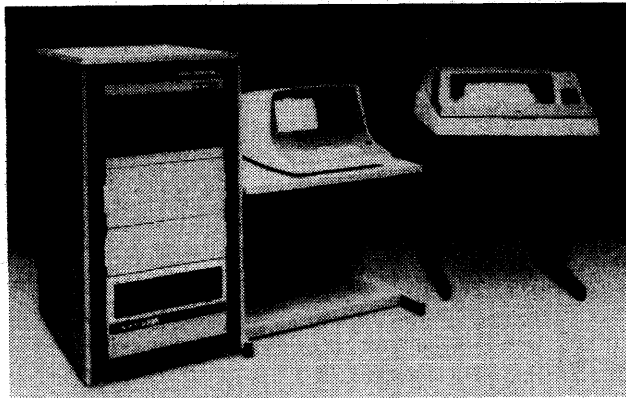


## General Automation Solution Series



The above Solution system, based on the GA-16/240 CPU, includes a 10-megabyte cartridge disk drive, a general-purpose display terminal, and a 300-lpm printer. The purchase price for this system, including 128K bytes of memory, is about \$31,100.

### MANAGEMENT SUMMARY

General Automation continues to enhance and expand the Solution Series product line with the introduction of four new processors in 1980. The latest members of the family are the GA-16/230, GA-16/240, GA-16/470, and GA-16/480.

The Solution Series, announced in September 1975, is an extension of GA's SPC-16 line intended for both end users and OEM's.

The original Solution Series computers, designated the 16/110, 16/220, and 16/440, are enhanced, micro-programmed versions of the SPC-16, the workhorse 16-bit mini that also served as the basis for GA's DM-100 Series computer systems. The 16/110 and /220 are built around the same two-chip LSI microprocessor, which has 16 accumulators and features a basic instruction nucleus of 91 instructions with 11 addressing modes. The 16/440 processor has the same general characteristics but is implemented in MSI and Schottky components to provide a 240-nanosecond cycle time and the capability for memory expansion to 1024K words. The 16/460 became available in February 1978 and joined the 16/440 in offering faster processor cycle time and larger memory capacities.

The basic instruction set consists of the original SPC-16 repertoire plus new instructions including four Shift Left instructions, another subroutine exit instruction, and a Trap (breakpoint) instruction. In addition, the 16/440 and /460 have stack and argument transfer instructions which bring their instruction set up to 122. These additional instructions are also available as options for the smaller LSI-based CPU's.

The Solution Series processors use all 16 bits of each direct address to access a full 65,536 words of memory directly. A ➤

GA's Solution Series includes six models ranging from the GA-16/110 "bare-bones" processor mounted on an 8-by-11-inch PC board to the 16/480 with error-correcting memory and a memory management system which extends the address range to two megabytes of physical memory. All Solution Series computers offer complete compatibility with previous GA equipment, permitting users to take advantage of existing software.

**MAIN MEMORY:** 32K bytes to two megabytes

**DISK CAPACITY:** (1-4) 0.5MB floppy, (1-4) 10MB cartridge, (1-8) 80 and 300MB data storage module

**WORKSTATIONS:** Multiple general purpose smart CRTs

**PRINTERS:** 165 cps to 600 lpm

**OTHER I/O:** Magnetic tape, card reader, paper tape, teleprinter, factory data collection terminals

### CHARACTERISTICS

**MANUFACTURER:** General Automation, Inc., 1055 South East Street, Anaheim, California 92805. Telephone (714) 778-4800.

General Automation was formed in 1967. The company manufactures minicomputers for message switching systems and for process control automation. It was one of the first to offer models compatible with the IBM 1130 and 1800 computers. More recently, General Automation has begun to offer data management systems for commercial applications, a departure from its original direction. GA currently employs 1,404 persons worldwide and has manufacturing facilities at Anaheim, California and near Aachen, West Germany. There are 32 field offices in the U.S. and Canada plus 12 field offices in western Europe.

**MODELS:** 16/110, 16/220, 16/230, 16/240, 16/440, 16/460, 16/470, and 16/480.

**DATE ANNOUNCED:** September 1975 (16/110, /220, and /440); February 1978 (16/460); February 1980 (16/230 and 16/240); March 1980 (16/470 and /480).

**DATE OF FIRST DELIVERY:** 16/110, December 1975; 16/220, January 1976; 16/440, June 1975; 16/230 and 240, May 1980; 16/460, May 1978; 16/420 and 480, August 1980.

**NUMBER INSTALLED:** 16/110 and 16/220—800; 16/440—700.

### DATA FORMATS

**BASIC UNIT:** 16-bit word and 8-bit byte.

**FIXED-POINT OPERANDS:** 16-bit words. ➤

## General Automation Solution Series

➤ 32K mode of operation is also implemented to allow the processors to function exactly as the SPC-16.

Optional features of the Solution Series include memory protection, signed multiply/divide hardware, memory parity, and error-correcting memories.

The 16/110, the low-end model of the line, is a basic "bare-bones" processor. It is intended for inclusion into OEM equipment, such as device controllers and terminals, and is mounted on an 8-by-10-inch PC board. A separate power supply and chassis are available as options. Incorporated in the one-board version are the basic instruction set, programmed I/O capabilities, and a direct memory transfer (DMT) port capable of driving two controllers. The DMT port uses the tri-state logic (0, 1, Hi-Z) found in many current microprocessor support components. General Automation has controllers that interface the DMT port.

Memory for the 16/110 and the /220 can be either 500-nanosecond MOS RAM or 100-nanosecond bipolar ROM or EPROM. Although the maximum capacity of both the 110 and 220 is 128K bytes, typical systems will probably be much smaller.

The 16/220 is a MOS semiconductor memory-based unit. One board is the 16/110, and the second board contains several useful options including the SPC-16-compatible DMA channel, a real-time clock, power fail/restart circuitry, and a TTY/CRT console device serial I/O controller. The 16/220 is packaged on 8-by-11-inch PC boards. A 16/110 can be upgraded to a 16/220 by adding the option board. The 16/220 is intended for small OEM data processing systems or data handling equipment in which the added options are useful.

The 16/230 and /240 use 500-nanosecond plug-in dynamic HYPAK RAM memory, 128K bytes on a single board. Both memories feature write protect and are CPU refresh independent with their own set of LED maintenance indicators. The 16/240 memory is also error correcting and expandable to 512K bytes in 128K-byte increments, all on the original single board.

The 16/440 is packaged in a more traditional mini-computer chassis and intended as a complete system. Prices are quoted with chassis and power supplies. Memory for the 16/440 is 720-nanosecond core, expandable to 1024K words through optional memory mapping.

The 16/440, /460, 470, and 480 do not use the LSI microprocessor found in the other Solution Series members. Instead, they are implemented in Schottky MSI logic and are nearly twice as fast as the LSI version: 240-nanosecond vs. 500-nanosecond processor cycle time. Applications for the four include large real-time multiprogramming systems or use as the host processor in a distributed processing system. ➤

➤ **FLOATING-POINT OPERANDS:** Single- and double-precision. Single-precision operands include a 6-bit signed exponent and 24-bit signed fraction. Double-precision operands include a 6-bit signed exponent and 56-bit signed fraction.

**INSTRUCTIONS:** One-word, two-word, or three-word.

Most of the instructions are memory reference and register-operate instructions, with either a one- or two-word format. Both types have a 4-bit operation code and a 12-bit operation code extension and/or qualifiers; the second word of the two-word types contains a 16-bit address or literal data.

The three-word format is used for argument transfer instructions and is generally the same as the two-word format except that both the second and third words contain 16-bit qualifiers.

**INTERNAL CODE:** ASCII.

### MAIN STORAGE

**TYPE:** For the 16/110, /220, and /460: NMOS (n-channel, metal oxide semiconductor) RAM (random-access memory) and bipolar ROM/PROM (read-only memory/programmable read-only memory). Error-correcting memory (ECC) is optional on the 16/460. For the 16/230 and /240: HYPAK, semiconductor, parity protect (on the /230), ECC (on the /240), NMOS RAM and bipolar PROM. For the 16/440: magnetic core. For the 16/470 and /480: HYPAK, semiconductor, parity protect, NMOS RAM, ECC.

**CYCLE TIME:** For NMOS RAM, 500 nanoseconds; for ROM/PROM, 100 nanoseconds; for magnetic core, 720 nanoseconds.

**CAPACITY:** Semiconductor memories for the 16/110 and /220 are available in two types: "piggyback" and "plug-in." Piggyback memories mount directly on the CPU board; 4K bytes of RAM or 6K bytes of EPROM and 2K bytes of RAM can be accommodated in this manner. Plug-in memory modules are available in 16K- or 32-byte increments. Parity checking (18-bit) versions are available for plug-in semiconductor memory modules.

Semiconductor plug-in memory is available for the 16/230 in one 128K-byte increment of 18-bit words. Semiconductor plug-in memory with ECC is available for the 16/240 in 128K-byte increments from 128K bytes to 512K bytes of 22-bit words.

Core memory for the 16/440 is available in 32K-byte increments with 18-bit words (up to two megabytes through the memory management option). Semiconductor memory is available for the 16/460 in 64K- or 128K-byte increments (up to two megabytes through the memory management option). ECC is a 16/460 option.

HYPAK MOS memory with ECC is available for the 16/470 on one 128K-byte board of 22-bit words. The same type memory is available for the 16/480 from 256K bytes to two megabytes in 256K-byte increments.

Direct addressing space for all Solution Series computers is 128K bytes; however, a special 32K mode provides compatibility with SPC-16 systems. The 16/440, /460, and /480 memories can be expanded to two megabytes if memory management, which is standard on the 16/480, is implemented.

**CHECKING:** Parity checking, one bit per byte, is standard on all Solution Series memories. Error-correcting (ECC) memory is standard on the 16/240, /470, and /480 and optional on the 16/460. These ECC memories use a 22-bit ➤

## General Automation Solution Series

## PERIPHERALS/TERMINALS

| DEVICE                              | DESCRIPTION & SPEED  | MANUFACTURER                            |
|-------------------------------------|--|---|
| MAGNETIC TAPE EQUIPMENT             |  |   |
| 3431                                | Transport; 9-track, 800/1600 bpi, 45 ips<br>Transport; 9-track, 800 bpi, 37.5 ips; 30KBS<br>Transport; 9-track, 800 bpi, 75 ips; 60KBS   | Tandberg<br>Wangco<br>Wangco            |
| PRINTERS                            |  |   |
| 3450<br>3450-1301<br>3450-1601      | Character Printer; 132-position, 7 x 7 dot matrix; 160 cps<br>Line Printer, 132-position, 300 lpm<br>Line Printer, 132-position, 600 lpm   | Tally<br>Data Products<br>Data Products |
| CARD EQUIPMENT                      |  |   |
| 3317-1000                           | Reader, 80-col.; 600 cpm   | Documation                              |
| PAPER TAPE EQUIPMENT                |  |   |
| 3321<br>3322<br>3323                | Reader; fanfold bins, spooler reels, or no tape pickup; 1500 cps<br>Punch; fanfold bins, spooler reels, or no tape pickup; 70 cps<br>Reader/Punch; fanfold bins, spooler reels, or no tape pickup; 1500/70 cps | Remex<br>Remex<br>Remex                 |
| TERMINALS                           |  |   |
| 3365-1001<br>3365-1101<br>3380-1431 | Teletypewriter; RO 110/300 baud<br>Teletypewriter; KSA 110/300 baud<br>CRT Keyboard Display; 25 lines by 80 char., TTY function keys, RS-232   | Teletype<br>Teletype<br>Ampex           |

➤ All models have some degree of microprogrammability. The LSI machines have an extra control ROM (CROM) socket that can be used to implement user-defined instructions or control functions. The 16/440 is also user-microprogrammable through 512 words of control ROM.

General Automation offers five operating system configurations for the Solution Series: CONTROL I, II, III, IV, and V. Only the 16/220 and larger models can support these software systems. The 16/110 does not have sufficient I/O capability to meet the minimum configuration requirements of the operating systems, although GA says that limited operation under CONTROL II is possible.

CONTROL I and II, respectively, are a batch and real-time operating system, each with a monitor and some level of job-control language processor. CONTROL III and IV combine the features of CONTROL I and II, offering both real-time operations in the foreground and batch processing in the background. CONTROL IV supports memory mapping and memory systems greater than 64K words and is usable only on the 16/440 and larger systems. CONTROL V supports multiple memory mapping.

General Automation's Multi-Terminal System (MTS) is a time-sharing system which operates in CONTROL-III, CONTROL-IV, or CONTROL-V foreground. Although operating in the foreground environment, MTS provides the user with capabilities similar to those provided by CONTROL background. The operation of MTS at an installation does not preclude other normal uses of CONTROL-III, CONTROL-IV or CONTROL-V except where the MTS scheduler requires changes to exercise specific options.

The various members of the Solution Series are competitive in performance with the various members of ➤

➤ word composed of sixteen data bits and a six-bit Hamming code for the 16/240 and a 32-bit data word plus a seven-bit Hamming code for the 16/460, 470 and 480. One-bit errors are detected and corrected "on the fly," while multiple-bit errors are nonrecoverable and cause a system interrupt.

**STORAGE PROTECTION:** The module containing the memory parity circuitry also contains memory protection circuitry. Memory can be protected, in 1024-word blocks, from overwriting either by the CPU or by I/O devices through DMA operations. The memory protect circuitry includes two 64-bit maps, one for CPU operations and one for DMA operations. A memory protection violation causes an internal interrupt. Protection is also provided through the memory management system (MMS) option.

**RESERVED STORAGE:** 194 memory locations (0 through 193) are reserved for operating system usage, data channel control blocks, interrupt vectors, and return vector storage. Locations 0 thru 15 cannot be write-protected.

**CONTROL STORAGE:** For the 16/110, /220, /230 and /240, control read-only memory (CROM) consists of 320 34-bit words. There is also a socket for the addition of 320 more words of CROM. For the 16/440, 16/460, 16/470 and 16/480 there are 512 64-bit words of CROM and space for additional 512 words.

### CENTRAL PROCESSORS

The 16/110, /220, 230, and 240 CPU's are built around a two-chip microprocessor set and differ only in options included or in packaging. The 16/110 represents the basic "no frills" processor with the basic instruction set, programmed I/O, and memory capacity of 64K words. The 16/220 adds a second board with a DMA channel, a real-time clock, power fail/restart, and a serial I/O controller. All of the 16/220 features can be added to the 16/110 as options. Both the 16/110 and 16/220 are offered as OEM components on 8-inch by 11-inch modules designed for incorporation into customer-assembled systems, or as full-blown LSI computers complete with chassis and power supplies.

The 16/230 and /240 have all the features of the 16/220 but are packaged on larger modules and offered as micro- ➤

## General Automation Solution Series

### SOLUTION SERIES SYSTEMS COMPARISONS

|                            | 16/110                                   | 16/220   | 16/230   | 16/240   |
|----------------------------|--|--|--|--|
| Intended Usage             | OEM; small dedicated-application systems | End user or OEM; small general-purpose systems | End user or OEM; small general-purpose systems | End user or OEM; small general-purpose systems |
| <b>MEMORY</b>              |  |  |  |  |
| Type and speed, nsec.      | RAM, 500; PROM, 100                      | RAM, 500; PROM, 100                            | HYPAK RAM, 500                                 | HYPAK RAM, 500                                 |
| Capacity                   | 128KB                                    | 128KB  | 128KB  | 512KB  |
| Memory increment           | 4KB, 8KB, 16KB, 32KB                     | 4KB, 8KB, 16KB, 32KB                           | 128KB*   | 128KB  |
| Parity checking            | Standard                                 | Standard                                       | Standard                                       | Standard                                       |
| Error correction           | None                                     | None   | Optional                                       | Standard                                       |
| Memory management          | None                                     | None   | Optional                                       | Optional                                       |
| Storage protection         | Optional                                 | Optional                                       | Optional                                       | Optional                                       |
| <b>PROCESSOR</b>           |  |  |  |  |
| Component technology       | LSI, Schottky TTL                        | LSI, Schottky TTL                              | LSI, Schottky TTL                              | LSI, Schottky TTL                              |
| Microcycle time, nsec.     | 500                                      | 500  | 500  | 500  |
| User microprogrammable     | No                                       | No   | No   | No   |
| Accumulators               | 16                                       | 16   | 16   | 16   |
| Index registers            | 8  | 8  | 8  | 8  |
| Instructions               | 91                                       | 91   | 91   | 91   |
| Addressing modes           | 11                                       | 11   | 11   | 11   |
| Directly addressable       | 128KB                                    | 128KB  | 128KB  | 128KB  |
| Multiply/Divide            | Standard; high-speed optional            | Standard; high-speed optional                  | Standard; high-speed optional                  | Standard; high-speed optional                  |
| Floating-point operations  | Optional                                 | Optional                                       | Optional                                       | Optional                                       |
| Hardware stack             | Optional                                 | Optional                                       | Optional                                       | Optional                                       |
| Interrupts                 | Unlimited, vectored                      | Unlimited, vectored                            | Unlimited, vectored                            | Unlimited, vectored                            |
| Max. I/O rates, bytes/sec. | 120K, programmed; 4MB DMT                | 120K, programmed; 4MB DMT; 1M, DMA             | 120K, programmed 1.7MB, DMA                    | 120K, programmed; 1.7MB, DMA                   |
| Price, CPU with Memory     | \$4775 (32KB)                            | \$5100 (32KB)                                  | \$7325 (128KB)                                 | \$9000 (128KB)                                 |

\*A 16/230 can be converted to a 16/240.

\*\*A 16/470 can be converted to a 16/480.

▷ DEC's PDP-11 line. Data General's Nova 3 series is closely matched to the 16/220 through 16/440 in both price and performance. Other systems with similar applications, performance, and prices include Hewlett-Packard's 21MX Series and Computer Automation's LSI Series.

The Solution Series also represents competition for GA's own SPC-16 computer system, which forms the base of the DM-100 Series, a family of configured systems that make up various levels of hierarchical processing networks. The new processors represent a less expensive, enhanced alternative to the core memory SPC-16.

#### USER REACTION

Datapro received responses from five users of General Automation's Solution Series in our 1980 user survey. The five users had a total of nine systems installed—six 16/440's and three 16/460's—all of which had been purchased. The average life of the systems was two and a half years with the shortest time being eleven months and the longest three years.

Three users reported manufacturing as one of their applications, two each reported engineering/scientific and transaction processing, and one each reported distributed processing and remote job entry. All five were using applications programs written by in-house personnel, while two had obtained "ready-made" programs from the manufacturer, and one was using proprietary software packages. Control III and Control IV were the operating systems in use. ▷

▶ computer systems complete with memory, power supply, and chassis.

The 16/440, 16/460, 16/470 and 16/480 have *architecture identical with that of the 16/110, /220, /230 and /240 CPU's* but use Schottky MSI logic components for greater processing speed. In addition, they have provisions for memory expansion to 1024K words through the memory management option (which is standard on the 16/480).

On the 16/110, /220, /230, /240, /440, /460, /470 and /480 a switch selects either the normal 64K mode or the 32K mode for SPC-16 compatibility. When in 64K mode, either the 32K or 64K mode can be selected under program control. (The SPC-16 can address only 32K words of memory, while the Solution Series processors can directly address up to 64K words.) The 32K operating mode causes the processor to ignore the most significant bit of each direct address.

**REGISTERS:** Sixteen 16-bit general-purpose registers are divided into two eight-register sets, one for foreground-mode operation and one for background-mode operation. Only one set is active at a time.

Three are general-purpose-only registers (A, B, C); three are index/general-purpose registers (X, Y, Z); one is a base addressing/general-purpose register for base-relative addressing (D); and one is a subroutine linking/general-purpose register (E). The second eight-register set is designated A<sup>1</sup> through Z<sup>1</sup>.

The Status (S) Register uses 8 of its 16 bits to hold the shift counter (4 bits) and the Link, Overflow, Plus, Zero, and Foreground/Background indicator bits; 8 bits are unused. Also provided are a 16-bit program counter (P-Register), a 16-bit Absolute Memory Location register (L-Register), a 16-bit Memory Buffer (M-Register), a 16-bit effective address register (W-Register), a 16-bit current instruction register (I- ▶

General Automation Solution Series

SOLUTION SERIES SYSTEMS COMPARISONS

| 16/440   | 16/460   | 16/470   | 16/480   |  |
|--|--|--|--|--|
| End user or OEM; large-scale real-time and batch systems   | End user or OEM; large-scale real-time and batch systems   | End user or OEM; large-scale real-time and batch systems   | End user or OEM; large-scale real-time and batch systems   | Intended Usage   |
| Core, 720  | MOS, 500   | HYPAK RAM, 500   | HYPAK RAM, 500   | MEMORY<br>Type and speed, nsec.  |
| 2MB<br>32KB<br>Standard<br>None<br>Optional<br>Optional  | 2MB<br>64K, 128K<br>Standard<br>Standard<br>Optional<br>Optional   | 128KB<br>128KB**<br>Standard<br>Standard<br>Optional<br>Optional   | 2MB<br>128KB, 256KB<br>Standard<br>Standard<br>Standard<br>Optional  | Capacity<br>Memory increment<br>Parity checking<br>Error correction<br>Memory management<br>Storage protection   |
| MSI, Schottky TTL<br>240<br>Yes<br>16<br>8<br>121<br>11<br>128KB<br>Standard; high-speed<br>optional<br>Optional<br>Standard<br>Unlimited, vectored<br>120K, programmed; 2.2MB,<br>DMA | MSI, Schottky TTL<br>240<br>Yes<br>16<br>8<br>121<br>11<br>128KB<br>Standard; high-speed<br>optional<br>Optional<br>Standard<br>Unlimited, vectored<br>120K, programmed; 2.2MB,<br>DMA | MSI, Schottky TTL<br>240<br>Yes<br>16<br>8<br>121<br>11<br>128KB<br>Standard; high-speed<br>optional<br>Optional<br>Standard<br>Unlimited, vectored<br>120K, programmed; 2.2MB,<br>DMA | MSI, Schottky TTL<br>240<br>Yes<br>16<br>8<br>121<br>11<br>128KB<br>Standard; high-speed<br>optional<br>Optional<br>Standard<br>Unlimited, vectored<br>120K; programmed; 2.2MB,<br>DMA | PROCESSOR<br>Component technology<br>Microcycle time, nsec.<br>User microprogrammable<br>Accumulators<br>Index registers<br>Instructions<br>Addressing modes<br>Directly addressable<br>Multiply/Divide<br><br>Floating-point operations<br>Hardware stack<br>Interrupts<br>Max. I/O rates, bytes/sec. |
| \$12,000 (32KB)  | \$14,500 (64KB)  | \$16,000 (128KB)   | \$19,250 (256KB)   | Price, CPU with Memory   |

\*A 16/230 can be converted to a 16/240.  
\*\*A 16/470 can be converted to a 16/480.

▷ FORTRAN was the programming language used by four installations; two used Assembler; and one used COBOL. Two users listed the File Management System (FMS) as their data base management system. The nine systems support a total of forty-five workstations, eight printers, three magnetic tape drives, and an average of 88K bytes of memory. All users reported the use of disk drives with capacities of from ten to fifty megabytes, and one user had two diskette drives.

The following table summarizes the ratings assigned by these users:

|                            | Excellent | Good | Fair | Poor | WA* |
|----------------------------|-----------|------|------|------|-----|
| Ease of operation          | 0         | 2    | 2    | 1    | 2.2 |
| Reliability of mainframe   | 2         | 0    | 2    | 1    | 2.6 |
| Reliability of peripherals | 1         | 0    | 3    | 1    | 2.2 |
| Maintenance service:       |           |      |      |      |     |
| Responsiveness             | 0         | 4    | 1    | 0    | 2.8 |
| Effectiveness              | 0         | 4    | 1    | 0    | 2.8 |
| Technical support:         |           |      |      |      |     |
| Trouble-shooting           | 0         | 1    | 1    | 3    | 1.6 |
| Education                  | 0         | 0    | 2    | 3    | 1.4 |
| Documentation              | 0         | 0    | 2    | 3    | 1.4 |
| Manufacturer's software:   |           |      |      |      |     |
| Operating system           | 1         | 0    | 2    | 2    | 2.0 |
| Compilers and assemblers   | 0         | 0    | 5    | 0    | 2.0 |
| Applications programs      | 0         | 0    | 5    | 0    | 2.0 |
| Ease of programming        | 0         | 1    | 2    | 2    | 1.8 |
| Ease of conversion         | 0         | 1    | 3    | 1    | 2.0 |
| Overall satisfaction       | 0         | 1    | 1    | 3    | 1.6 |

\*Weighted Average on a scale of 4.0 for Excellent.

▶ Register), two 16-bit general-purpose register-buffers (Q, R-Registers), and a 16-bit register display buffer (K-Register).

The optional memory parity/protect feature, available on all Solution Series processors, adds two 64-bit registers which provide program-write and DMA-write protection to each of 64 1024-word memory blocks.

The memory management system (MMS) option, available on the 16/440, /460, /470 and standard on the 16/480, adds four map registers composed of 64 16-bit words each. The map registers provide mapping for program access or DMA access to memory.

STACKS: In addition to the hardware registers, two stacks of any length can be implemented in memory. Five reserved locations function as registers to support stack operations. Four locations serve as stack pointer and stack fault vector storage for each of the two stacks. The fifth location holds the P register contents after detection of the stack fault (overflow or underflow). The first location in each stack also functions as a register for storing the upper boundary address of each stack.

ADDRESSING: All Solution Series minicomputers have eleven addressing modes. These include direct, immediate (literal), indirect, indexed, indirect-indexed, program-relative (1024 locations), program relative-indirect, base register relative, base register relative-indexed, base register relative-indirect, and base register relative-indirect-indexed. Indirect addressing is to one level only.

INSTRUCTION REPERTOIRE: 91 standard instructions plus 2 optional instructions. Standard instructions include 2 multiply/divide, 4 memory reference, 12 memory reference with indexing, 8 conditional jump (skip), 11 register operate, 11 register operate and compare, 17 register change, 8 shift, 10

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➤ The advantages of General Automation's Solution Series which these users mentioned were that the systems are easy to expand and reconfigure, that programs and data from other systems were compatible with the new system, that terminals and peripherals were also compatible, and that their equipment had been delivered ahead of schedule.

On the complaint side, comments were made that the proposed system had proven to be too small and had to be replaced or expanded, that delivery or installation of equipment or software had been late, that costs had exceeded the expected total, that promised software or support had not been provided, that programs and data from other systems were not compatible with the new system, that enhancements and changes to hardware or software were difficult to keep up with, and that the power or cooling requirements of the systems were excessive.

The highest satisfaction these GA users expressed was for the hardware and maintenance service, while the most dissatisfaction was in software and technical support.□

► control, and 8 programmed I/O instructions. The stack, standard in the 16/440, /460, /470, and /480, adds 26 instructions, and argument transfer adds 4. The argument transfer instructions and the stack are emulated by the CONTROL operating systems for the 16/220, /230, and /240. Floating-point and memory management hardware are treated as I/O devices, and their instruction sets are variations of programmed I/O instructions.

**INSTRUCTION TIMINGS:** All times are in microseconds for full-word fixed-point operands:

|                  | <u>16/220/230/240</u> | <u>16/460/470/480</u> |
|------------------|-----------------------|-----------------------|
| Load/Store       | 2.6                   | 1.4/2.1               |
| Add/Subtract     | 2.1                   | 0.85                  |
| Multiply/Divide  | 19.5*                 | 7.74*                 |
| Compare & Branch | 2.1                   | 0.85                  |

\*Average, based on best- and worst-case operands.

**INTERRUPTS:** All Solution Series processors have two types of interrupts: internal and external. There are six internal interrupts, three of which are non-inhibitible and three inhibitible. Power-fail, auto restart, memory management interrupts, and parity cannot be inhibited. The real-time clock and two console interrupts can be inhibited under the program control. All external interrupts are also inhibitible.

Two consecutive memory locations are reserved for each interrupt, one for the interrupt vector and one for the interrupt system status (one bit).

For internal interrupts, standard memory locations are reserved for vector and status storage. For external interrupts, any pair of memory locations can be reserved because each I/O device contains an address generator.

**PHYSICAL SPECIFICATIONS:** The 16/110 and 16/220 processors are sold as separate modules without chassis and power supply or incomplete systems with memory, power supply, and chassis. These CPU's are mounted on 7.75-by-11-inch PC boards. The optional power supply for the 16/110 and /220 CPU's is 10.57 inches high, 19 inches wide, and 5.75 inches deep. All chassis for the 16/110 and /220 measure 8.75 inches high, 19 inches wide and 15.3 inches deep. The

Compact chassis with internal power supply provides 12 slots, while a Jumbo chassis has an external power supply and 17 slots.

The 16/230, /240, /440, /460, /470, and /480 processors are sold in complete systems and include memory, power supply, and chassis. The processor chassis is separate from the power supply chassis and is 19 inches wide and 8.75 inches high. The depths of the chassis vary: the 16/230 and /240 chassis are 15.3 inches deep, and the other chassis are 21.15 inches deep without cables or 22.25 inches deep with cables. Power supply chassis for the 16/230, /240, /440, /460, /470, and /480, are 10.57 inches high, 19 inches wide, 5.75 inches deep without cables, and 7.75 inches deep with cables.

Power requirements for all Solution Series are 115, 220, 100 or 200 VAC ± 10%, single-phase, 47-63 Hz. Operating environment for all systems is 32 to 122 degrees F. and up to 90 per cent relative humidity (noncondensing).

### INPUT/OUTPUT CONTROL

**I/O CHANNELS:** Three types of I/O operations are implemented in various Solution Series processors. The 16/110 and /220 feature programmed I/O and a two-channel direct memory transfer (DMT) port. All models except the 16/110 also include a DMA channel. Direct memory transfer differs from DMA in that the DMA uses multiplexed hardware channel facilities integrated in the processor, whereas the DMT merely connects to the memory bus and all control functions are performed by the individual device controllers. At present, users must design their own DMT controllers.

**SIMULTANEOUS OPERATIONS:** DMA/DMT operations can occur during normal processing.

### CONFIGURATION RULES

The 16/110 and 16/220 CPU boards have the same dimensions and mount in a chassis with two CPU slots. The 16/110 requires one slot, while the 16/220 requires both CPU slots. In the Compact Chassis configuration, there are 10 remaining controller slots for the 16/110 and 9 for the 16/220. In the Jumbo chassis configuration, there are 16 remaining controller slots for the 16/110 and 15 for the 16/220. Each memory or peripheral controller module occupies one slot.

The GA-16/230 subsystem includes CPU, power supply, chassis, RS-232/current loop serial I/O adapter, system console interface with IPL, memory service module and 128KB parity HYPACK memory. Slot allocation is identical to the 16/220.

The GA-16/240 subsystem is the same as the 16/230 except it includes 128KB ECC HYPACK memory and or extended instruction set.

The 16/440 has an 8-slot chassis with three slots reserved for the CPU, one for options, and four for memory modules. Up to 64K words can be accommodated in the basic chassis. Memory expansion, up to 1024K words, is achieved through additional 4-slot chassis, each capable of housing 64K words. One power supply supports up to 128K words of memory (two chassis). Expansion chassis are included in the basic price of each memory expansion. All GA power supplies are separately mounted.

The 16/460 has the same chassis as the 16/440 but with a different backpanel. Three slots are reserved for the CPU, two for memory, and one each for the dual-port memory interface, cache memory, and memory management. Up to 512K bytes of parity memory or 256K bytes of ECC memory can be accommodated in this chassis. ►

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► The GA-16/470 subsystem includes CPU, power supply, chassis, RS-232/current loop serial I/O adapter, memory parity and protect, IPL, and 128KB ECC HYPAK memory. Slot allocation is identical to the 16/460.

The GA-16/480 subsystem is the same as the 16/470 except it includes 256KB ECC HYPAK memory and memory management instead of memory parity and protect.

**WORKSTATIONS:** Multiple general purpose smart CRTs are limited in number by the application and number of available I/O slots for controllers.

**MASS STORAGE:** From one to four 0.5MB floppy disk drives, one to four 10MB cartridge disk drives, or from one to eight 80MB or 300MB data storage modules can be attached to Solution Series systems.

**MAGNETIC TAPE UNITS:** From one to four 9 track, 45-ips, 800/1600-bpi transports can be attached to the systems.

**PRINTERS:** Printers that can be configured with Solution Series systems include a 160-cps serial printer, 300- and 600-lpm baud printer, and 110/300 baud teleprinter.

**MASS STORAGE**

**3346 10-MEGABYTE DISK STORAGE SYSTEM:** Consists of a controller and one drive, with the capability to add three additional drives. Each drive contains one IBM 2315-type removable cartridge and one fixed cartridge. Each disk stores 800 bytes per sector, 8 sectors per track, 4 tracks per cylinder, and 400 cylinders per unit, for a capacity of 10 million bytes per drive. Average access time is 45 milliseconds, and the data transfer rate is 194K bytes per second. The controller requires two slot positions. The 3346 disk drives are manufactured by Wangco.

**3345 80-MEGABYTE REMOVABLE DISK STORAGE SYSTEM:** Consists of a controller and one disk drive, with the capacity to attach up to seven additional drives. Average access time is 30 milliseconds. Data transfer rate is 1.2M bytes per second. The controller requires three slot positions. The 3345 disk drives are manufactured by Control Data Corp.

**3345 300-MEGABYTE REMOVABLE DISK STORAGE SYSTEM:** Consists of similar disk drives to the ones in the 80MB subsystem.

**3442 STANDARD FLOPPY DISK SYSTEM:** Consists of one controller and one drive expandable to 4 drives. The 3442 floppy disk system is double-sided, single density with 0.5MB per diskette. It is also IBM 3740 record format compatible. Transfer rate is 250K bits per second. The disk drives are manufactured by Remex.

**INPUT/OUTPUT UNITS**

See Peripherals/Terminals table.

**COMMUNICATIONS CONTROL**

**1561 ASYNCHRONOUS COMMUNICATION CONTROLLER:** Provides an interface for one to four full-duplex RS-232 lines with rates of 75 to 9600 bps. The basic subsystem includes facilities for one or two lines and requires one slot position. Expansion to four lines requires two slot positions.

**1571 SYNCHRONOUS COMMUNICATION CONTROLLER:** Provides an interface for one double-buffered, full-duplex, RS-232 line at speeds from 2000 to 9600 bps and occupies one slot position.

**1567 AUTOMATIC CALLING EQUIPMENT:** Provides an interface for four ACU's and requires one slot position.

**1581 CURRENT LOOP CONTROLLERS:** Provide interfaces for one to four 20ma or 60ma current loops at rates of 75 to 9600 bps. The basic unit handles one or two loops and requires one slot position. Expansion to four loops requires two slot positions.

**1595 COMMUNICATION MULTIPLEXER EQUIPMENT:** Provides interfaces for sixteen to thirty-two double-buffered, full-duplex, asynchronous communications lines at 50 to 4800 bps. A 40-indicator status display board as well as 20ma or 60ma current loop adapters (for four full-duplex lines) and a 4-line RS-232 modem interface are available. Each 4-line adapter requires one slot position.

**SOFTWARE**

The CONTROL operating systems have been added to exploit the enhancements present in the Solution Series processors.

The five operating system configurations are CONTROL I, II, III, IV, and V, and are usable with the 16/220. The five software configurations form an upward-compatible family in which both batch and multiprogrammed, real-time processing are supported.

*CONTROL I* is a disk-based batch processing system designed for single-job processing or program development. The system consists of a monitor, batch job control language interpreter, and software for program generation and debugging including a macro assembler, the FMS file management system, Extended and Commercial FORTRAN, COBOL, BASIC, and associated subroutine libraries. The monitor contains the I/O and file system and the routines for loading, executing, and termination of user programs. The monitor also holds any special user-configured routines, such as a re-entrant FORTRAN or COBOL subroutines. If the memory parity/protect option has been implemented, the monitor is write-protected from all running programs.

All operations are initiated from the system console or with job control strings appended to the user program through the job control language interpreter. The interpreter either executes the job control commands or passes control to appropriate program modules brought into memory from the disk.

Minimum configuration for CONTROL I is any 16/220 or larger CPU with 16K words of memory, console device (CRT or teletypewriter), any disk, and one card reader or high-speed paper tape reader.

*CONTROL II* is a multiprogrammed real-time system that supports up to 255 user programs; it does not need a system disk but supports disks as peripherals. The CONTROL II monitor and all user programs are always memory-resident. Because of the large memory/storage space required, program development is not possible using CONTROL II, and users must generate both their own programs and the monitor on a larger system under CONTROL I, III, or IV.

The operating system consists of a monitor and a primitive control language processor which provides only job initialization and system start-up. The CONTROL II monitor consists of a real-time scheduler, timing routine, input/output system, and other routines requested by the user programs at system generation time. User programs are scheduled on a priority basis, and real-time scheduling utilities are provided to permit dynamic scheduling and priority changes.

CONTROL II uses the memory parity/protect option to provide two levels of system protection. The first level protects only the CONTROL II monitor, and the second level protects both the monitor and all inactive user programs from ►

## General Automation Solution Series

► the currently active user program. The desired levels of system protection are defined at system generation time.

The minimum configuration required for CONTROL II is a 16/220 or larger CPU with 8K words of memory, a teletypewriter or CRT system console device, and a card reader or high-speed paper tape reader.

*CONTROL III* is a disk-based operating system that combines the real-time multiprogramming capabilities of CONTROL II with the batch processing capabilities of CONTROL I, executing user programs in a foreground/background mode. The operating system consists of a monitor, the batch job control language processor of CONTROL I, the foreground control language subset processor of CONTROL II, and all program development and generation software available under CONTROL I. The CONTROL III monitor has all the elements of the CONTROL I and II monitors plus additional facilities to provide dynamic disk and memory management. It supports the same languages as CONTROL I.

All programs (user and system) are stored on disk in core image, and only the monitor and the currently active program are in memory. User programs are switched between memory and disk by roll-in/roll-out techniques.

User programs are developed and generated in batch mode in the background and then dynamically added to the foreground job list.

With the memory parity/protect option installed, three levels of system protection are selectable at system generation time: monitor and foreground area protected from background programs, monitor protected from foreground programs and all programs protected from background programs, and all programs protected from both background and foreground programs.

The minimum configuration required for CONTROL III is a 16/220 or larger CPU with 24K words of memory, a teletypewriter or CRT console device, any disk or drum, and a card reader or high-speed paper tape reader. A 16K-word system can be implemented if full program generation capabilities are not required.

*CONTROL IV* provides essentially the same features as CONTROL III but additionally supports the memory management (MMS) option available only on the 16/440, 16/460 and 16/470. MMS is standard on the 16/480. Through MMS, the system can support up to one million words of memory through four 64-word address translation maps.

CONTROL V provide essentially the same features as CONTROL IV but additionally supports multi-mapping, system generation, patching facility, communication emulators, and multi-language configurations.

*File Management System (FMS)*, a disk-based file management system, is a group of software modules, including object-time file tables and file logic, which are used to facilitate creation and manipulation of a data base or any large data collection residing on bulk storage units such as disks or magnetic tape units. Specifically, index sequential (ISAM) and partition sequential (PSAM) files are supported by FMS.

PSAM files differ from ISAM files in that the former consists of partitioned groups of records, each group preceded by a key identifier, while the latter makes use of file directories to determine record locations.

FMS permits ISAM files of up to eight million records, ISAM keys of up to 392 alphanumeric values, and PSAM

files of up to 65,000 records. Variable records can be up to 790 characters long, including the key. The system also has provisions for automatic ISAM record packing and optional PSAM record packing, fixed or variable record lengths, allowance for both random and sequential ISAM record processing, n-level ISAM directories, on-line record insertion to create both file directories and data records, lockout for multi-user access by either file or record, and in-line or field-defined calls. FMS also manages physical storage space by reusing space vacated by deleted records and by storing all variable-length alphanumeric or numeric fields without trailing blanks or nonsignificant digits. A system overflow file is used during editing functions to provide temporary storage for inserted records which exceed the allocated space.

FMS is interfaced to both Commercial FORTRAN and FORTRAN IV Language. Application programs are executable in RTOS multiprogramming or batch processing environments.

FMS also permits operations on combinations of ISAM and PSAM files, including the indexing of PSAM files through keyed indices located in the ISAM files and appending additional ISAM files to PSAM files indexed using the above techniques. Structuring files in this manner permits additional indexing levels.

FMS application programs are implemented in two stages: development and data insertion/editing. The first stage logically segments a data base into logically distinct files and further divides these files into records and fields. Once defined, the data base is filled by user-generated application programs.

FMS contains five modules which are used to define user files and file accesses. These are: FILGEN, used to define files initially; User Interface Module (UIF), which handles file access requests; File Access Methods (FAM), which performs the operations; Core and Random Access Manager (CRAM), which controls I/O operations and queues FAM access requests; and Disk I/O Module, which operates under control of CRAM.

The *MTS Multi-Terminal System* is a time-sharing system which operates in CONTROL-III, CONTROL-IV or CONTROL-V foreground. Although operating in the foreground environment, MTS provides the user with capabilities similar to those provided by CONTROL background. CONTROL background and MTS basically facilitate manipulation of data to, from, and among bulk files. MTS protects against unauthorized users by providing an optional password controlled by one privileged user.

Bulk files in MTS utilize a pool of bulk storage space which is allocated dynamically among bulk files. In both CONTROL and MTS, the set of system bulk files is defined at configuration time. Some bulk files are intended for temporary storage of data. These are known as non-directory files.

Under MTS, each authorized user (whether active or inactive) can have a unique set of directory files, independent of other users. Each active user also has access to a unique set on non-directory files. Such files, which are seen by each user as unique to him, are private files. Additionally, certain directory files are made available to all users. These are the public files. Non-directory files cannot be public files.

Write protection, when set, prevents users from writing into a protected data space. Write protected data spaces cannot be written into by any user, including the privileged user. When a data space is created in a private file, its write protect status is YES.

LANGUAGES: Four program development languages are provided. ►



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► **COMFORT COMMERCIAL FORTRAN** is an enhanced set of ANSI FORTRAN that includes string handling routines to aid in report program generation. Strings can be up to 255 characters in length. Since these lines of data can be operated on as other FORTRAN data types, messages and report heads can be moved in memory or transferred to and from peripherals easily.

**FORTRAN IV** is an enhanced version of American National Standard FORTRAN, X3.9-1968. In addition to the normal FORTRAN IV characteristics, the following extensions are included: allowance for in-line assembly-language statements, bit and byte arrays, logical operations on data, provisions for relational expressions, two-named COMMON areas, free-form I/O, an executable END statement, and provisions for the H descriptor for read-in of formatted strings.

**BASIC** is offered in two versions, a standard BASIC and an extended BASIC. In addition, there are stand-alone versions available which reside in 4K words of memory. All versions are single-user conversational compilers and must be executed off-line.

**COBOL** is based on ANSI X3.23-1974 COBOL and incorporates all Level 1 capabilities and several Level 2 enhancements. Level 1 sort, library, table handling, and inter-program communications have been implemented in the current version. Sequential I/O operations and relative I/O operations conform to Level 1 and most of the Level 2 specifications. Level 2 I/O extensions include multiple-operand options of the OPEN and CLOSE statements and I/O logical unit assignments which are compatible with those used in all other GA operating systems.

The compiler builds and maintains directory tables to permit compilation of unlimited-length programs. Overflow program segments are automatically created on disk, with automatic segment chaining during execution.

Separately written and compiled programs can be stored in a library and linked for execution. This technique is used to include assembly-language strings or statements from other

languages in the COBOL programs. File structures are the same as those used by other GA operating systems, providing complete software compatibility.

COBOL is supported by all GA operating systems and requires the minimum configuration for the specific operating software plus an additional 16K words for compilation.

**MACRO ASSEMBLER (CAP-16)** is a symbolic macro assembler that can produce either relocatable or absolute object code. It includes provisions for program linking through the Core Load Overlay Builder (CLOB) program. CAP-16 requires a minimum system with 8K words of memory and a console device.

## PRICING

**POLICY:** General Automation offers the Solution Series systems for purchase only. Maintenance is separately priced. Quantity discounts are available on GA-manufactured hardware; equipment not manufactured by GA is generally discounted at a lower rate.

Software is provided on a single-use licensing arrangement or "right to copy" for multiple-use licensing.

General Automation provides maintenance either on a contract basis or on a per-call basis. Contract maintenance prices for 16/440 and large systems are typically one percent of the purchase price per month. Charges for on-call maintenance are computed at \$70 per hour for service provided between 8 a.m. and 5 p.m., Monday through Friday; \$85 per hour between 5 p.m. and 8 a.m., Monday through Friday and all day Saturday; and \$85 per hour on Sundays and holidays.

Service calls beyond 50 miles from a GA service center also incur \$0.25 per mile. All times are figured to the nearest half-hour. All parts used in contract service or on-call service are charged at list price. Minimum time charged is 4 hours.

General Automation provides customer training at its headquarters in Anaheim, California. Course fees and schedules can be obtained through the company's sales offices.

## EQUIPMENT PRICES

|                                  |  | <u>Purchase Price</u> |
|----------------------------------|--|-----------------------|
| <b>PROCESSORS AND SUBSYSTEMS</b> |  |                       |
| 1611-0001                        | 16/110 CPU, one PC board; includes CPU, controls, indicators, I/O bus, memory bus, vectored priority interrupts, PF/AR, OMA, RTC input, cold start functions. Memory, power supply, chassis, software, documentation must be ordered separately.                       | \$ 875                |
| 1611-1013                        | Compact 16/110 Subsystem; includes 16/110 CPU plus Compact chassis and system power supply   | 3,275                 |
| 1611-1012                        | Jumbo 16/110 Subsystem; includes 16/110 CPU plus Jumbo chassis and system power supply   | 3,800                 |
| 1622-0001                        | Second CPU board to upgrade 16/110 to 16/220; adds DMA port, serial I/O controller, additional controls  | 575                   |
| 1622-0020                        | 16/220 Microcomputer, two PC boards; includes CPU, controls, indicators, I/O bus, memory bus, DMA port, vectored priority interrupts, serial I/O port and controller for console TTY/CRT, PF/AR, OMA, cold start functions   | 1,450                 |
| 1622-1023                        | Compact 16/220 Subsystem; includes 16/220 CPU, Compact chassis and system power supply   | 3,600                 |
| 1622-1022                        | Jumbo 16/220 Subsystem; includes 16/220 CPU, Jumbo chassis and power supply  | 4,200                 |
| 1623-1030                        | Compact 16/230 Subsystem; includes 16/230 CPU, Compact chassis and system power supply, RS-232 current loop serial I/O adapter, system console interface with initial program load (IPL), memory service module, 128K-byte HYPACK memory                               | 7,325                 |
| 1623-1040                        | Jumbo 16/230 Subsystem; same as 1623-1030 but with Jumbo chassis and system power supply   | 7,975                 |
| 1624-0724                        | 16/230 to 16/240 Conversion Kit; includes conversion of non-ECC to ECC HYPACK memory, error correction, extended instruction set   | 2,500                 |
| 1624-1031                        | Compact 16/240 Subsystem; includes 16/240 CPU, Compact chassis and system power supply, RS-232 current loop serial I/O adapter, system console interface with initial program load (IPL), memory service module, 128K-byte ECC HYPACK memory, extended instruction set | 9,000                 |
| 1624-1041                        | Jumbo 16/240 Subsystem; same as 1624-1031 but with Jumbo chassis and system power supply   | 9,650                 |
| 1644-1305                        | 16/440 General-Purpose Computer; includes 32K bytes of 18-bit, 720-nanosecond core memory; 128K-byte maximum memory expansion  | 12,000                |
| 1644-1404                        | 16/440 General-Purpose Computer; same as 1644-1305 plus byte parity error detection and memory write protection  | 13,500                |
| 1644-1504                        | 16/440 General-Purpose Computer; same as 1644-1404 plus two-megabyte maximum memory expansion, memory management and allocation system   | 15,000                |
| 1646-1001                        | 16/460 General-Purpose Computer Without Memory; 240-nanosecond microprogrammed processor, chassis with four memory slots, programmer's console, combined RS-232 current loop serial I/O adapter, processor power supply, and MOS memory power converter                | 11,000                |

General Automation Solution Series

EQUIPMENT PRICES

Purchase  
Price

PROCESSORS AND SUBSYSTEMS (Continued)

|           |  |        |
|-----------|--|--------|
| 1646-1002 | 16/460 General-Purpose Computer Without Memory; same as 1646-1001 plus memory parity and protect   | 12,500 |
| 1646-1003 | 16/460 General-Purpose Computer Without Memory; same as 1646-1001 plus memory management system  | 14,000 |
| 1647-1201 | 16/470 Subsystem; includes 16/470 minicomputer, 128K-byte ECC HYPAK memory, Jumbo system power supply, MOS memory power converter, RS-232 current loop serial I/O adapter, memory parity and protect (MPP), initial program load (IPL) | 16,000 |
| 1648-0322 | 16/460 to 16/480 Conversion Kit; includes 256K-byte ECC HYPAK memory, memory management system   | 10,400 |
| 1648-0310 | 16/470 to 16/480 Conversion Kit; includes 128K-byte ECC HYPAK memory, memory management system   | 4,650  |
| 1648-1302 | 16/480 Subsystem; includes 16/480 minicomputer, 256K-byte ECC HYPAK memory, Jumbo system power supply, MOS memory power converter, RS-232 current loop serial I/O adapter, memory management system, initial program load (IPL)        | 20,500 |

PROCESSOR OPTIONS

16/110, /220, /230, and /240 options—

|           |   |     |
|-----------|---|-----|
| 1622-0012 | System Console Interface Option; includes ability to control computer from system console device (TTY or CRT) or remote master computer, 256 words of RAM and space for 256 words of ROM; for /220 only | 320 |
| 1622-0013 | Same as 1622-0012 plus multi-device initial program load (IPL) bootstrap ROM  | 380 |
| 1622-0016 | Same as 1622-0013 but with ability to load from more devices  | 420 |
| 1622-0050 | Memory Parity and Protect Option, for /220  | 750 |
| 1623-0050 | Memory Parity and Protect Option, for /230  | 750 |
| 1624-0050 | Memory Parity and Protect Option, for /240  | 750 |

16/440 and /460 options—

|           |  |       |
|-----------|--|-------|
| 1644-0450 | Memory Parity Error Detection and Memory Write Protect Module; parity features require 18-bit memory   | 1,500 |
| 1644-0550 | Memory Management System; provides memory management by random address allocations of 1K memory increments, privileged instructions, memory parity generation and error detection, and memory write violation detection; parity feature requires 18-bit memory | 3,000 |
| 1644-0070 | Initial Program Load—Disk/CR/PTR; provides MOS ROM to load from 3346 disk, 3316 and 3318 card readers, and 3321, 3323, and 3325 paper tape readers   | 180   |
| 1644-0071 | Initial Program Load—Disk/PTR/TTY; provides MOS ROM to load from 3346 disk, 3362 and 3363 teletypes, and 3321, 3323, and 3325 paper tape readers   | 180   |
| 1644-0072 | Initial Program Load—Disk/CR/TTY; provides MOS ROM to load from 3346 disk, 3316 and 3318 card readers, and 3362 and 3363 teletypes   | 180   |
| 1644-0075 | Initial Program Load—FD/CR/PTR; provides MOS ROM to load from 3349 floppy disk, 3316 and 3318 card readers, and 3321, 3323, and 3325 paper tape readers  | 180   |
| 1644-0076 | Initial Program Load—FD/PTR/TTY; provides MOS ROM to load from 3349 floppy disk, 3362 and 3363 teletypes, and 3321, 3323, and 3325 paper tape readers  | 180   |
| 1644-0078 | Initial Program Load—DSM/CR/TTY; provides MOS ROM to load from 3345 disk storage module, 3316 or 3318 card readers, and 3362 and 3363 teletypes  | 180   |
| 1644-0079 | Initial Program Load—DSM/PTR/TTY; provides MOS ROM to load from 3345 disk storage module, 3362 and 3363 teletypes, and 3321, 3323, and 3325 paper tape readers   | 180   |
| 1644-0088 | Initial Program Load—HPT/TTY; provides MOS ROM to load from 3342 HPT storage drive and 3362 and 3363 teletypes   |       |

MEMORY

16/110 and /220

|           |  |       |
|-----------|--|-------|
| 1622-0305 | 16K x 18 bits Plug-in RAM, 32K bytes; dynamic MOS read/write memory, on-board refresh, byte parity generation and checking | 1,500 |
|-----------|--|-------|

16/240

|           |   |       |
|-----------|---|-------|
| 1624-0823 | Memory Expansion Kit for Jumbo 16/240; includes 128K-byte HYPAK memory modules for board insertion                      | 3,250 |
| 1624-0893 | Memory Expander for Jumbo 16/240; includes 128K-byte HYPAK memory modules for board insertion, memory management system | 4,000 |

16/440 and /460

|           |  |       |
|-----------|--|-------|
| 1644-0401 | Memory module; 32K-byte, 720-nanosecond core memory  | 4,000 |
| 1646-0211 | Memory module; 64K-byte, 500-nanosecond parity MOS memory  | 3,500 |
| 1646-0228 | Memory module; 128K-byte, 500-nanosecond parity MOS memory   | 6,250 |
| 1646-0213 | Memory module; 64K-byte, 500-nanosecond ECC MOS memory   | 4,900 |
| 1646-0216 | Memory expansion module; expands 1646-0211 to 1646-0228  | 2,850 |
| 1646-0214 | ECC expansion module; expands 1646-0211 to 1646-0213   | 1,550 |
| 1644-1804 | 16/440 memory expansion module; enclosure, memory control logic board, 32K bytes of 18-bit 720-nanosecond core memory, power supply; maximum expansion 128K bytes per module | 9,000 |
| 1644-0804 | 16/440 memory expansion module; same as 1644-1804 minus power supply   | 8,250 |

16/480

|           |   |       |
|-----------|---|-------|
| 1648-0010 | Memory expansion kit; 128K-byte HYPAK memory modules for board insertion        | 3,250 |
| 1648-0543 | Memory module for expansion beyond 1024K bytes; 256K-byte ECC HYPAK memory, PCB | 7,500 |

I/O INTERFACES

|           |  |     |
|-----------|--|-----|
| 1622-0024 | Combined RS-232 and Current Loop Serial I/O Adapter (without loop power), for 16/220 | 180 |
|-----------|--|-----|

## General Automation Solution Series

## EQUIPMENT PRICES

|   |   | <u>Purchase<br/>Price</u> |
|---|---|---------------------------|
| <b>POWER SUPPLIES (for 16/110 and /2x0)</b>                                   |   |                           |
| 162x-1003   | Power supply and battery backup for auxiliary memory subsystems, includes 1.5 ampere-hour battery | 850                       |
| 1622-1004   | Memory service module for auxiliary memory subsystem, no battery backup                           | 125                       |
| <b>MASS STORAGE</b>   |   |                           |
| 3346-1500   | Disk Drive and Controller; 10 MB, 1 fixed and 1 removable disk; max. four drives                  | 9,175                     |
| 3346-1510   | Add-on 10 MB disk drive   | 7,325                     |
| 3346-6200   | Separate controller for up to four 3346 disk drives   | 4,000                     |
| 3346-9000   | Cartridge Disk for 3346 disk drives   | 130                       |
| 3345-1144   | Disk Drive and formatter; 80 MB, removable pack; max. 8 drives                                    | 26,000                    |
| 3345-1644   | Add-on 80 MB disk drive   | 15,500                    |
| 3345-6120   | Separate formatter for up to 8 disk drives  | 10,000                    |
| 3345-9104   | Disk pack for 8019B disk drives   | 650                       |
| 3345-1148   | Disk Drive and formatter; 300 MB, removable pack; max. 8 drives                                   | 42,000                    |
| 3345-1648   | Add-on 300 MB disk drive  | 31,500                    |
| 3345-9108   | Disk pack for 300 MB disk drives  | 1,675                     |
| 3442-1001   | Floppy Disk Drive and Controller for up to four disk drives; 0.5 MB                               | 3,850                     |
| 3442-1002   | Floppy Disk Drive and Controller for up to two disk drives  | 5,000                     |
| 3442-6005   | Floppy Disk Controller for up to four drives and controller cable                                 | 2,925                     |
| <b>MAGNETIC TAPE EQUIPMENT</b>  |   |                           |
| All magnetic tape subsystems require a 1932-1100 enclosure for each transport |   |                           |
| 3431-1000   | Magnetic Tape Transport and Controller; up to 4 transports, 9-track, 45 ips, 800/1600 bpi         | 13,100                    |
| 3431-1010   | Magnetic Tape Transport (add-on)  | 7,925                     |
| 3431-6006   | Separate controller for up to four transports and controller cable                                | 2,500                     |
| <b>LINE PRINTERS</b>  |   |                           |
| 3450-1301   | Line Printer & Controller; 300 lpm  | 11,300                    |
| 3450-1601   | Line Printer & Controller; 600 lpm  | 14,600                    |
| 3450-695  | Line printer controller and cable   | 2,500                     |
| <b>CARD EQUIPMENT</b>   |   |                           |
| 3317-1000   | Card Reader & Controller; 600 cpm   | 10,000                    |
| 3317-6200   | Card Reader Controller  | 1,300                     |
| <b>PAPER TAPE EQUIPMENT</b>   |   |                           |
| 3321-1320   | Paper Tape Reader and Controller; 1500 cps  | 3,780                     |
| 3321-6200   | Paper Tape Reader Controller  | 1,100                     |
| 3322-1320   | Paper Tape Punch and Controller; 70 cps   | 3,475                     |
| 3322-6205   | Paper Tape Punch Controller   | 1,100                     |
| 3323-1320   | Paper Tape Reader, Punch, and Controller; combines 3321-1320 and 3322-1320                        | 6,725                     |
| 3323-6203   | Separate Paper Tape Reader and Punch Controller   | 1,700                     |
| <b>COMMUNICATIONS EQUIPMENT</b>   |   |                           |
| 1561-0011   | Asynchronous Communication Controller; RS-232 (1-line)  | 800                       |
| 1562-0012   | Asynchronous Communication Controller; RS-232 (2-line)  | 1,100                     |
| 1561-0013   | 2-line expansion  | 575                       |
| 1561-0212   | Asynchronous Communication Controller; RS-232 (2-line)  | 1,100                     |
| 1571-0011   | Synchronous Communication Controller; RS-232 (1 line)   | 770                       |
| 1567-0014   | Automatic Calling Unit Controller   | 990                       |
| 1581-1X11   | Asynchronous Communication Controller; 20/60ma current loop (1-line)                              | 825                       |
| 1581-1X12   | Asynchronous Communication Controller; 20/60ma current loop (2-line)                              | 1,100                     |
| 1581-1013   | 2-line expansion  | 770                       |
| 1581-1212   | Asynchronous Communication Controller; 20ma/60ma current loop (2-line)                            | 1,100                     |
| 1590-0040   | Status Display Board for 1590-100X  | 330                       |
| <b>TERMINALS</b>  |   |                           |
| 3365-1001   | System Console TTY  | 2,150                     |
| 3365-1101   | System Console TTY; KSA   | 2,425                     |
| 3380-1431   | CRT Display; 80-character line, 25 line program keys, RS-232                                      | 1,625                     |

## General Automation Solution Series

### EQUIPMENT PRICES

|                      |   | <u>Purchase<br/>Price</u> |
|----------------------|---|---------------------------|
| <b>MISCELLANEOUS</b> |   |                           |
| 1622-0035            | Compact Chassis; standard 8.75-inch by 19-inch chassis; includes master interconnect board with twelve front-access, 140-pin slots; rear connectors and positive retainer for I/O cables                | 775                       |
| 1622-0034            | Jumbo Chassis; standard 8.75-inch by 19-inch chassis; includes master interconnect board with seventeen front-access, 140-pin slots; rear connectors for power and I/O and positive I/O cable retainers | 925                       |
| 162x-0036            | Smoked plastic dress panel, 8.75 inches, for 16/110 and /2x0 microcomputers   | 95                        |

### SOFTWARE PRICES

|                              | <u>License<br/>Fee</u> |
|------------------------------|------------------------|
| Operating Systems—           |                        |
| CONTROL I                    | \$1,500                |
| CONTROL II                   | 1,500                  |
| CONTROL III                  | 1,500                  |
| CONTROL IV                   | 2,500                  |
| CONTROL V                    | 2,500                  |
| COBOL Compiler               | 6,000                  |
| COMFORT (Commercial FORTRAN) | 3,000                  |
| Data File Management (DFM)   | 2,000                  |
| Multi-Terminal System (MTS)  | 2,000                  |