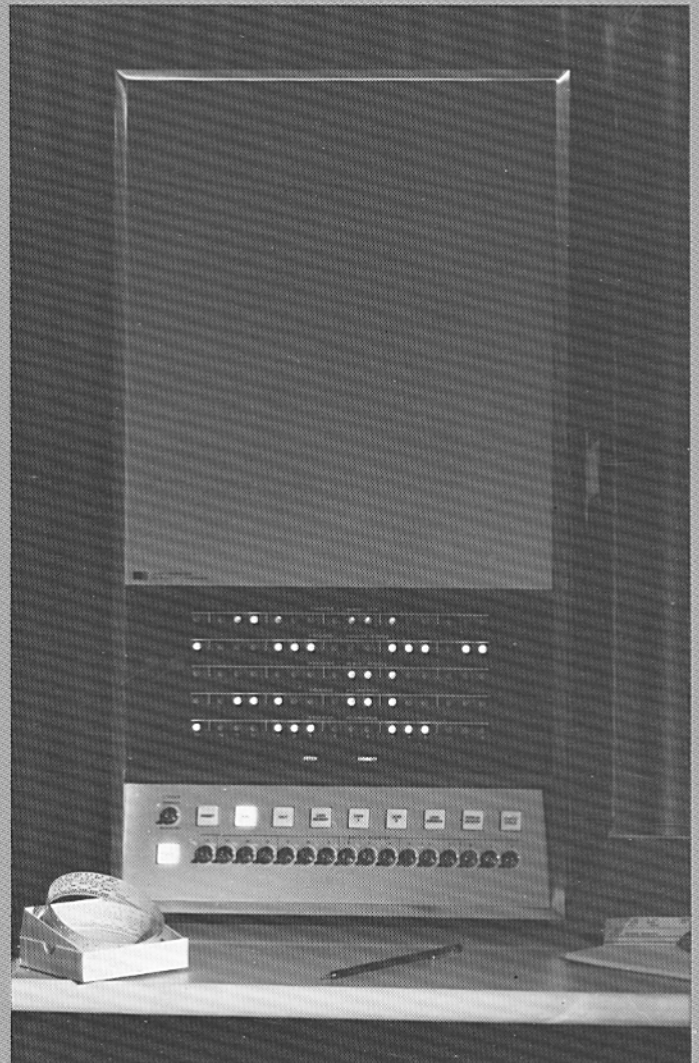


HP-2116A COMPUTER

TECHNICAL DATA 18 AUG 67



*A General-Purpose Computer for Scientific Computation
and Instrumentation Systems*

HEWLETT  PACKARD



FEATURES

PROCESSOR

- 16-bit word length.
- 4096-word memory, expandable to 8192 words in main frame, or 16,384 words with accessory memory extender.
- 1024-word page size; up to 2048 words directly addressable.
- Memory cycle time 1.6 microseconds.
- Dual, directly-addressable accumulators.
- Nine registers — contents of seven registers displayed on operator panel.
- 70 basic one-word instructions. Register Reference instructions allow extensive micro-programming.
- Instructions executable in 1.6 or 3.2 microseconds.
- Multiple-step indirect addressing.
- Protected loader.
- Wide environmental operating tolerance — ambient temperatures to 55°C (130°F), humidity to 95%.
- Rack-mountable for system use, with front access to plug-in cards.

INPUT/OUTPUT

- 16 individually-buffered input/output channels, with multi-channel priority interrupt, in basic main frame. Expandable to 48 channels with accessory I/O extender.
- Plug-in interface cards for all I/O options — no wiring changes necessary to add or delete peripherals.
- Plug-in interface for Hewlett-Packard measuring instruments — digital voltmeters, counters, nuclear scalars, quartz thermometer.
- Standard plug-in general-purpose interface for user-furnished devices.

SOFTWARE

- Complete software package, fully operable with basic system configuration (4096-word memory, Teleprinter input/output).
- Extended ASA Basic FORTRAN Compiler.
- Modular, flexible I/O control system — allows device-independent programming.
- Linking, relocating loader.
- Assembly language programs may be linked to compiler-generated code at execution time.
- Utility routines — software configurator, debugging package, hardware diagnostics.

HP-2116A — A COMPUTER FOR SCIENTIFIC PROBLEM SOLVING

The HP-2116A is a versatile, general-purpose digital computer, particularly suited in computational power and input/output flexibility to scientific and industrial measurement applications. The HP-2116A Computer may be used both as a free-standing system for solving scientific and engineering design problems, and in instrumentation systems, where it can be combined with Hewlett-Packard measuring instruments to provide complete solutions in a broad spectrum of measurement tasks in science and industry.

The HP-2116A Computer

The HP-2116A Computer is compact, portable, fast, (1.6 microsecond cycle time) and offers a flexible instruction repertoire of 70 basic one-word instructions, with the capability of extensive micro-programming through one-word combinations of register reference instructions.

The HP-2116A is supported by a full set of powerful software — FORTRAN Compiler, Assembler, Symbolic Editor and Basic Control System. The Compiler accepts programs written in a universally accepted language — ASA Basic FORTRAN — plus additional features which enhance programming flexibility. Software utility routines are also provided for debugging programs and diagnosing hardware malfunctions.

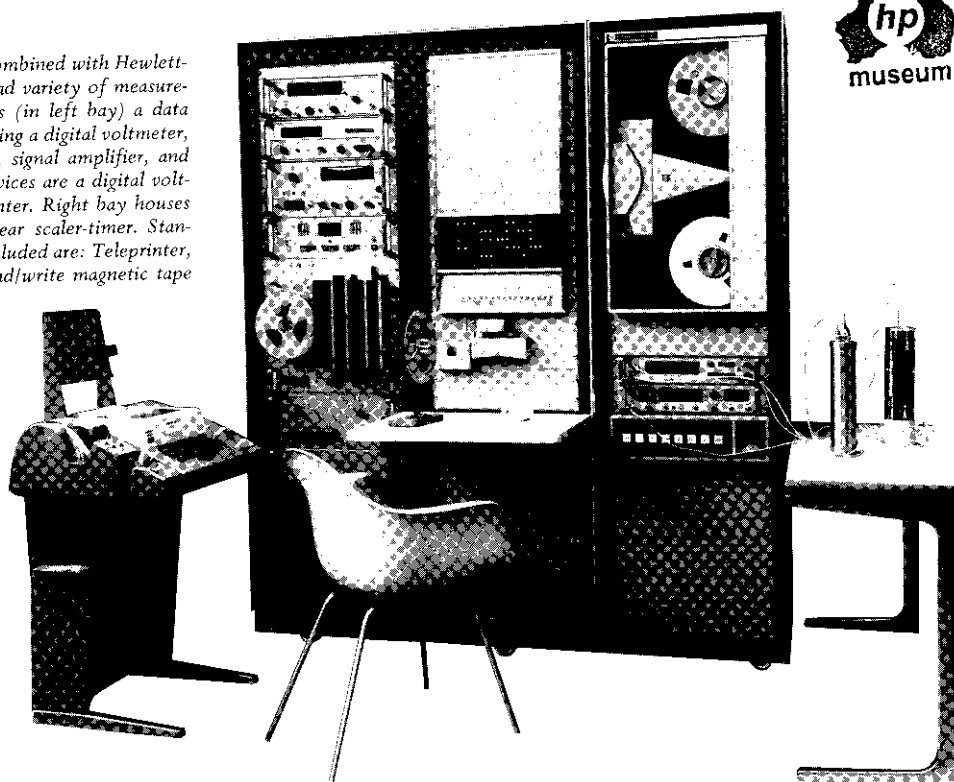
In its minimum configuration, consisting of 4096-word memory and Teleprinter input/output, the HP-2116A may be used with any of the standard software packages, thus constituting a powerful, yet inexpensive, computational tool. Its small size (it will stand on a laboratory bench) allows it to be moved to where it is needed. And, at any time, the HP-2116A can be expanded in computational power by adding memory capacity, and in input/output capability by adding peripheral devices, on a plug-in basis.

Interfacing with HP Measuring Instruments

The HP-2116A Computer operates, through standard plug-in interfaces, with virtually all Hewlett-Packard measurement instruments providing a digital data output. This very broad range of instruments includes:

- Digital voltmeters and associated signal converters, for measuring dc and ac voltages, currents and resistances. With suitable transducers, physical quantities such as pressures, loads, temperatures, and fluid flows can be measured with an HP-2116A system.
- Electronic counters, for frequency or period measurements from a few cycles per second into the microwave region.

HP-2116A Computer may be combined with Hewlett-Packard instruments for a broad variety of measurements. System shown includes (in left bay) a data acquisition sub-system comprising a digital voltmeter, ac voltage/resistance converter, signal amplifier, and analog scanner; other input devices are a digital voltmeter and high frequency counter. Right bay houses quartz thermometer and nuclear scaler-timer. Standard HP-2116A peripherals included are: Teleprinter, high-speed tape punch, and read/write magnetic tape unit.



- Scaler-timers for nuclear radiation measurements.
- Quartz thermometer for high-resolution temperature measurements in chemical analysis and oceanography.

Analog input scanners are available for multiplexing signals into these measuring instruments. Digital scanners are also available for applications where it is desirable to multiplex the data outputs of these instruments before entry into the HP-2116A Computer.

General-Purpose Interface

A general-purpose plug-in interface is available which enables the customer to operate a wide variety of devices of his own choosing with the HP-2116A Computer.

Data Input/Output Peripherals

Instructions or data may be entered on punched tape through a Teleprinter or high-speed photoelectric reader. Data output devices include the Teleprinter, which provides typewritten and punched tape records, a high-speed tape punch, and magnetic tape units for IBM-compatible, 7-channel recording at 200 or 556 bpi density. Data can be entered on-line from Hewlett-Packard data sources and computed in real time, or recorded on punched tape or magnetic tape and processed subsequently with the HP-2116A. For example, the HP-2116A Computer accepts punched tapes and magnetic tapes recorded by Hewlett-Packard data acquisition systems (2010 and 2013 series). A Data Phone interface is also available which enables information to be transmitted over the telephone system, into or out of the HP-2116A.

Input/Output Flexibility

Besides the obvious convenience of plug-in interface cards, the HP-2116A provides, as standard features, unique channel identification and service priority interrupt with every input/output channel used. Priority levels can be altered simply by interchanging the positions of interface cards.

The input/output software has been designed to make full use of this hardware flexibility. A modular control system allows source programs to be written without concern for specific operating requirements of peripheral devices, and a software configurator is furnished which allows the user to easily modify his control system to fit different input/output hardware configurations. Systems can be upgraded (say by switching from a low-speed to a high-speed tape punch) without changing the source program. The HP-2116A thus offers programming which is very nearly independent of the input/output devices used.

Measurement Applications of HP-2116A Computer Systems

Used in conjunction with Hewlett-Packard measuring instruments, the HP-2116A Computer enables on-line computations on single and multiple variable data inputs, such as:

- measurement units conversion
- transducer linearizing
- comparison against limits
- converting strain gage rosette readings to stresses
- calculating mass flow from pressure transducer data
- integrating of areas under curves, such as in gas chromatography
- averaging or taking the root mean square of successive measurements on one channel, or on multiple channels
- transducer calibration by least squares fitting
- determining engine horsepower and efficiency
- calorimetry; solving equations to find total heat generated in a reaction

Advantages of 'Local' Computation

While it is, of course, possible to record measurement data and subsequently obtain the answers needed by processing this raw data on a large, central computer, there are attractive advantages in on-line computation with a small computer. Projects proceed more quickly because the computerized measuring system provides answers immediately. With critical tests, this instant feedback allows equipment set-ups to be changed and tests re-run while the necessary conditions still prevail.

The small computer system can be used as and when needed – there is no feeling of obligation to gather large amounts of data to make the effort of central processing worthwhile. On the other hand, the small computer cannot solve all problems. In situations where the large data capacity and computational power of the big computer are needed, the HP-2116A can supply partially-computed output data in a form suitable for further processing.

The HP-2116A Operates in a Demanding Environment

Another feature of the HP-2116A Computer, not visible but nonetheless very important to its use in instrumentation systems, is that it has been designed to meet the same demanding environmental specifications as the Hewlett-Packard instruments with which it will frequently be operated. These conditions include an ambient temperature range from 0 to 55 °C (the memory uses wide temperature range cores and compensated drive circuits), relative humidity to 95%, vibration and shock.

MACHINE ORGANIZATION

The HP-2116A Computer has nine internal registers; eight of these are flip-flop (integrated circuit) registers, while the ninth consists of toggle switches for manual data entry. The contents of all but one of the flip-flop registers are available to the programmer, and are displayed on the front panel.

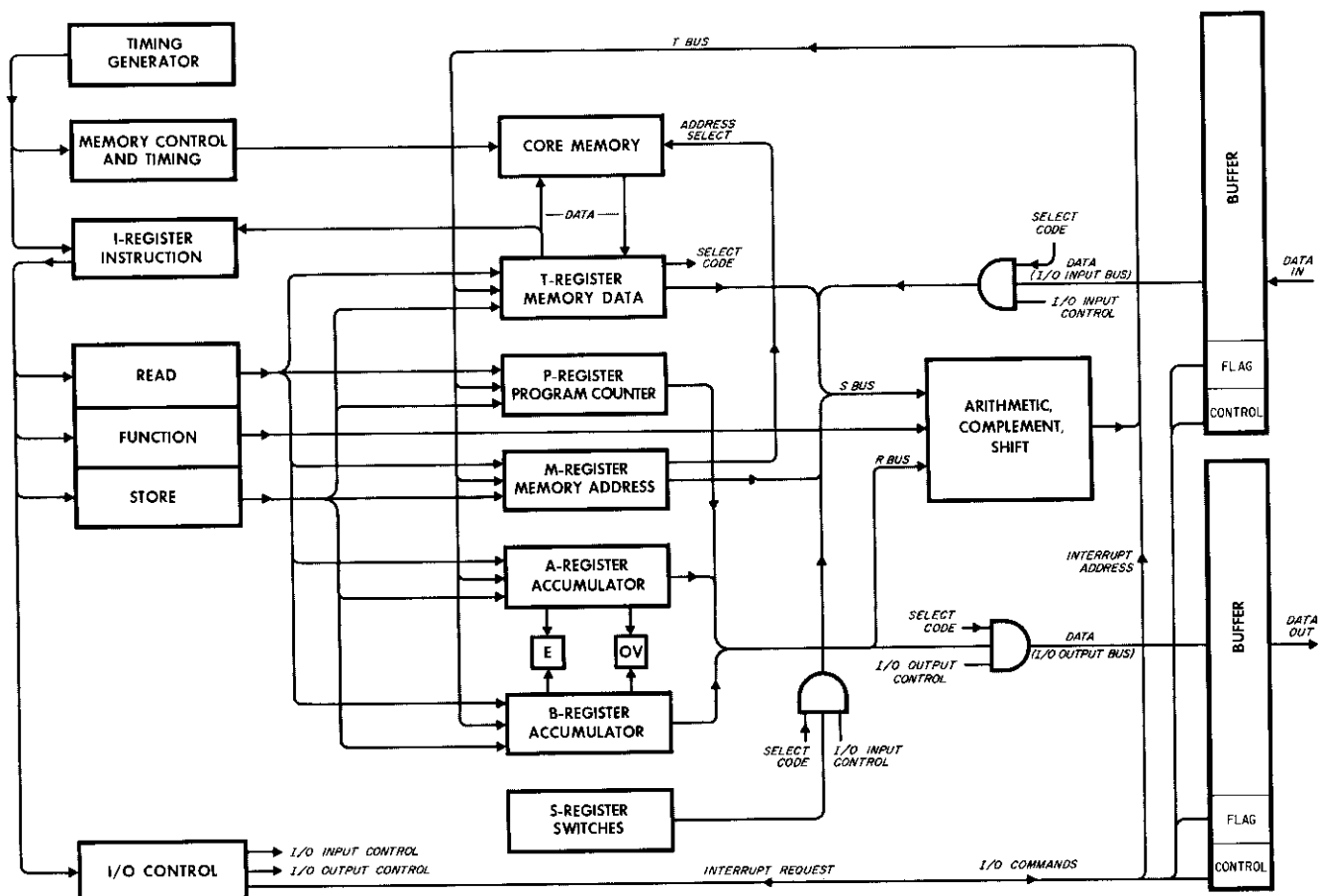
T-REGISTER (MEMORY TRANSFER): All data transferred into or out of memory is routed through the T-Register. The T-Register display therefore indicates the information that went into or out of a memory cell during the preceding memory cycle.

P-REGISTER (PROGRAM COUNTER): The P-Register holds the address of the next instruction to be fetched from memory (or the address of the current instruction in the case of a multi-phase instruction). The P-Register increments by one after the execution of each instruction (or by two if executing a skip instruction). A jump instruction can set the P-Register to any core location number.

M-REGISTER (MEMORY ADDRESS): The M-Register holds the address of the next memory cell to be accessed.

A and B REGISTERS (ACCUMULATORS): The A and B Registers execute and hold the results of arithmetic and logical operations performed by programmed instructions. The registers operate independently, allowing the programmer considerable freedom in program design. While they are flip-flop registers, they may be addressed by any Memory Reference instruction as location 00000 and 00001 respectively, thus permitting inter-register operations such as "add (B) to (A)", "compare (B) with (A)", etc., using a single-word instruction.

E-REGISTER (EXTEND): This is a 1-bit register, used to link the A and B Registers by rotate instructions, or to indicate a carry from bit 15 of the A or B Register by any add or increment instruction (only) which references these registers. This is of significance primarily for multiple-precision arithmetic.



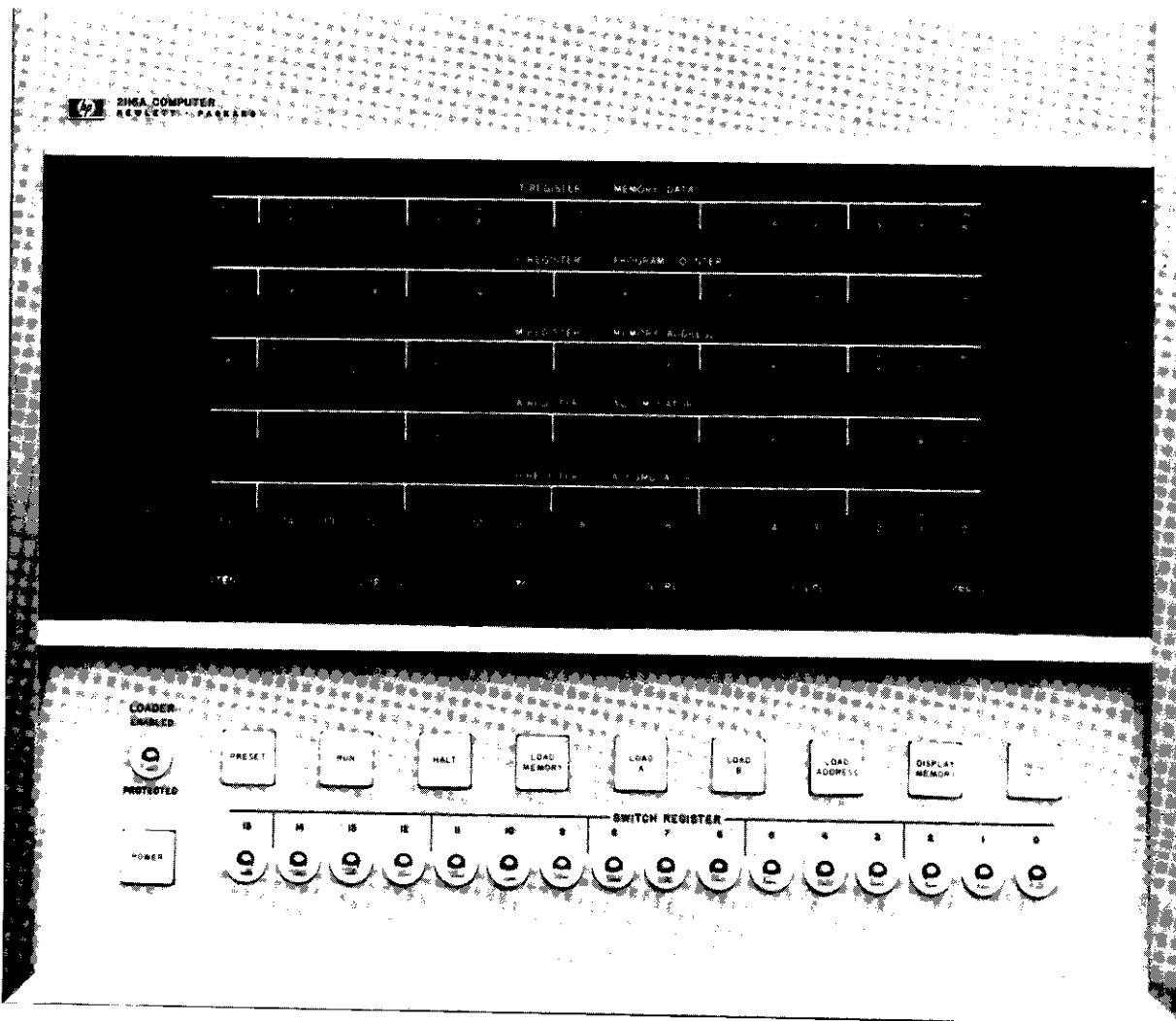
HP-2116A COMPUTER - BLOCK DIAGRAM

MACHINE ORGANIZATION (Cont'd)

OV-REGISTER (ARITHMETIC OVERFLOW): This 1-bit register indicates if an add or increment instruction referencing the A or B Register has caused one of these accumulators to exceed the maximum positive or negative number which can be contained (+32767 or -32768, decimal). By program instructions, the Overflow bit may be cleared, set or tested. The overflow bit is not complemented if a second overflow occurs before it is cleared. It is not set by shift or rotate instructions.

I-REGISTER (INSTRUCTION): This register decodes each of the Memory Reference instructions, and identifies the Register Reference and Input/Output instruction types. The I-Register also holds indicators to direct the computer to page zero or remain on the current page, and to denote direct or indirect addressing. (Contents of the I-Register are not displayed.)

S-REGISTER (SWITCH REGISTER): This is a 16-bit register set manually through 16 toggle switches on the front panel, described further under 'Panel Controls'.



Control Panel of the HP-2116A Computer is designed for smooth, efficient operation. Operator has complete access to the machine. Contents of seven working registers are displayed. Note Loader switch at left, which protects Basic Binary Loader.

PANEL CONTROLS

SWITCH REGISTER: This comprises sixteen toggle switches for manually entering information into the computer. The setting of the Switch Register (switch in up position is binary 1) may be transferred into the computer in the following ways:

By program: may be loaded or merged into the A or B Register, using a load or merge instruction with the Switch Register's select code.

Manually: may be (1) loaded simultaneously into the P and M Registers, using the LOAD ADDRESS switch, thus directing the computer to a specific memory cell (2) loaded into the memory cell specified by the M-Register, using the LOAD MEMORY switch, thus permitting the user to change the contents of any memory cell (3) loaded into the A or B register, using the LOAD A or LOAD B switch.

POWER: Controls power input to the computer.

LOADER: Protects block of memory normally occupied by the Basic Binary Loader. (Last 64 locations of memory, octal addresses 07700 through 07777 with 4K memory, or 17700 through 17777 with 8K memory.) In the ENABLED position, this block of memory can be read or loaded; in the PROTECTED position this block cannot be altered or used.

PRESET: Momentary switch which presets the computer to the Fetch phase, turns off the interrupt system and all input/output control bits, sets all input/output flag bits, and resets the parity error indication (Option M2).

RUN: Momentary switch to start operation at the current state of the computer. When the RUN light is on, all front panel switches except HALT, POWER, LOADER and the Switch Register are disabled. This avoids the possibility of the operator destroying the program during running, by accidentally moving the wrong control.

HALT: Momentary switch to stop computer operation at the end of the current phase. When the computer is halted (HALT light on) all front-panel switches are enabled.

LOAD MEMORY: Momentary switch to store the contents of the Switch Register in the memory location specified by the address in the M-Register. The P and M Registers are automatically incremented after operation of the LOAD MEMORY switch, to simplify storing data into consecutive memory locations. The stored data remains displayed in the T-Register, and the Fetch phase is set at the end of the load operation.

LOAD A, LOAD B: Momentary switches to transfer the contents of the Switch Register into the A or B Register, respectively. The computer's phase status is not altered.

LOAD ADDRESS: Momentary switch to transfer the contents of the Switch Register into both the P and M Registers, thus directing the computer to the desired address. The Fetch phase is set at the end of the load operation.

DISPLAY MEMORY: Momentary switch to display, in the T-Register, the contents of the location specified by the address in the M-Register. The P and M Registers are automatically incremented after operation of the DISPLAY MEMORY switch, so that consecutive memory locations may be examined simply by repeated operation of this switch. The Fetch phase is set after incrementing of the P and M Registers.

SINGLE CYCLE: Momentary switch to execute one machine cycle each time the switch is pressed.

WORD FORMATS

Memory Reference Instructions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D/I	INSTRUCTION					Z/C	MEMORY ADDRESS								

Register Reference Instructions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
REG. REF. INSTR.		A/B	SR/AS	MICRO-INSTRUCTION											

Input/Output Instructions

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I/O INSTRUCTION		A/B	INSTRUCTION					I/O SELECT CODE							

Full Address

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D/I	PAGE ADDRESS					WORD ADDRESS									

Data, Fixed Point

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SIGN		INTEGER													

Data, Floating Point

(Magnitude, 23 bits & sign. Exponent, 7 bits & sign.)

15	14	-----											0	15	-----						8	7	-----				1	0
MAG. SIGN		MAGNITUDE, MOST SIG. BITS														MAGNITUDE, LEAST SIG. BITS		EXPONENT			EXP. SIGN							

D/I = Direct/Indirect.

Z/C = Page Zero/Current Page.

A/B = Register Identifier.

SR/AS = Shift-Rotate/Alter-Skip Identifier.



INSTRUCTIONS

The HP-2116A has 70 basic one-word (16-bit) instructions, all executable in one or two machine cycles— 1.6 or 3.2 microseconds¹— plus 1.6 microseconds for each step of indirect addressing. These instructions are grouped in three types:

Memory Reference (2-cycle)	14	}	70 total
Register Reference (1-cycle)	43		
Input/Output (1-cycle)	13		

The Register Reference instructions are micro-operations which can be variously combined to form over 1000 additional one-word, single-cycle instructions.

Memory Reference Instructions

Memory addressing of the HP-2116A is based on a 1024-word page structure. All memory reference instructions address either the current page, a 1024-word block containing the current instruction, or the base page, the first 1024 words of memory. Thus, up to 2048 words are directly addressable.

The large page size of the HP-2116A allows the user to design compact programs with a minimum of indirect addressing. It also enables programs to share a large block of storage in the base page, easing communication between routines using common data bases.

There are fourteen Memory Reference instructions, including eight (add, compare, load, store) that apply to both accumulators (registers A and B). Although the accumulators are flip-flop registers, they are addressable as if they were memory locations 0 and 1. This enables the programmer to add the A and B registers together, compare them, and so on.

Register Reference Instructions

The HP-2116A has an extensive set of Register Reference instructions for data manipulation. With these instructions it is easy to:

- 1) Edit character strings,
- 2) Shift data within and between accumulators,
- 3) Test the accumulators for zero/non-zero, positive/negative, and odd/even results,
- 4) Clear, set, increment by one, and form the one's and two's complement of the accumulator contents.

¹ One instruction, ISZ, requires 3.6 microseconds. Times for all instructions shown in table on page 9.

Input/Output Instructions

The Input/Output instructions of the HP-2116A are used to:

- 1) Control peripheral devices.
- 2) Transfer data to and from peripheral devices.
- 3) Control the interrupt system.
- 4) Read data from the switch register.
- 5) Test, clear, or set the Overflow indication.

Each Input/Output command directly addresses the I/O channel on which it operates, making it unnecessary to first establish communication before beginning information transfer.

COMBINING GUIDE FOR REGISTER REFERENCE INSTRUCTIONS

SHIFT-ROTATE GROUP			
Select up to 4 instructions, one from each column. Sequence of execution is from column 1 through column 4. References to A and B registers cannot be mixed.			
1	2	3	4
ALS ARS RAL RAR ALR ERA ELA ALF	CLE	SLA	ALS ARS RAL RAR ALR ERA ELA ALF
BLS BRS RBL RBR BLR ERB ELB BLF	CLE	SLB	BLS BRS RBL RBR BLR ERB ELB BLF

ALTER-SKIP GROUP							
Select up to 8 instructions, one from each column. Sequence of execution is from column 1 through column 8. References to A and B registers cannot be mixed.							
1	2	3	4	5	6	7	8
CLA CMA CCA	SEZ	CLE CME CCE	SSA	SLA	INA	SZA	RSS
CLB CMB CCB	SEZ	CLE CME CCE	SSB	SLB	INB	SZB	RSS

INSTRUCTION REPERTOIRE

TYPE	MNEMONIC	DESCRIPTION	TIME Microsec	
MEMORY REFERENCE (14)	AND	'And' (M) to A; result in A	3.2	
	XOR	Exclusive 'or' (M) to A; result in A	3.2	
	IOR	Inclusive 'or' (M) to A; result in A	3.2	
	JSB	Jump to subroutine	3.2	
	JMP	Jump, unconditionally	1.6	
	ISZ	Increment (M); skip if result zero	3.6	
	ADA/B	Add (M) to A or B; result in A or B	3.2	
	CPA/B	Compare (M) with A or B; skip if not equal	3.2	
	LDA/B	Load (M) into A or B	3.2	
	STA/B	Store (A) or (B) into M; A, B unchanged	3.2	
REGISTER REFERENCE (43) Shift-Rotate Group (20)	NOP	No operation	All 1.6*	
	CLE	Clear E-Register		
	SLA/B	Skip if least significant bit of A/B is zero		
	A/BLS	A or B arithmetic left shift one bit		
	A/BRS	A or B arithmetic right shift one bit		
	RA/BL	Rotate A or B left one bit		
	RA/BR	Rotate A or B right one bit		
	A/BLR	A or B left shift one bit (sign cleared)		
	ERA/B	Rotate E right one bit with A or B		
	ELA/B	Rotate E left one bit with A or B		
	A/BLF	Rotate A or B left four bits		
	Alter-Skip Group (19)	CLA/B	Clear A or B	All 1.6*
		CMA/B	Complement A or B (ones complement)	
		CCA/B	Clear, then complement A or B (sets A/B to -1)	
		CLE	Clear E-Register	
		CME	Complement E-Register	
		CCE	Clear, then complement E-Register (sets E to 1)	
		SEZ	Skip if E-Register is zero	
		SSA/B	Skip if sign of (A) or (B) is zero (A/B positive)	
		SLA/B	Skip if least significant bit of (A) or (B) is zero	
INA/B		Increment (A) or (B) by one		
SZA/B	Skip if (A) or (B) is zero			
RSS	Reverse skip sense			
Overflow** (4)	STO	Set arithmetic overflow	All 1.6	
	CLO	Clear arithmetic overflow		
	SOC	Skip if arithmetic overflow clear		
	SOS	Skip if arithmetic overflow set		
INPUT/OUTPUT (13)	HLT	Halt program	All 1.6	
	STF	Set flag bit of selected channel		
	CLF	Clear flag of selected channel		
	SFC	Skip if flag clear		
	SFS	Skip if flag set		
	MIA/B	Merge contents of selected channel into A or B (inclusive 'or')		
	LIA/B	Load contents of selected channel into A or B		
	OTA/B	Output from A or B to selected channel		
	STC	Set control bit of selected device		
CLC	Clear control bit of selected device			

* Register Reference Instructions can be combined to execute in 1.6 microseconds. This allows, for example, shifts and rotations up to 8 places in 1.6 microseconds total.

** Coded under I/O group.

(M) = Contents of memory Location M.



INPUT/OUTPUT SYSTEM

48-Channel Capacity

The HP-2116A Computer input/output system provides up to 48, 16-bit parallel channels, with priority interrupt associated with unique memory locations. Sixteen of these channels may be utilized with the basic unit, and a further 32 channels with an HP-2150A Extender. The input/output channels may be run one at a time under program control, or simultaneously under interrupt control.

Hardware Flexibility

Peripherals can be added, upgraded or deleted, and service priorities changed, on a plug-in basis — no wiring changes to the standard HP-2116A Computer are involved. Input/output software is modular — a software configurator is furnished which allows the user to change his operating system to handle different hardware configurations with minimal programming effort.

Utilizing the I/O System

The HP-2116A basic unit (main frame) accommodates sixteen input/output channels, and is pre-wired to accept plug-in interface cards to operate peripherals, on a card-per-channel basis.

Interface circuitry to run a specific peripheral is contained on one or more cards that plug into any I/O slot in the HP-2116A main frame. To achieve this, all interface cards have identical pin assignments, and the computer backplane is uniformly wired. Interconnecting cables mate directly with the I/O interface cards (see photo) reducing the number of mechanical connections in the system, and minimizing the possibility of noise injection from the I/O device into the backplane. All peripherals draw their own power directly from the power line; the interface cards are powered from the computer's internal power supply.

The HP-2150A Extender has the same physical configuration as the HP-2116A Computer (omitting the front panel display and controls). It provides slots for 32 plug-in interface cards, which are utilized in the same manner as those in the HP-2116A main frame.

Priority Interrupt

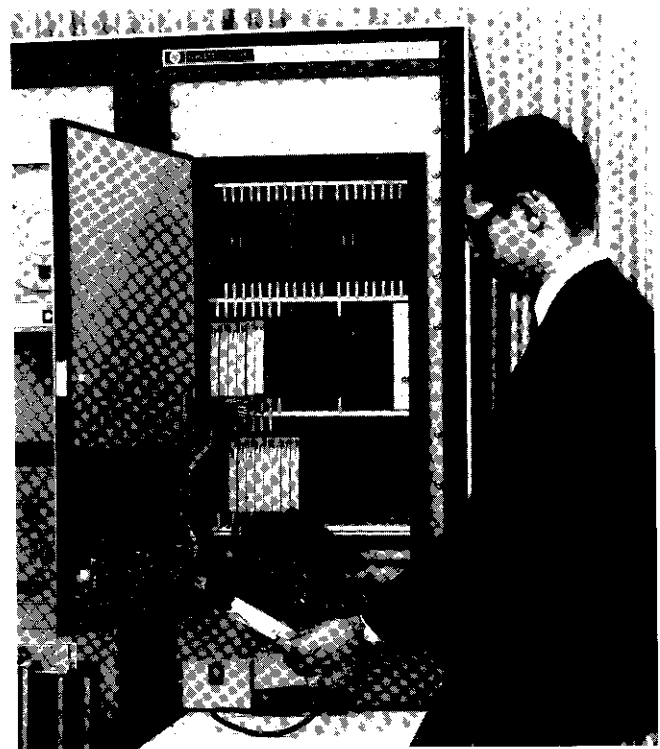
Multichannel priority interrupt capability is included as a standard hardware feature in the HP-2116A — an interrupt channel associated with a unique memory location is provided with each I/O interface. That is, an interrupt request from an I/O device directly executes a location in memory uniquely associated with that I/O channel. This interrupt location will typically contain the entry instruction for a subroutine to service the I/O device. Priority level for an input/output device is determined by the I/O slot into which its interface card is installed, so priority levels can be rearranged simply by moving cards into differ-

ent slots. Peripherals can also be programmed 'in' or 'out' of the interrupt chain by enabling or disabling the control bit associated with their I/O address. (The interrupt system can also be bypassed and all peripherals run under direct program control.)

Interrupts are recognized by the end of the current machine cycle, that is, in less than 1.6 microseconds. More important, overall response is fast. In a multi-device system, a service request by a higher priority device causes the first 'useful' instruction which communicates with that device to be executed in less than 7 microseconds. When operating with only one I/O device, the response time is less than 3 microseconds. The multi-channel interrupt feature and fast response promote efficient operation in a real time environment, as in instrumentation systems.

How Input/Output Options are Ordered

All I/O options available for the HP-2116A Computer are summarized in the ordering table on page 19. I/O options include all necessary interface cards, cables and software. Some options (K1 through K9) also include the peripheral. Again, one of the advantages of the HP-2116A I/O system is the ability to add peripherals at any time. Interface kits may be ordered under the interface numbers listed in the table on page 19 (for example, Data Phone Interface, number 12540A) while peripherals may be ordered by model number (for example, HP-2801A Quartz Thermometer).



I/O interface cards can be installed or moved (to reassign service priority) simply by swinging open the HP-2116A front panel.

INPUT/OUTPUT SYSTEM (Cont'd)

Peripherals in common use are illustrated on pages 17 and 18. Some HP measuring instruments require standard options for operation with the HP-2116A Computer; these are called out both in the table and on page 17. (For example, the various HP counters require their optional 8421 bcd output.) Some peripherals may be associated with more than one interface. The HP-2401C Integrating Digital Voltmeter, for instance, uses one interface (K12/12541A) to transfer its data into the computer, and another interface (K20/12533A) if the application requires the voltmeter to be programmed by the computer.

Teleprinter Input/Output

The simplest configuration of an HP-2116A Computer system is provided under Option K1, consisting of an HP-2752A Teleprinter (modified Teletype ASR-33) and its interface. This device combines a typewriter, punched tape reader and tape punch. Data and instructions may be entered from punched tape or the keyboard. Output information is recorded on the typewriter, and may be recorded simultaneously on punched tape. The Teleprinter operates at 10 characters/second for both data entry and data recording.

Where heavy use of the Teleprinter is anticipated, exceeding say 5 hours per day or 30 hours per week, a heavy duty HP-2754A Teleprinter (modified Teletype ASR-35) is recommended. This is available as Option K2. The HP-2752A and HP-2754A Teleprinters perform the same functions and operate at the same speed.

High-Speed Punched Tape Input

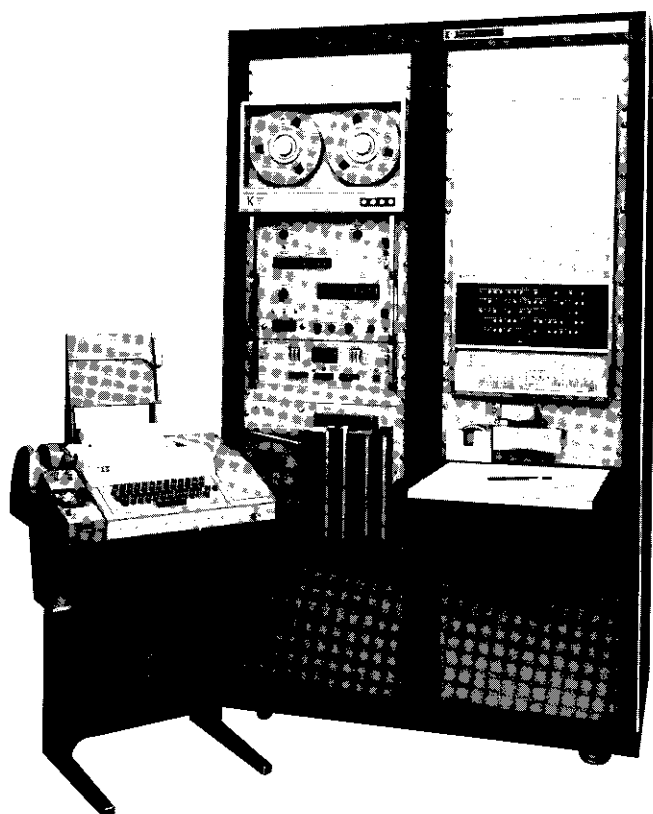
For rapid entry of punched tape programs and data into the HP-2116A Computer, a 300 characters/second HP-2737A Punched Tape Reader is available as Option K3. Use of this device is highly recommended if the computer is going to be re-programmed frequently, because of the 30:1 speed advantage it offers over the Teleprinter.

High-Speed Punched Tape Output

Data output of the HP-2116A Computer can be recorded (asynchronously) on punched tape at 120 characters/second with an HP-2753A Tape Punch, Option K5. Besides enabling data to be logged 10 times faster than with the Teleprinter, this device speeds up the process of compiling, assembling, and editing programs. The punch includes a tape spooler, which accepts approximately 1000 feet of tape.

Incremental Magnetic Tape Output

Data output of the HP-2116A Computer can be recorded on 1/2-inch magnetic tape in 7-channel, NRZI, IBM-compatible format with Option K6. This option consists of a Kennedy 1406 Incremental Magnetic Tape Transport and I/O interface. Data is recorded with a density of 200 bpi, at a speed of 400 characters/second.



HP-2018A Data Acquisition System incorporates HP-2116A Computer, provides 200 analog data channels for dc/ac voltage, resistance and frequency inputs. System records on IBM-compatible magnetic tape and/or punched tape.

The Kennedy 1406 uses side-by-side 8-1/2 inch reels to economize in panel height (12-1/4 inches). Reel capacity is 1200 feet of tape. Kennedy Model 1506 (Option K7) is essentially the same transport, but features 10-1/2 inch, 2400-foot capacity reels. (Panel height 24-1/2 inches.)

Magnetic Tape Input/Output

The HP-2116A Computer both records on and reads from 1/2-inch, 7-channel, NRZI, IBM-compatible magnetic tape with Options K8 and K9. Option K8 comprises an HP(H26)2020A Tape Unit with interface, and reads/records at 200 bpi density. Tape speed is 30 ips, providing a data transfer rate of 6000 characters/second. With Option K9 a Dual Density (H26)2020B Tape Unit is used which operates at both 200 and 556 bpi density, switch selectable. Tape speed is also 30 ips, providing a data transfer rate of 16,700 characters/second at 556 bpi.

Data Source Interfaces

The HP-2116A Computer operates, through a plug-in interface card, with virtually all Hewlett-Packard instruments providing a digital data output in binary or binary-coded decimal, positive or negative-true form. This encompasses a very broad variety of instruments, principal examples being digital voltmeters, electronic counters, nuclear scalars, and the quartz thermometer.

INPUT/OUTPUT SYSTEM (Cont'd)

The same interface card, which accepts 32 bits (8 bcd digits), is used with all these instruments (one card for each instrument) but different interconnecting cables are involved. Therefore, for simplicity in assembling a system, the interface card coupled with the appropriate cable is listed as an option for a specific group of data sources, under Options K12 through K19 (see page 19).

Since these instruments require no special modification to interface their data output with the HP-2116A, they can be ordered directly from the Hewlett-Packard catalog. Some frequently used examples are described on page 18.

Digital Voltmeter Programmer

When using a digital voltmeter as a data input to the HP-2116A, the computer may select voltmeter functions such as mode (dc/ac volts, ohms), range, and resolution (sample period). For this purpose, Option K20 comprises the interface card and interconnecting cable for the HP-2401C Integrating Digital Voltmeter. No additional interface circuitry is required when this voltmeter is used with its signal amplifier and converter. The Digital Voltmeter Programmer interface card provides 20 output lines, each capable of switching 200 ma from an external 35 volt negative supply.

Crossbar Scanner Programmer

For multiple-channel analog measurements with the HP-2116A, a scanner must interconnect signal input channels with one or more analog-to-digital converters. Each signal path is enabled on command from the HP-2116A, which selects the input to be measured and diverts it to the appropriate a-d converter. It also initiates a 'measurement delay' before sampling (encoding) commences, if required for converter settling. The interface card and cable for programming an HP-2911 Guarded Crossbar Scanner are provided under Option K23.

Time Base Generator

The Time Base Generator (Option K10) provides the computer with a train of program interrupts at real time intervals. It consists of a crystal oscillator and decade frequency dividers, contained on one I/O card. The interval between interrupts is computer-selectable in decade steps from 100 microseconds to 1000 seconds (about 16 minutes). Time-of-day can be obtained from this reference by software. Accuracy is better than 1/2 second per 24-hour day, under typical operating conditions. (Aging rate $< 2/10^6$ per week; temperature effect $< 2/10^5$, +15 to 35°C.)

Data-Phone Interface

Information can be transferred in or out of the HP-2116A Computer over the telephone system with Option K11, which consists of the data inter-

face cards and interconnecting cable to operate with a Bell Telephone Data Set 103A. Data transfer occurs bit-serially at a rate of ten 8-bit characters/second.

General Purpose Register

Data can be transferred bidirectionally between the HP-2116A and an external device with a General Purpose Register (Option K24). This plug-in card contains a 16-bit flip-flop register which operates with the computer I/O interrupt system. The 16 flip-flops may be set by the computer or by the external device. (Changeover from receive to transmit mode is less than 8 microseconds.) One or more registers provide a convenient means of controlling external equipment through the computer. (Input levels from external device: true = 12 mA max current sink to ground from positive supply in 2116A; false = open circuit able to withstand +12V. Output levels: true = 12 mA max current sink to ground from positive external supply; false = open circuit able to withstand +12V.)

Relay Output Register

This plug-in I/O card (Option K25) provides 16 form-A contacts for operating external equipment through the HP-2116A Computer. (Maximum contact ratings are: current 0.5A, voltage 100V, power 10W. Contact resistance is about 0.1Ω.)

HP-2116A ASSEMBLER PSEUDO INSTRUCTIONS

ASSEMBLER CONTROL	
NAM	Specifies relocatable program and its name.
ORG	Gives absolute program origin or origin for segment of relocatable or absolute program.
ORR	Resets main program location counter at value existing when first ORG or ORB of string encountered.
ORB	Defines base page portion of relocatable program.
END	Terminates source language program. Produces transfer to program starting location, if given.
OBJECT PROGRAM LINKAGE	
COM	Reserves block of common storage locations.
ENT	Defines entry points that may be referred by other programs.
EXT	Defines external locations which are labels of other programs, referred by this program.
ADDRESS AND SYMBOL DEFINITION	
DEF	Generates a 15-bit address which may be referenced indirectly through the label.
ABS	Defines a 16-bit absolute value to be referenced by the label.
EQU	Equates the value specified to the label.
CONSTANT DEFINITION	
ASC	Generates a string of ASCII characters.
DEC	Generates a string of decimal constants.
OCT	Generates a string of octal constants.
STORAGE ALLOCATION	
BSS	Reserves storage area.
ARITHMETIC SUBROUTINE CALLS	
MPY	Fixed point multiply.
DIV	Fixed point divide.
FAD	Floating point add.
FSB	Floating point subtract.
FMP	Floating point multiply.
FDV	Floating point divide.
DLD	Double word load.
DST	Double word store.

PROGRAMMING

The HP-2116A Computer is supported by a full range of software, furnished in the form of punched tape. The following software packages are available:

HP-2116A	FORTRAN Compiler
HP-2116A	Assembler
HP-2116A	Symbolic Editor
HP-2116A	Basic Control System
HP-2116A	Hardware Diagnostics

All HP-2116A software packages will run in the minimum HP-2116A Computer system configuration — 4K memory and Teleprinter input/output. Programs written in FORTRAN or Assembly language are independent of the hardware I/O configuration. All I/O devices are identified by logical unit numbers which the programmer uses to specify I/O operations. At execution time the Basic Control System relates these logical unit numbers to physical numbers that correspond to the I/O slots occupied by the cards for the I/O device in question. The Basic Control System is therefore configured to suit a particular system. An auxiliary software package, Prepare Control System, is furnished which allows the user to change his Basic Control System to fit different input/output arrangements. A dynamic Program Debugging Package is also supplied.

HP-2116A FORTRAN

The FORTRAN Compiler system for the HP-2116A Computer accepts source programs written in American Standards Association Basic FORTRAN. It produces a relocatable machine language object program which can be loaded and executed under control of the Basic Control System.

In addition to the ASA Basic FORTRAN language, HP-2116A FORTRAN includes a number of features which extend the flexibility of the system. Included are:

- Free-field data input: the input list and symbols prepared with ASCII input data define the format in which the data is stored; a format statement need not be specified in the source program.
- Variable-length headings and editing information can be introduced into the program by enclosing them in quotation marks; this enables alphanumeric data to be written without giving the character count.
- Array declarations may be made within a COMMON statement (a feature of ASA FORTRAN).
- Basic External Functions are provided to perform masking (Boolean) operations (AND, OR, NOT).
- In addition to a 3-branch IF statement, a 2-branch IF statement is also provided which conserves core space.
- Octal integer constants may be used, providing programming flexibility.
- Octal and alphanumeric format specifications are allowed.
- Multiple program compilation: up to five independent source programs may be processed together through each compilation phase, with a significant saving in the time required for loading operations.

HP-2116A ASSEMBLER

The HP-2116A Assembler translates symbolic source language instructions into an object program for execution on the computer. The source language provides operation codes, assembly-directing pseudo codes, and symbolic addressing. The assembled program may be absolute or relocatable.

The source program may be assembled as a complete entity, or it may be divided into several sub-programs, (or a main program and several subroutines) each of which may be assembled separately. The loader of the Basic Control System loads and links relocatable programs (at execution time); the Basic Binary Loader loads absolute programs.

Features of the Assembler include:

- Page-free programming: the Assembler and Basic Control System loader together provide base page references and indirect addressing, such that the programmer does not have to be concerned with page boundaries. (The programmer may also specify indirect addressing, if he wishes.)
- Simplified addressing notation allows easier use of multiple-level indirect addressing.
- Free field source statements: fields of a source statement are not restricted to certain positions on a coding form or source tape.
- Fixed and floating point arithmetic pseudo operations.

An Extended Assembler, for use with 8K memory, also allows:

- Literal values to be used as operands (Assembler recognizes actual values preceded by = sign instead of symbols defining addresses of these values)
- Output listing control operations (such as suppress or resume assembly listing, skip to top of next page or specified number of lines, etc.)

Pseudo instructions provided in the HP-2116A Assembler are listed in the table on page 12.

SYMBOLIC EDITOR

The HP-2116A Symbolic Editor enables the user to edit and update a symbolic file tape which can be an Assembler program, a FORTRAN program, or a data file. The Editor produces an updated tape from the source tape and change instructions. Individual characters and entire source statements can be inserted, deleted, or replaced. The Editor will also provide a listing of a symbolic file (sequentially numbering the statements). Diagnostic messages are produced for errors detected in the format of edit control statements.

BASIC CONTROL SYSTEM

The Basic Control System for the HP-2116A Computer provides an efficient loading, input/output control and debugging capability for relocatable

PROGRAMMING (Cont'd)

programs produced by the HP-2116A Assembler or FORTRAN Compiler. The system is modular in design and may be constructed or modified to fit the user's particular hardware configuration. The following modules are provided, from which the Basic Control System is prepared:

Relocating Loader
I/O Control
I/O Drivers

Two other software packages are associated with the Basic Control System. These are:

Prepare Control System
Debugging Routine

Relocating Loader

The Loader loads, links, and initiates the execution of relocatable object programs produced by the HP-2116A Assembler or FORTRAN Compiler. Source language sub-programs can be changed, then compiled and/or assembled and loaded together with other object sub-programs, avoiding reassembly of entire source programs. The Loader also creates indirect and base page addressing where necessary, and selects and loads referenced library subroutines. Optionally, the Loader can produce an absolute binary tape for "production" programs.

Input/Output Control

This provides for general input/output device control and software buffered data transmission between I/O devices and computer memory. Any number of characters or words may be read into or written from a buffer storage area specified by the user. The Input/Output Control system allows the user to write programs without concern for the specific operating requirements of the input/output devices used.

Input/Output Drivers

These routines provide the instructions necessary to operate specific input/output devices, and serve as an interface between the I/O Control system and the peripheral devices.

Prepare Control System

The Prepare Control System routine combines the Basic Control System component modules—Loader, I/O Control and I/O Drivers— together with equipment tables — to generate a Basic Control System for a particular hardware configuration. This routine may also be used to modify the Basic Control System when the I/O hardware configuration is changed. Upgrading from, say, a Teleprinter input to a high-speed punched tape reader, or switching from a high-speed tape punch to a Teleprinter, requires only modification of the Basic Control System table entry; no changes are necessary in the object program.

Debugging Routine

The Debugging Routine is a relocatable program which interprets and executes machine instructions. Functions to be performed are normally selected by typing in control statements on the Teleprinter. The following functions are available:

- Dump (print) specified areas of memory in octal or ASCII format.
- Specify trace printout of selected areas of the program.
- Modify registers and selected areas of memory.
- Specify breakpoint stops before execution of a designated instruction or before completing a reference to a specified address.
- Initiate or continue execution of a program at any point.

SUBROUTINES

The Basic Control System loads and links object code library subroutines according to calls generated by Assembler or FORTRAN programs. The following subroutines are available:

- Fixed point multiply and divide.
- Floating point add, subtract, multiply and divide.
- Double-word load and store.
- Conversion from integer to real, and real to integer.
- Math functions — exponential, natural log, sine, cosine, tan, tanh, arctan, square root.
- Boolean functions — AND, OR, NOT.
- Test individual switches of Switch Register.
- Position magnetic tape.

HARDWARE DIAGNOSTICS

These routines allow an HP-2116A Computer system to be checked out in its principal operating modes, which include:

- Memory Reference Test — Executes and checks the result of all Memory Reference type instructions.
- Register Reference Test — Executes and checks all possible combinations of Alter-Skip and Shift-Rotate instructions, for both A and B registers.
- Memory Address Test — Checks the memory address logic.
- Memory Checkerboard Test — Checks all memory locations under worst-case patterns, using the double-checkerboard method.
- I/O Diagnostics — these check out the input/output devices available with the HP-2116A Computer.

SPECIFICATIONS

TYPE

General-purpose digital computer, with input/output system and modular software organized for flexible application in on-line instrumentation systems.

MEMORY

Type: Magnetic core.

Size: 4096 16-bit words. Expandable to 8192 words (in main frame) with plug-in 4096-word module and associated cards, Option M4. Expandable to 16,384 words (total) with HP-2150A Extender. (Parity bit included in standard stack for use with Option M2, Memory Parity Check.)

Addressing: Memory is organized in 1024-word pages, 2048 words directly addressable.

Speed: 1.6 microsecond cycle time.

Loader Protection: Last 64 locations of memory reserved for Basic Binary Loader. Front panel switch, in 'Protect' position, prevents alteration of contents of these locations.

Memory Parity Check (Option M2): Permits parity checking within memory. Consists of one plug-in card for memory up to 8K. Additional card needed for memory up to 16K.

Memory Test (Option M3): Enables memory to be tested independently of program control. Consists of one plug-in card for memory up to 16K.

ARITHMETIC

Parallel, binary, fixed point, two's complement.

SPEED

Add	3.2 μ s
Subtract	4.8 μ s
Multiply	150 μ s
Divide	200 μ s
Floating point add	700 μ s
Floating point subtract	700 μ s
Floating point multiply	900 μ s
Floating point divide	1.1 ms

(Above are subroutine operations except for Add. Times shown are approximate.)

REGISTERS

Eight internal hardware (flip-flop) registers and Switch register. Contents of all registers except Instruction and Switch register displayed by front panel lamps.

A-Register: Accumulator, input/output. (16 bits.)

B-Register: Accumulator, input/output. (16 bits.)

E-Register: Extend register, links A and B register; indicates carry from A or B register. (1 bit.)

OV-Register: Overflow register, indicates overflow from A or B register. (1 bit.)

T-Register: Transfer register, temporarily holds data transferred in or out of memory. (16 bits.)

P-Register: Program counter. (15 bits.)

M-Register: Memory address register, holds address of next memory location to be accessed. (15 bits.)

I-Register: Instruction register, decodes Memory Reference instructions, holds indicators for zero/current page and direct/indirect addressing. (6 bits, 10-15.)

S-Register: Toggle switches on front panel for manual data entry. Contents of register indicated by switch positions. (16 bits.)

INSTRUCTIONS

70 basic, one-word instructions, in three types:

Memory Reference (2-cycle)	14
Register Reference (1-cycle)	43
Input/Output (1-cycle)	13

Register Reference instructions are micro-operations, can be combined to form over 1000 one-word, single-cycle instructions.

INPUT/OUTPUT

Number of Channels: 48, 16-bit parallel interrupting channels, with priority control, utilized through plug-in I/O interface cards (1 per channel). 16 channels available in main frame; 32 additional channels provided by HP-2150A Extender.

Power: Power for I/O interface cards available in HP-2116A Computer and HP-2150A Extender. Auxiliary HP-2160A Power Supply may be required when using most of the available channels; consult factory. (Peripherals draw power directly from 115/230v line.)

Interrupt Response: Servicing of interrupt request (execution of first useful instruction) begins within 3 μ s with one I/O channel in use, or within 7 μ s for highest priority channel in multiple-channel system.

DATA FORM

Punched Tape: ASCII. Parity not used, 8th level always punched. (1-inch tape.)

Magnetic Tape: IBM-compatible, 7-channel NRZI. (1/2-inch tape.)

SOFTWARE

Software (punched tape) available consists of:

Compiler, ASA Basic FORTRAN (Extended)

Assembler

Extended Assembler (requires 8K memory)

Symbolic Editor

Basic Control System

FORTRAN Library Routines

Debugging Routine

Hardware Diagnostics

Basic Control System is modular, includes configurator (Prepare Control System) to permit adaptation by user to different I/O hardware arrangements.



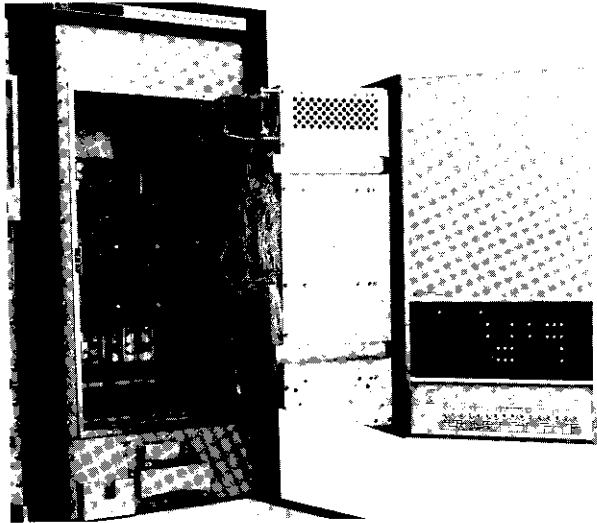
PHYSICAL SPECIFICATIONS

VENTILATION

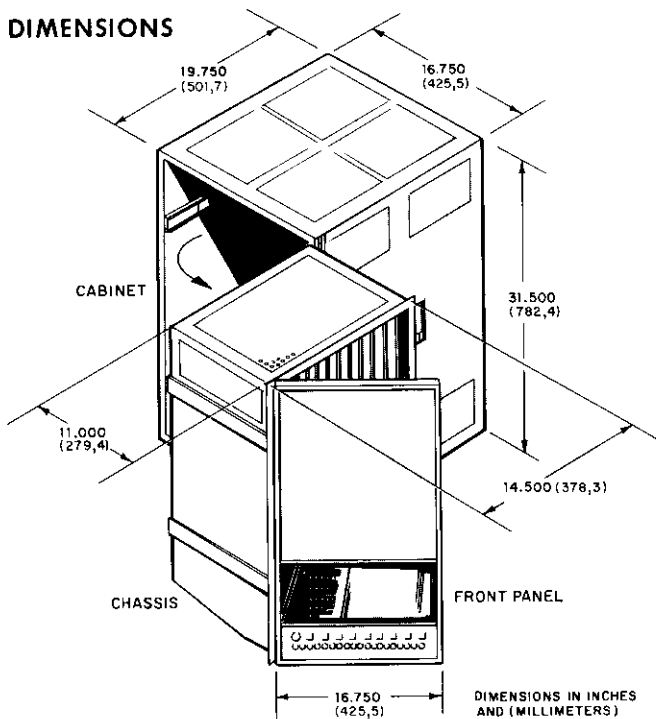
Intake on sides and back at bottom, exhaust at top. Air flow 600 cfm. Heat dissipation 5500 BTU/hr.

SERVICE ACCESS

Front panel hinged at left side, permitting front access to input/output connectors, test switches, plug-in circuit boards, and panel wiring. Main chassis slides forward out of cabinet and swings to right. Permits front access to backplane wiring, power supply, fuses, and 115/230v jumpers.



DIMENSIONS



INSTALLATION

Supplied fully enclosed for use on bench, or may be mounted in standard 19-inch rack, using adapters furnished (panel height 31-1/2 inches). Requires no special wiring, subflooring, or other special installation preparation.

WEIGHT

(With all plug-in options installed.)
Net wt. 230 lb (104 kg); shipping wt. 330 lb (150 kg).

POWER REQUIRED

115/230v ±10%, 50 to 60 Hz. Main frame power consumption: 1000w approx. with minimum configuration (4K memory, Teleprinter I/O) increasing to 1600w maximum with internal supply fully loaded by plug-in options.

ENVIRONMENTAL CONDITIONS

Operates in ambient temperatures from 0 to +55°C (32 to 131°F); relative humidity to 95% at 40°C.

CABINETS

Single, dual and triple bay cabinets are available for rack-mounting the HP-2116A Computer and peripherals. Cabinets include: power strip, switch and indicator lamp, power cord, caster base, fan and filter, instrument mounting rails, and blank panels for unoccupied panel space. A drawer, 3-1/2 inches high, for storing tapes, manuals, etc., is available as accessory no. 12528A, price \$75.00. A Desk Top Writing Surface is available in widths for single, dual and triple bay cabinets. (Single bay model occupies 3-1/2 inches of vertical panel space; double and triple bay models occupy 7 inches.)

If an HP-2020A/B Tape Unit is to be installed, a front base extension (pontoon base) is recommended. This extends 6 inches in front of the cabinet. Stipulate Cabinet Option M3 when ordering.

CABINET WIDTH	DESK TOP		BASE EXTENSION	
	Accessory No.	Price	Option No	Price
SINGLE-BAY	12526A	\$ 150	M 3	\$ 40
DOUBLE-BAY	12517A	\$ 200	M 3	\$ 55
TRIPLE-BAY	12518A	\$ 275	M 3	\$ 75

SINGLE-BAY CABINETS									
Panel	HEIGHT		DEPTH		WIDTH Overall	WEIGHT		MODEL NUMBER	PRICE
	Overall	Usable	Usable	Overall		Net	Ship		
56 (1,422)	64 (1,626)	28-1/4 (716)	32-3/4 (832)	23-1/8 (587)	255 (115,6)	374 (169,8)	2991B	\$ 825	
70 (1,778)	78 (1,981)				300 (136,2)	451 (204,8)	2991C	\$ 875	

DOUBLE-BAY CABINETS									
Panel	HEIGHT		DEPTH		WIDTH Overall	WEIGHT		MODEL NUMBER	PRICE
	Overall	Usable	Usable	Overall		Net	Ship		
2 x 56 (2x1,422)	64 (1,626)	28-1/4 (716)	32-3/4 (832)	46 (1,168)	430 (195,2)	607 (275,6)	2993B	\$1,250	
2 x 70 (2x1,778)	78 (1,981)				509 (231,1)	735 (333,7)	2993C	\$1,400	

TRIPLE-BAY CABINETS									
Panel	HEIGHT		DEPTH		WIDTH Overall	WEIGHT		MODEL NUMBER	PRICE
	Overall	Usable	Usable	Overall		Net	Ship		
3 x 56 (3x1,422)	64 (1,626)	28-1/4 (716)	32-3/4 (832)	69 (1,753)	607 (275,6)	845 (383,6)	2997B	\$1,600	
3 x 70 (3x1,778)	78 (1,981)				717 (325,5)	1,019 (462,6)	2997C	\$1,825	

Dimensions in inches and (millimeters)

PERIPHERALS

The peripherals described on this page are devices for inputting and outputting data or instructions. They are included with Input/Output Options listed on page 19.

TELEPRINTER

HP-2752A Teleprinter (modified Teletype ASR-33) inputs through keyboard and punched tape, outputs on typewriter and punched tape, at 10 char/sec. Model HP-2752A furnished with Option K1. Alternate HP-2754A Teleprinter (modified Teletype ASR-35) operates at same speed, recommended for heavy-duty applications. (Option K2.) Both instruments furnished with floor stand.

POWER REQUIRED

HP-2752A 115v, 60 Hz, 230w.
HP-2754A 115v, 60 Hz, 350w.

DIMENSIONS

MODEL NO.	HEIGHT	WIDTH	DEPTH
HP-2752A	33 in. (838 mm)	22 in. (559 mm)	18-1/2 in. (470 mm)
HP-2754A	38-1/2 in. (978 mm)	40 in. (1,02 m)	24 in. (610 mm)

WEIGHT

	Net	Ship
HP-2752A	77 lb (34,7 kg)	92 lb (41,8 kg)
HP-2754A	225 lb (102 kg)	270 lb (123 kg)



HP-2752A Teleprinter

HIGH-SPEED PUNCHED TAPE READER

HP-2737A Punched Tape Reader reads 5 through 8-level codes at 300 char/sec. Accepts 11/16, 7/8 and 1-inch tape. (Tape must be opaque - transmissivity 40% maximum.) Model HP-2737A furnished with Option K3 (includes accessory tape container).

POWER REQUIRED

HP-2737A 115v, 50-60 Hz, 150w.

DIMENSIONS

HP-2737A 19-inch rack mounting, panel height 7 inches (178 mm).

WEIGHT

	Net	Ship
HP-2737A	15 lb (6,8 kg)	25 lb (11,4 kg)



HP-2737A Punched Tape Reader

HIGH-SPEED TAPE PUNCH

HP-2753A Tape Punch records in 5 through 8-level codes at 120 char/sec, asynchronous. Adjustable for 11/16, 7/8 and 1-inch tape. Furnished with Option K5. Includes 8-inch supply and 8-1/2 inch take-up reels for 1000 feet of tape.

POWER REQUIRED

115v 60 Hz, 450w.

DIMENSIONS

19-inch rack mounting, panel height 14 inches (356 mm)

WEIGHT

Net 59 lb (26,8 kg); ship 82 lb (37,2 kg)



HP-2753A Tape Punch

INCREMENTAL MAGNETIC TAPE TRANSPORT (Write Only)

Kennedy 1406 Incremental Magnetic Tape Transport records on 1/2 inch magnetic tape; 7-channel NRZI, IBM-compatible format. Density 200 bpi, speed 400 char/sec. 8-1/2 inch reels, capacity 1200 feet. Model 1406 furnished with Option K6. Alternate Kennedy 1506, furnished with Option K7, has 10-1/2 inch reels, capacity 2400 feet.

POWER REQUIRED

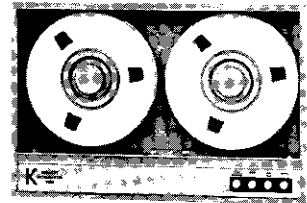
1406/1506: 115v, 50-60 Hz, 110w.

DIMENSIONS

Both transports 19-inch rack mounting. Panel heights:
1406 12-1/4 inches (310 mm)
1506 24-1/2 inches (622 mm)

WEIGHT

	Net	Ship
1406	50 lb (22,7 kg)	68 lb (30,9 kg)
1506	65 lb (29,2 kg)	88 lb (39,6 kg)



Kennedy 1406 Tape Transport

HIGH-SPEED MAGNETIC TAPE UNIT (Read/Write)

Hewlett-Packard H26-2020A Magnetic Tape Unit records on and reads from 1/2 inch tape; 7-channel NRZI, IBM-compatible format. Density 200 bpi, speed 30 ips, data transfer rate 6000 char/sec. 10-1/2 inch reels, capacity 2400 feet. Furnished with Data Electronics and Operator Control Panel, under Option K8. Alternate Dual/Density H26-2020B Magnetic Tape Unit, furnished under Option K9, provides switch-selectable density, 200/556 bpi. Data transfer rates (at 30 ips) 6000 and 16,700 char/sec respectively. Specifications below apply to both units.

POWER REQUIRED

115v, 60 Hz, 970w max.

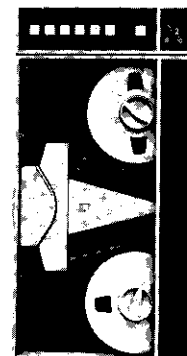
DIMENSIONS

19-inch rack mounting, panel heights:

Tape Unit	31-1/2 inches (800 mm)
Data Electronics	5-1/4 inches (133 mm)
Operator Panel	5-1/4 inches (133 mm)
Total	42 inches (1,07 m)

WEIGHT

	Net	Ship
Tape Unit	138 lb (62,7 kg)	230 lb (105 kg) (Total)
Data Electronics	35 lb (15,9 kg)	
Operator Panel	20 lb (9,1 kg)	
Total	193 lb (87,7 kg)	



HP-2020 Tape Unit

PERIPHERALS

The peripheral devices described on this page may be used as data inputs to the HP-2116A Computer. They are used in conjunction with Input/Output Options listed on page 19.

INTEGRATING DIGITAL VOLTMETER

HP-2401C Integrating Digital Voltmeter measures dc voltages in 5 ranges from 100 mv to 1000v full scale (valid overranging to 3 times full scale, except 1000v range). 5-digit resolution. Accuracy $\pm 0.01\%$ rdg. Sample rates to 50 readings/second with 3-digit resolution. Also measures frequency inputs to 300 kHz.

Accessory HP-2411A Amplifier provides 10 mv full scale range. Accessory HP-2410B AC/Ohms Converter permits ac voltage (50 Hz to 100 kHz) and resistance measurements. All instruments floated and guarded to eliminate common mode noise. Integrating feature averages out superimposed noise. I/O Option K12 required to input voltmeter data to computer; Option K20 required to program voltmeter.

POWER REQUIRED

HP-2401C 115/230v, 50-60 Hz, 150w
 HP-2411A 115/230v, 50-1000 Hz, 16w
 HP-2410B 115/230v, 50-60 Hz, 110w

DIMENSIONS

All 19-inch rack mounting. Panel heights:
 HP-2401C 7 inches (177 mm)
 HP-2411A 3-1/2 inches (88 mm)
 HP-2410B 7 inches (177 mm)

WEIGHT

	Net	Ship
HP-2401C	48 lb (22 kg)	66 lb (30 kg)
HP-2411A	17 lb (7,7 kg)	26 lb (11,8 kg)
HP-2410B	43 lb (19,5 kg)	60 lb (27,2 kg)



HP-2401C Digital Voltmeter

ANALOG INPUT SCANNER

HP-2911 Guarded Crossbar Scanner comprises HP-2911A Guarded Crossbar Switch and HP-2911B Scanner Control. Utilizes crossbar switch to scan 200 3-wire analog channels (floated signal pair and guard). Will also scan 100 6-wire channels for guarded 4-wire resistance measurements. Any channel accessed in < 30 ms under computer control. I/O Option K23 required to program HP-2911.

POWER REQUIRED

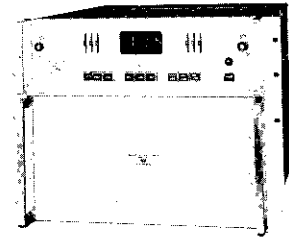
115/230v, 50-1000 Hz, 23w

DIMENSIONS

19-inch rack mounting, panel heights:
 HP-2911A 8-3/4 inches (146 mm)
 HP-2911B 5-1/4 inches (133 mm)
 Total 14 inches (279 mm)

WEIGHT

	Net	Ship
HP-2911A	35 lb (15,9 kg)	60 lb (27,2 kg)
HP-2911B	26 lb (11,8 kg)	44 lb (20,0 kg)
Total	61 lb (27,7 kg)	104 lb (47,2 kg)



HP-2911 Guarded Crossbar Scanner

ELECTRONIC COUNTER

Over 20 different Hewlett-Packard counters available to operate with HP-2116A Computer. By way of example, photo shows HP-5245L, which measures to 50 MHz directly, and to 18 GHz with plug-ins and accessory instruments.

All 5000 series counters are 19-inch rack mounting, panel heights 3-1/2 or 5-1/4 inches. Refer to I/O Options K15 through K19 for interfaces for specific counters.

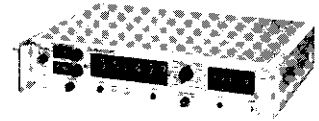


HP-5245L Electronic Counter

NUCLEAR SCALER

Three models available. HP-5201L Scaler-Timer contains single-channel pulse height analyzer and can count or time events. HP-5202L has simple integral discriminator in place of pulse height analyzer. HP-5203L has integral discriminator but no timer. All models have same input

counting capability with multiple pulse resolution of 200 nsec. All 19-inch rack-mounting, panel height 3-1/2 inches (88 mm). I/O Option K17 required to input to HP-2116A.



HP-5201L Scaler-Timer

QUARTZ THERMOMETER

HP-2801A Quartz Thermometer provides digital temperature readout in Centigrade or Fahrenheit, from -80 to +250°C (-112 to +482°F). Resolution and sample times for Centigrade measurements are: .0001°, 10 sec; .001°, 1 sec; .01°, 0.1 sec. Sample times for Fahrenheit measurements are increased by factor of 1.8. Dual input for two individual, or differential, measurements.

Probes are 3/8 inch diameter, available in lengths from 11/16 to 9 inches or more. Probes can be separated from instrument by over 1000 feet of cable. I/O option K15 required to input data to computer.

POWER REQUIRED

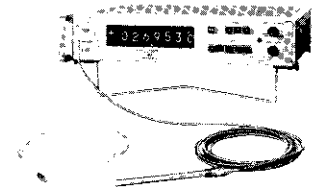
HP-2801A 115/230v, 50-60 Hz, 85w

DIMENSIONS

19-inch rack mounting, panel height 3-1/2 inches (88 mm).

WEIGHT

	Net	Ship
HP-2801A	23 lb (10,1 kg)	35 lb (15,9 kg)



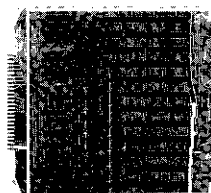
HP-2801A Quartz Thermometer

GENERAL PURPOSE REGISTER

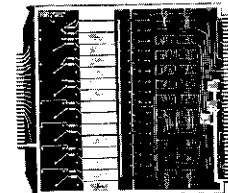
Plug-in I/O card provides 16-bit flip-flop register for data transfer either from computer to external device, or vice-versa. (Changeover requires < 8 μ s). Interface specifications on page 10. Available as Option K24.

RELAY REGISTER

Plug-in I/O card provides 16 form A contacts for operating external devices. See page 10 for contact ratings. Available as Option K25.



12549A General Purpose Register



12551A Relay Register

ORDERING INFORMATION

HP-2116A COMPUTER	\$22,000.
(4096-word memory, no I/O options)	
8192-Word Memory	Option M4 (or field kit 12568A) \$ 8,000.
(basic 4K + 4K additional)	
Memory Parity Check	Option M2 (or field kit 12569A) \$ 1,000.
Memory Test	Option M3 (or field kit 12570A) \$ 420.

(Modifications M2, M3 may be field-installed without assistance from HP. Modification M4 may also be field-installed, but assistance of computer field service engineer recommended.)



HP-2116A INPUT/OUTPUT OPTIONS

● I/O options consist of interface kit (which includes software) and peripheral. I/O options K1 through K9 include peripheral; options K10 through K25 do not include peripheral. ● I/O options may be ordered by option number, either with original purchase of HP-2116A or subsequently. Later orders must state serial number of HP-2116A so that proper software is furnished. Computer field service assistance is recommended for installation of I/O options subsequent to original purchase of HP-2116A; consult computer sales engineer or factory for service charge involved. ● Auxiliary HP-2160A power supply may be needed when using most of the available I/O slots; consult computer sales engineer or factory.

I/O OPTION	CAPABILITY	I/O SLOTS USED	INTERFACE KIT	PERIPHERAL	OPTION NO.	PRICE \$	
						115v, 60Hz	230v, 50 Hz
TELEPRINTER INPUT/OUTPUT	HP-2116A records on typewriter and punched tape, and inputs from keyboard and punched tape, at 10 characters/sec. (ASCII code)	2	12531A	HP-2752A Teleprinter (modified Teletype ASR-33)	K1	2,000	2,200
HEAVY-DUTY TELEPRINTER INPUT/OUTPUT	Similar to Option K1 above, except heavy-duty Teleprinter is furnished. Recommended where use exceeds 5 hrs/day or 30 hrs/week.	2	12531A	HP-2754A Teleprinter (modified Teletype ASR-35)	K2	4,600	Not Available
HIGH-SPEED PUNCHED TAPE INPUT	HP-2116A inputs from punched tape at 300 characters/sec. (ASCII code)	1	12532A	HP-2737A Punched Tape Reader (with accessory 12525A Tape Holder)	K3	2,100	2,200
HIGH-SPEED PUNCHED TAPE OUTPUT	HP-2116A records on punched tape at 120 characters/sec. (ASCII code)	1	12536A	HP-2753A Tape Punch	K5	4,100	4,150
INCREMENTAL MAGNETIC TAPE OUTPUT (1200 FT REELS)	HP-2116A records on IBM-compatible, 1/2 inch, 7 channel NRZI tape. Bit density 200 bpi. Recording speed 400 characters/sec. Reel capacity 1200 feet.	1	12537A	Kennedy 1406 Incremental Tape Transport	K6	6,250	6,400
INCREMENTAL MAGNETIC TAPE OUTPUT (2400 FT REELS)	Similar to Option K6 above, but reel capacity 2400 feet.	1	12537A	Kennedy 1506 Incremental Tape Transport	K7	7,500	7,650
LOW DENSITY MAGNETIC TAPE INPUT/OUTPUT	HP-2116A records on, and reads from, IBM-compatible 1/2 inch 7-channel NRZI tape. Bit density 200 bpi. Speed 30 ips.	2	12538A	HP (H26) 2020A Magnetic Tape Unit	K8	12,500	12,700
DUAL DENSITY MAGNETIC TAPE INPUT/OUTPUT	Similar to Option K8 above, but HP-2116A records and reads at both 200 and 556 bpi.	2	12538A	HP (H26) 2020B Magnetic Tape Unit	K9	15,000	15,200

● Following I/O Options K10 through K25 do not include the peripheral.

TIME BASE GENERATOR	Generates real time intervals in decade steps from 100 μs to 1000 sec (derived from crystal oscillator). Used as source of timed interrupts for software clock.	1	12539A	None required	K10	1,400	1,400
DATA PHONE INTERFACE	Interfaces HP-2116A with Bell System Data Phone service	1	12540A	Bell System Data Set 103A	K11	1,000	Not Available
DIGITAL VOLTMETER DATA INPUT (HP-2401C)	HP-2116A accepts bcd (8421) data output from HP-2401C Integrating Digital Voltmeter	1	12541A	HP-2401C Integrating Digital Voltmeter (with mod. M21)	K12	1,250	1,250
DIGITAL VOLTMETER DATA INPUT (HP-3440A)	HP-2116A accepts bcd (8421) data output from HP-3440A Digital Voltmeter	1	12543A	HP-3440A Digital Voltmeter (with 8421 output)	K14	1,250	1,250
COUNTER/THERMOMETER DATA INPUT (8 DIGITS)	HP-2116A accepts bcd (8421) data output from 8-digit electronic counter and the quartz thermometer	1	12544A	HP-5245L Electronic Counter (with option 02), HP-2801A Quartz Thermometer (with mod. M6)	K15	1,250	1,250
COUNTER DATA INPUT (7 DIGITS)	HP-2116A accepts bcd (8421) data output from 7-digit electronic counters	1	12545A	HP-5244L, 5275A Electronic Counters (with option 02).	K16	1,250	1,250
COUNTER DATA INPUT (6 DIGITS)	HP-2116A accepts bcd (8421) data output from 6-digit electronic counters	1	12546A	HP-5201L, 5202L, 5203L, 5232A, 5233L, 5532A, Counters (with option 02)	K17	1,250	1,250
COUNTER DATA INPUT (5 DIGITS)	HP-2116A accepts bcd (8421) data output from 5-digit electronic counters	1	12547A	HP-5212A, 5214L, 5233L, 5512A Counters (with option 02)	K18	1,250	1,250
COUNTER DATA INPUT (4 DIGITS)	HP-2116A accepts bcd (8421) data output from 4-digit electronic counters	1	12548A	HP-5211A/B Counters (with option 02)	K19	1,250	1,250
DIGITAL VOLTMETER PROGRAM OUTPUT (HP-2401C)	Enables HP-2116A to select function, range, etc., of HP-2401C Integrating Digital Voltmeter	1	12533A	HP-2401C Integrating Digital Voltmeter (with mods. M21, 146)	K20	1,000	1,000
DIGITAL VOLTMETER PROGRAM OUTPUT (HP-2401C/2411A)	Same as Option K20 above, except HP-2411A Data Amplifier included	1	12550A	HP-2401C (M21, 146) Digital Voltmeter and HP-2411A Data Amplifier	K21	1,000	1,000
CROSSBAR SCANNER PROGRAM OUTPUT (HP-2911)	Enables HP-2116A to select channel, settling delay, for HP-2911 Guarded Crossbar Scanner	1	12535A	HP-2911A Guarded Crossbar Switch and 2911B (M33) Scanner Control	K23	1,500	1,500
GENERAL PURPOSE REGISTER	16-bit flip-flop register. Permits bidirectional transfer of information between HP-2116A and external devices. (Accessory kit includes 48-pin mating connector.)	1	12549A	Determined by user	K24	950	950
RELAY OUTPUT REGISTER	Provides 16 form A contacts for operating external devices. (Accessory kit includes 48-pin mating connector.)	1	12551A	Determined by user	K25	600	600

HEWLETT-PACKARD SERVICES

USER (PROGRAMMING) TRAINING

Training courses for the user-programmer are provided at the Dymec Division factory in Palo Alto, California, on a scheduled basis. Training and materials are provided at no charge. The complete User Training Course occupies two weeks, and assumes no knowledge of computer programming or electronic systems operation. The course covers instruction on programming languages and operating system. Two full days are devoted to hands-on experience.

MAINTENANCE TRAINING

Two-week scheduled training courses are available at the Dymec Division factory in Palo Alto, California, at no charge for attendance or supplies.

The hardware Maintenance Training Course assumes familiarity with digital logic circuits and covers the following subjects in depth: HP-2116A Computer organization; logic operation and timing; I/O interfaces; fault diagnosis and repair. Preventive maintenance and repair of peripheral equipment are also covered.

REPAIR AND PARTS SERVICE

Service and parts assistance are available from Hewlett-Packard field offices throughout the United States, Canada and Europe. Local office facilities are backed up by Regional Service Centers. Major parts warehouses are located in Mountain View, California and Rockaway, New Jersey. Parts orders are filled promptly. Hewlett-Packard uses a computer-controlled parts ordering and processing system which ensures that over 90% of orders for replacement parts are shipped the same day they are received.

HEWLETT-PACKARD COMPANY, DYMEC DIVISION

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