." Access to each box can be controlled by specifying who is allowed to read messages from it, who is allowed to write messages to it, and who can delete messages from it or change its attributes. Users can also place messages on "bulletin boards" for general attention.

TEXT8 is a powerful document editing and formatting system. It may be used by writers, programmers, and other users for creating, editing, and formatting letters, reports, manuals, programs, and other kinds of documents. A line-oriented editor, TEXT8 provides commands to add, insert, replace, delete, modify, duplicate, split and join text lines, and change selected character strings within lines. Lines

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may be moved within the work file, and lines from other files may be copied into the work area. Documents can be displayed and printed in almost any format. Functions include line indention, justification, underlining, spacing, boldface printing, tabs, and centering. Page headers and footers can be included. Words and phrases can be flagged for automatic inclusion in the document index, and headings similarly included in the table of contents.

The *MAILER* system compiles, maintains, and prints mailing lists and mailing labels. In combination with TEXT8, MAILER also produces personalized form letters. Entries may be sorted and listed by name, company, or zip code, and may be selected for mailing labels by name, zip code, last response date, or class code.

APPLICATIONS: BTI does not generate applications software, but assists in the marketing of selected user-generated packages and third-party software. For example, in April, BTI announced that MCBA business software was being offered for the BTI 8000 system. The Generalized Accounting system is available now. At the time of this writing, the Distribution system is scheduled for release on July 1, and the Manufacturing software is scheduled for release in January 1986.

PRICING

POLICY: BTI offers the 8000 system on a purchase-only basis. The base system configuration is complete and includes the operating system, Control Mode, the utilities package, a file system, and one programming language. BTI warrants all hardware for 90 days. Software is licensed for use on one system, but discounts are offered for multiple installations by one customer. BTI-furnished software is maintained free for one year, and continuing maintenance is available on a yearly contract basis. Upgrades of BTI software are offered for a nominal handling fee to customers using the existing software. The BTI 8000 is not listed on the GSA schedule.

SUPPORT: BTI features a unique customer-participation service and support system that combines human resources and hardware features of the 8000 system. The 8000 contains integrated maintenance aids for automatic fault diagnosis by a remote computer located at BTI's factory service center. BTI customer engineers can gain access to the operating system through a user port and exercise various system components. Customer cooperation, in the form of a person standing by the system to perform specified actions, may be required to aid the BTI engineer in testing and evaluating a failed system. The customer's responsibility to provide such assistance is noted in BTI's corrective maintenance contract.

Under the contract terms, BTI furnishes both parts and labor to correct all failures and to provide 7-day, 24-hour telephone service. Replacement parts are shipped from the factory or one of BTI's regional parts banks by air freight, scheduled airline, or package express service to users who replace them and return the failed parts. A BTI field engineer is dispatched from Sunnyvale or from a regional office to any site where telephone consulting and testing cannot correct the malfunction.

BTI Corrective Maintenance Plan charges are based on the hardware configuration. Typical monthly charges covering both preventive and corrective maintenance are less than one percent of the purchase price.

TRAINING: System purchase prices include training by BTI personnel. Customer training for the BTI 8000 consists of a two-week course covering user familiarization, and system management and operation.

The first week is devoted to system features and use, and is suitable for persons already fluent in a high-level programming language (Cobol, Fortran, Pascal, or Basic). Students learn how to design, write, and debug terminal-oriented programs using Control Mode and other BTI-user software facilities. Approximately half of this section of the course is hands-on instruction.

The second week addresses system management and operations. Subjects covered include resource allocation and account structure, showing how account structures are set-up to fit the needs of individual installations. Students learn machine room operations, including how to establish proper backup procedures.

Purchase of a system includes attendance for two students. The charge, per person, for additional students is $1,500.

TYPICAL CONFIGURATIONS: Typical small, medium, and large BTI 8000 systems can be configured as shown below. All system configurations are priced as additions to the base system.

Small BTI 8000 System Configuration

8000	Base System, which includes computational processing unit, memory control unit, 1MB memory module, memory power supply, peripheral processing unit, system services unit, disk controller with one port, asynchronous communications controller, eight-port interface, system cabinet, operator panel, and power supply	$ 79,950
8144	1MB memory module	7,500
8210	Disk controller port	5,000
8230	67MB fixed storage disk drive	7,500
8232	67MB removable storage disk drive	10,500
8310	Cartridge magnetic tape controller and drive	7,000
8320	Magnetic tape controller	5,000
8330	9-track, 45-ips magnetic tape drive	9,000
8515	8-port interface, three @ $3,600	10,800
TOTAL		$142,250

Medium BTI 8000 System Configuration

8000	Base System, which includes computational processing unit, memory control unit, 1MB memory module, memory power supply, peripheral processing unit, system services unit, disk controller with one port, asynchronous communications controller, eight-port interface, system cabinet, operator panel, and power supply	$ 79,950
8112	Computational Processing Unit	20,000
8130	Memory Control Unit	10,000
8170	Peripheral Processing Unit	12,000
8144	1MB memory module, quantity two	14,000
8154	Memory power supply	8,000
8210	Disk controller port	5,000
8234	135MB fixed storage disk drive	12,000
8232	67MB removable storage disk drive	10,500
8310	Cartridge magnetic tape controller and drive	7,000
8320	Magnetic tape controller	5,000
8330	9-track, 45-ips magnetic tape drive	9,000
8415	Line printer controller	5,000
8425	600-lpm line printer	13,300
8515	8-port interface, seven @ $3,600	25,200
TOTAL		$235,950

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Large BTI 8000 System Configuration

8000	Base System, which includes computational processing unit, memory control unit, 1MB memory module, memory power supply, peripheral processing unit, system services unit, disk controller with one port, asynchronous communications controller, eight-port interface, system cabinet, operator panel, and power supply	$ 79,950
8112	Computational processing unit, two @ $20,000	40,000
8130	Memory control unit, two @ $10,000	20,000
8170	Peripheral processing unit	12,000
8144	1MB Memory Module, quantity eight	47,500
8154	Memory Power Supply, five @ $8,000	40,000
8210	Disk controller port, two @ 5,000	10,000
8236	279MB fixed storage disk drive, quantity two	30,000
8232	67MB removable storage disk drive	10,500
8310	Cartridge magnetic tape controller and drive	7,000
8324	Magnetic tape controller	5,000
8340	9-track, 75-ips magnetic tape drive	14,000
8415	Line printer controller	5,000
8435	1200-lpm Line Printer	27,600
8510	Asychronous Communications Controller, two @ $10,000	20,000
8515	8-port Interface, 23 @ $3,600	82,800
8815	Cabinet extension	3,000
TOTAL		$454,350

EQUIPMENT PRICES

		Purchase Price ($)	Monthly Maint. ($)
BASE SYSTEM			
8000	Includes Computational Processing Unit, Memory Control Unit, 1MB of memory, Peripheral Processing Unit, disk controller, asynchronous communications controller, 8-port interface, System Services Unit, double-bay system cabinet with bus backplane, operator control panel, and system power supply.	79,950	827
SYSTEM RESOURCE MODULES			
8112	Computational Processing Unit (CPU)	20,000	96
8130	Memory Control Unit (MCU)	10,000	30
8170	Peripheral Processing Unit (PPU)	12,000	48
8190	System Services Unit (SSU)	8,000	30
MEMORY			
8144	Memory module, 1MB of semiconductor memory (quantity one)	7,500	210
8154	Memory power supply, supports up to 2MB of one MCU	8,000	56
MASS STORAGE			
8208	Disk controller, with one port, for all drives listed below. Supports up to four drives when Model 8210 ports are added.	10,000	60
8210	Disk controller port. One port required for each disk drive. Up to three ports may be added to Model 8208 for a total of four ports per controller	5,000	—
8225	254M-byte (14-inch) removable storage drive, with one 8227 disk pack	20,000	300
8230	67M-byte (8-inch) fixed storage drive	7,500	115
8232	67M-byte (8-inch) removable storage drive	10,500	135
8234	135M-byte (8-inch) fixed storage drive	12,000	170
8236	279MB (8-inch) fixed storage drive, quantity one	16,000	—
MAGNETIC TAPE EQUIPMENT			
8310	Magnetic tape controller, tape-drive housing, one tape cartridge drive	7,000	72
8315	Additional tape cartridge drive; installs in 8310 module (up to three additional drives can be installed)	2,650	36
8320	Magnetic tape controller for up to four 8330 drives	5,000	30
8330	45 ips, 9-track, reel-to-reel magnetic tape drive, 800/1600 bpi	9,000	120
8324	Magnetic tape controller for up to four 8340 drives	5,000	30
8340	75 ips, 9-track, reel-to-reel magnetic tape drive, 800/1600 bpi	14,000	150
PRINTERS			
8415	Line-printer controller; supports any one printer listed below	5,000	30
8420	Line printer, 300 lpm, 64-character set	10,300	125
8422	Line printer, 220 lpm, 96-character set	10,300	125
8425	Line printer, 600 lpm, 64-character set	13,300	163
8427	Line printer, 440 lpm, 96-character set	13,300	163
8430	Line printer, 900 lpm, 64-character set	19,000	234
8432	Line printer, 660 lpm, 96-character set	19,000	234
8435	Line printer, 1200 lpm, 64-character set	27,600	340
8436	Line printer, 880 lpm, 96-character set	27,600	340

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EQUIPMENT PRICES

		Purchase Price ($)	Monthly Maint. ($)
	COMMUNICATIONS		
8510	Asynchronous communications controller, supports up to eight 8515 8-port interfaces	10,000	48
8515	8-port interface, EIA RS-232-C, at rates to 19.2K bps	3,600	12
	ACCESSORIES		
8815	Cabinet extension (extends 8810 cabinet to triple-bay and larger configurations)	3,000	—
8816	Side cover	800	—
8850	System power supply (one included in 8810 cabinet furnished with base system)	3,000	30

SOFTWARE PRICES

		License Fee* ($)
8911	PASCAL/8000, on reel-to-reel tape	5,000
8912	PASCAL/8000, on cartridge tape	5,000
8921	ANS 77 FORTRAN, on reel-to-reel tape	5,000
8922	ANS 77 FORTRAN, on cartridge tape	5,000
8941	ANS 74 COBOL, on reel-to-reel tape	5,000
8942	ANS 74 COBOL, on cartridge tape	5,000
8951	BASIC-X, on reel-to-reel tape	5,000
8952	BASIC-X, on cartridge tape	5,000
8961	Assembler, on reel-to-reel tape	5,000
8962	Assembler, on cartridge tape	5,000 ■

**Discounts are offered for multiple installations by one customer.*