CONTROL DATA® 160G COMPUTER SYSTEM

INTRODUCTION

System operation in the **Control Data®** 160G is based on field-proven programming systems and field-proven hardware.

Employing two modes of operation – the A and the G modes – the 160G user can immediately employ the widely used 160-A instruction repertoire and programming systems (FORTRAN, OSAS-A, AUTOCOMM, SICOM, INTERFOR, CEPS), and take advantage of new and faster operating methods that include:

- Fully integrated programming and operating procedures through a new monitor/assembly system (MASS).
- A method that runs FORTRAN problems approximately 10 times faster than on an optimum 160-A system.
- A multiple precision arithmetic package.
- An extensive library of diagnostic, mathematical, and conversion routines.

As for 160G hardware, it follows the traditional excellence of Control Data system design with:

- **Control Data** 3600 logic and circuitry for highest performance standards.
- Less than 1.35 microsecond memory cycle time for high-speed operations.
- Completely modular design for planned system growth, efficient long-range expansion.
- A wide choice of Control Data peripheral equipment.

Already in demand for preflight checkout of important space vehicle systems, the **Control Data** 160G Computing System can accelerate problem solution in many applications requiring on-time and full-time operation – in government, industry, and commerce.

160G CHARACTERISTICS

- Stored program, general purpose digital computer
- Parallel mode of operation
- **Control Data** 3600 logic and memory
- 1.35 microsecond memory cycle time; .7 microsecond memory access time
- True modular design for system expansion
- 13-bit word length plus one parity bit
- Compute Module with:
  - 8192 words of memory
  - One buffered I/O channel
  - One non-buffered I/O channel
- Memory module of 8192 13-bit words for broad system expansion
- Input/Output Module featuring two completely buffered I/O channels
- Flexible system configuration with any number of Compute Modules (and associated memory and I/O). A total of 9 Compute and/or Input/Output Modules can be attached to any one Memory Module.
- Three I/O Modules and 15 Memory Modules can be added to a Compute Module for a maximum of 8 I/O channels and 131,072 words of memory per Compute Module.
- High-speed communication ability with computer systems at remote locations
- Flexible repertoire of instructions
- Inclusion of all 160-A instructions
- Built-in multiply and divide
- Advanced arithmetic speeds
  - Average instruction time: less than 3 microseconds
  - Typical multiply time: 7 microseconds
  - Typical divide time: 8:5 microseconds
- Total program compatibility with the **Control Data** 160 and 160-A Computers
- Complete software package, including:
  - MASS – an integrated monitor system
  - GASS – 160G general assembly program
  - FORTRAN
  - An extensive library of diagnostic, mathematical, and conversion routines
  - Multiple precision arithmetic package used with the GASS assembler

  All 160 and 160-A programming systems, including:

  FORTRAN SICOM OSAS-A
  INTERFOR AUTOCOMM CEPS

160G SYSTEM MODULARITY

The Compute Module

The 160G uses a high degree of modularity. In its basic form – the single Compute Module – the user starts with a functioning computer. This module operates independently of additional memory and input/output.

The Compute Module of the 160G performs all basic functions:

- It contains a complete and flexible repertoire of instructions employing 15 basic commands and 12 modes of addressing.
- The 160G Compute Module contains 8192 13-bit words of core storage. Each word has a complete cycle time of 1.35 microseconds.
- It also includes two Input/Output channels, one buffered and one non-buffered.

This parallel, single address electronic data processor operates under control of an internally stored program which is located in sequential addresses in its memory. The majority of the 160G instructions can be executed in one to four storage cycles.

Examples of the 160G execution rates are:

- Average instruction time: less than 3 microseconds
- Typical multiply time: 7 microseconds
- Typical divide time: 8.5 microseconds

The 160G also contains, as a subset, the entire 160-A repertoire of instructions. As a result, any program written for the 160-A will run on the 160G Compute Module without modification.

For operation and maintenance control, each 160G Compute Module includes a console that provides all controls and indicators necessary to operate both the Compute Module and any associated Memory and I/O Modules that are added to the system.

Not only does the 160G Compute Module handle the full 160-A instruction repertoire, but Control Data engineers have added several new programming features which measurably increase the computing capability of the 160G. These features include:

- **Two Operating Modes**

The two operating modes are the A mode for 160-A programs and the G mode for 160G programs. Most of the 160G instructions will operate in either mode.

- **Index Registers**

62 Index Registers are available on the 160G. This feature provides the capability and flexibility usually found only in large computer systems.

- **Addressing Modes**

Four new addressing modes have been added in the 160G design:

ENTIRE MEMORY
INDIRECT ENTIRE BANK
RELATIVE ENTIRE BANK
MEMORY INDEX

- **New Instructions**

A number of new instructions are included in the 160G repertoire, such as:

Multiply
Divide
High-Low comparison
Bit-by-Bit jump

- **Automatic Load**

The Automatic Load feature allows read-in of the first record from magnetic tape or cards to provide a bootstrap capability.

- **Breakpoint**

A Breakpoint switch is provided on the 160G console to allow the program to be stopped at any location.

With this basic start – 160G Compute Module – the user is assured of highly efficient and economical operation and can expect the same efficient and economical expansion for greater system capability through addition of the other two modules.

The Memory Module

Beginning with the basic 8192 words of memory in the Compute Module, the storage level of the 160G can be expanded to include 131,072 words of high speed memory for each Compute Module. The size of the system is controlled by the user selecting as many Memory Modules as are needed for his application.

Each Memory Module contains storage for 8192 13-bit words with both memory control logic and a scanner. This scanner is used to sequentially examine the request lines from both the Compute and Input/Output modules. Each Memory Module has its own read/write and parity circuitry.

Of unusual interest is a basic feature of the Memory Module – the 9-place access to memory. This is the feature that makes the 160G Computer System extremely flexible and powerful in its class. With 9-place access to memory, the 160G system allows up to 9 computers sharing one Memory Module. An alternative allows any combination of Compute Modules and I/O channels up to a total of 9 accesses to be attached to each Memory Module.

The Input/Output Module

If additional input/output data channels are desirable in a 160G Computer system, the Input/Output module can be used. Each I/O Module contains two buffered bi-directional data channels. Up to three I/O Modules can be added to any one Compute Module in a 160G system giving a total of:

7 buffered channels
1 non-buffered channel

As many as eight peripheral units may be operated on each channel, and up to 1000 feet of cable may be used to interconnect them.

Associated with each buffered channel are hardware registers to hold the addresses in use during data transfer. As a result, for example, a one-word information transfer needs only one memory reference.

Each I/O Module contains control logic, external function circuitry and interrupt circuitry. Two interrupt lines are associated with each data channel, and any unit of equipment attached to a channel can activate either of these interrupt lines.

REMOTE COMMUNICATION

Users with applications requiring high-speed remote functions between computer systems will benefit not only by the increased internal speed of the 160G but also by its ability to "hook-up" with remote locations. In addition, by adding a special interface, the 160G may be tied directly – memory to memory – with other Control Data systems. This can be of significant value in real-time operations that

demand long-range and high-speed remote data transfer and in complex scientific functions where site location, subject investigation, and final solution are separate.

THE 160G PROGRAMMING SYSTEMS

Three considerations are of prime importance in reviewing the full software system available in the 160G:

- New programming features built into the 160G
- Complete 160-A repertoire of instructions and the complete 160-A software is included
- New monitor and general assembly systems (MASS and GASS)

The new programming features have already been discussed including the A and G modes of operation, the 62 Index Registers, the new addressing modes, the new 160G instructions, etc. The 160-A instruction repertoire and its field-proven software are also widely known and accepted:

FORTRAN – includes a compiler, a subroutine library, and an interpreter.

OSAS-A – a symbolic assembler.

AUTOCOMM – designed for data processing applications.

SICOM – a general purpose interpretive system utilizing floating point arithmetic.

INTERFOR – an interpretive programming system.

CEPS – programming system for solution of civil engineering problems.

In the 160G, these considerations with the addition of MASS (Monitor and Assembly System) and GASS (Generalized Assembly System) provide the user with an extremely efficient and well organized programming capability.

160G Monitor and Assembly System

The 160G Monitor and Assembly System (MASS) is an integrated series of programs and operating procedures that bring together previously written library and systems programs for the programmer's use on the 160G. The 160G programmer can expect four major advantages:

1. MASS provides a series of standard I/O routines. Macro instructions in the 160G Assembly System (GASS) allow the programmer to easily and efficiently write the calling sequences to these MASS I/O routines.

2. MASS provides the loader programs to place assembled programs in the 160G memory. A linking loader and control system enables the programmer to combine separately assembled programs and binary library routines at their running times. That same linking loader will complete the assembly process and provide all cross references between independently assembled programs.

3. MASS provides a simple interrupt handling system for the 23 distinct interrupts in the 160G.

4. MASS also provides an executive handling system for the calling, sequencing, and execution of a series of programs. Executive instructions may originate from the typewriter, card reader or magnetic tape units to allow for complete automatic operation of a number of programs.

160G Generalized Assembly System

The General Assembly Program (GASS) of the 160G performs two major functions for any assembly program:

1. Allows the use of mnemonic terms for the instructions to be performed;

2. Allows the use of symbolic terms in referencing memory locations.

GASS will process a program written in this form and produce the required absolute machine language program.

GASS also provides for the inclusion of symbolic library programs from the library tape at assembly time. It can also localize a symbol's "area of definition" to prevent conflicts between various routines written by different programmers. Macro instruction capabilities in GASS can generate frequently used calling sequences to the MASS system. The GASS output is a listing of the assembled program and a binary copy of the program relocatable at load time.

Additional Features:

Also of importance are:

- FORTRAN – a typical problem will run approximately ten times as fast as on an optimum 160-A System.
- An extensive library of diagnostic, mathematical, and conversion routines.
- Multiple precision arithmetic package used with the GASS Assembler.

THE 160G AND PERIPHERAL EQUIPMENT

Peripheral equipment for the 160G system is similar to the complete line on the **Control Data** 160-A. The 160G peripherals satisfy all external functions that a user may require. They include:

161G Typewriter – an optional I/O device for flexible system monitoring.

162G Magnetic Tape Controller – controls 606 Magnetic tape system for status checks, search, back space, rewind load or unload, and information transfer.

165G Line Plotter – a digital recorder containing high-speed, dual-axis recorders for plotting one variable against another.

166G Line Printer – provides direct on-line print-out of data at 150 or 600 lines per minute.

167G Card Reader – reads standard 80-column punched cards at 250/minute; stacker capacity is 500 cards.

170G Card Punch Controller – assembles data from the computer into 80-column words and sets the punch operations.

177G Card Reader Controller – permits direct connection with model 405 Card Reader.

405 Card Reader – for read and transfer of punched card data to computer, magnetic tape, or printer. The 405 reads cards at 1,200 cpm, column-by-column, and transfers data in a 12-bit per word parallel mode.

603 Magnetic Tape Unit – one of the 600 series of magnetic tape systems; pneumatically controlled operation with selectable recording densities of 200 and 556 frames per inch; character rates in order of recording density are 15 and 41.7 kc; 75 inches per second.

604 Magnetic Tape Unit – 75 inches per second, 200,556, and 800 bpi, 15, 41.7, and 60 kc.

606 Magnetic Tape Unit – selectable recording densities are 200 and 556 frames per inch with corresponding character rates of 30,000 and 83,400 characters per second.

1612G Line Printer – a high-speed on-line printer with selective speeds up to 1000 lines/minute. 160G buffered channels allow simultaneous computing and printing.

1619G Disk File Controller – controls one to four 818 Disk Files.

818 Magnetic Disk File – 201 million bits of storage.

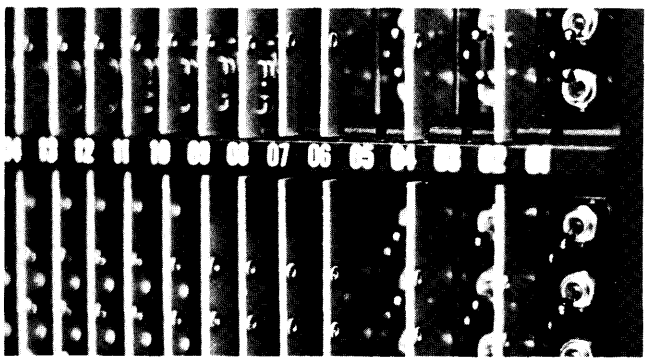
8528G Digital Communication Terminal – an inter-computer communication device to provide long distance data transfer; entirely program controlled for unmodified use on the 160G normal channel with or without interrupt.

160G CIRCUITRY

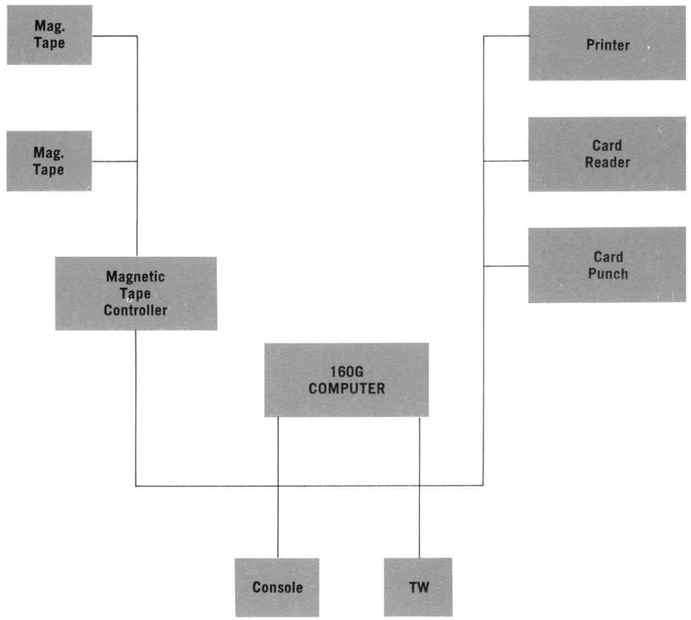
The circuits used in the 160G Scientific Computing System have been under development at Control Data Corporation for over two years. They are the result of extensive development efforts expended in producing the **Control Data** 3600 and the **Control Data** 160G Computing Systems. These circuits benefit by many refinements made in evaluating the most reliable commercially available components.

The basic building block is a bi-level amplifier-inverter which operates at an equivalent phase rate of 16 megacycles. Several levels of logic can be performed in one phase time of 62.5 nanoseconds.

Printed-circuit cards similar to those found in the 1604 and 160-A Computer are used in the 160G. The dimensions have been changed slightly, and the component packing density has been increased. The voltage levels are −5.5 volts and −1.5 volts. All cards are pluggable and have eyelet test points for attaching oscilloscopes. All test points are accessible while the computer is operating.



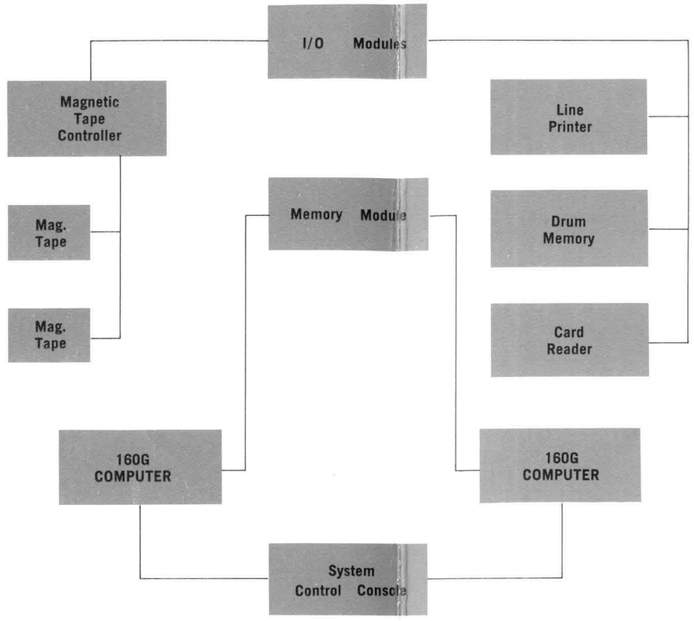
TYPICAL 160G COMPUTER SYSTEM



This diagram illustrates a typical 160G system, one with which the user can employ all 160G software.

Any program written for the 160-A will run four to five times as fast on this typical 160G system. A typical FORTRAN problem will run approximately 10 times faster.

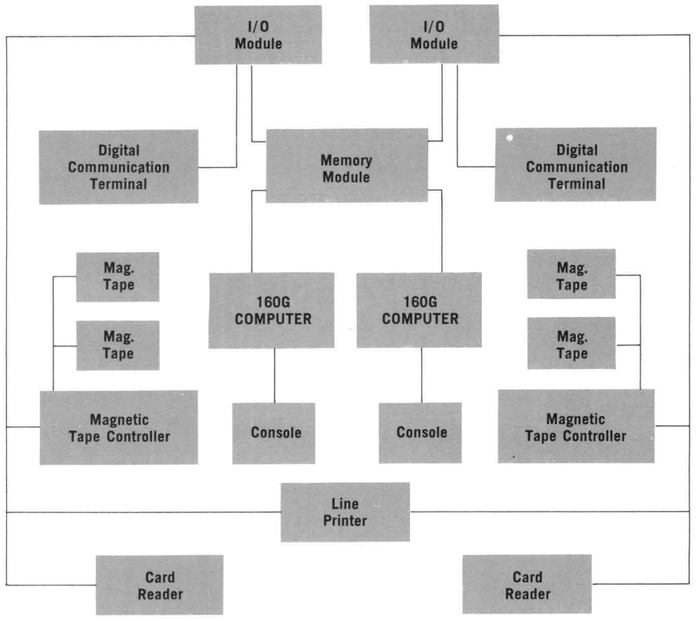
EXPANDED 160G (2-Computer System)



This expanded 160G System is ideally suited to high-speed message and data switching applications.

Using this 160G system, input/output rates in excess of 500 KC can easily be attained.

EXPANDED 160G (2-Computer System)



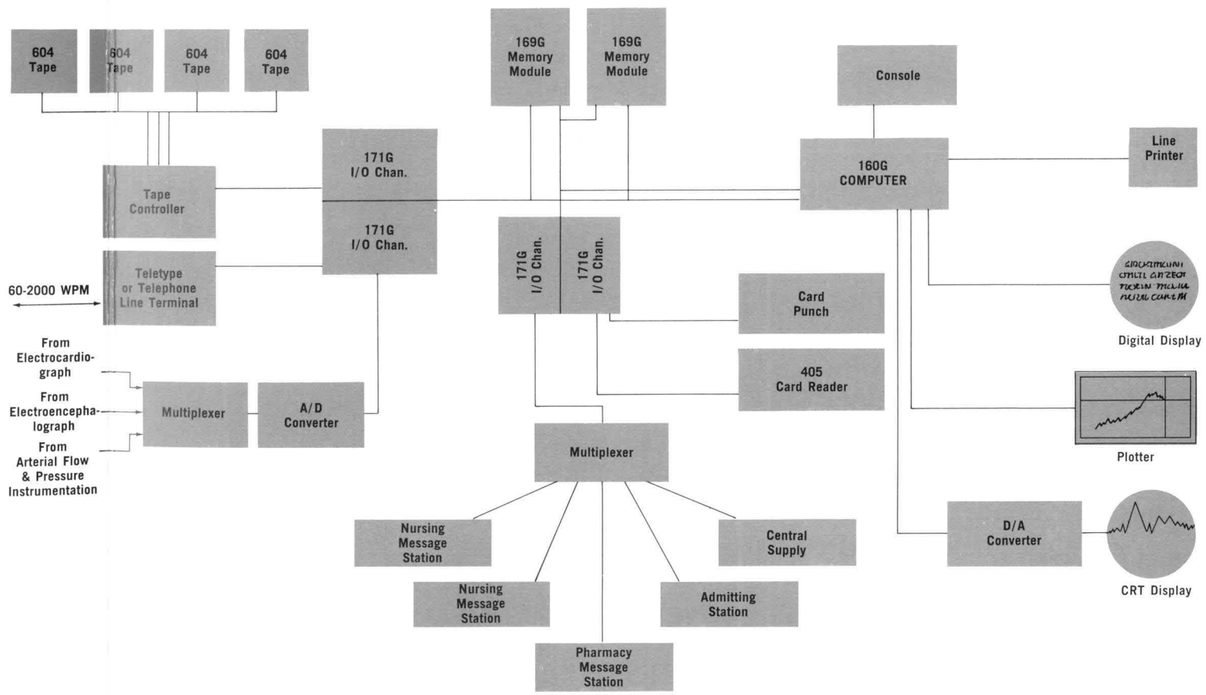
This expanded 160G system is suited to real-time satellite tracking.

The pair of Memory Modules are shared by both computers and both Input/Output Modules. The line printer is connected to two Input/Output channels and may be controlled by either Compute Module.

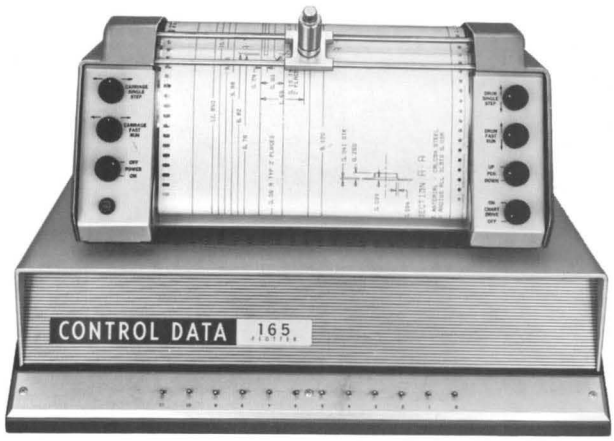
160G SYSTEM FOR MEDICAL APPLICATIONS

This 160G computer system is ideal for Medical Applications demanding:

Real-Time Data Collection
Scientific Research Data Processing
Telephone or Teletype Line Communication
Business Accounting and Data Processing
Patient Treatment Record Keeping
Real-Time Display of Experimental Data

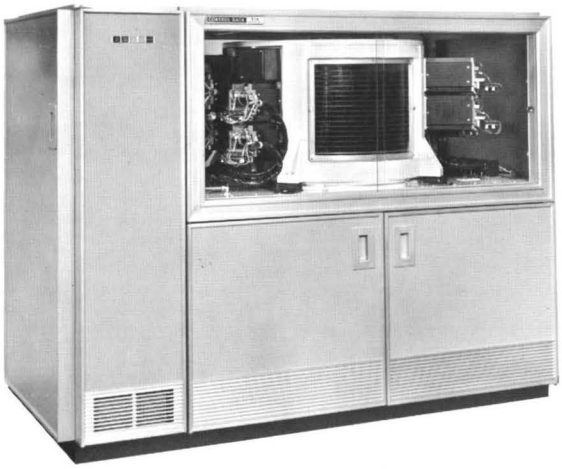


606 MAGNETIC TAPE UNIT



165G PLOTTER

166G LINE PRINTER



818 DISK FILE

405 CARD READER

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