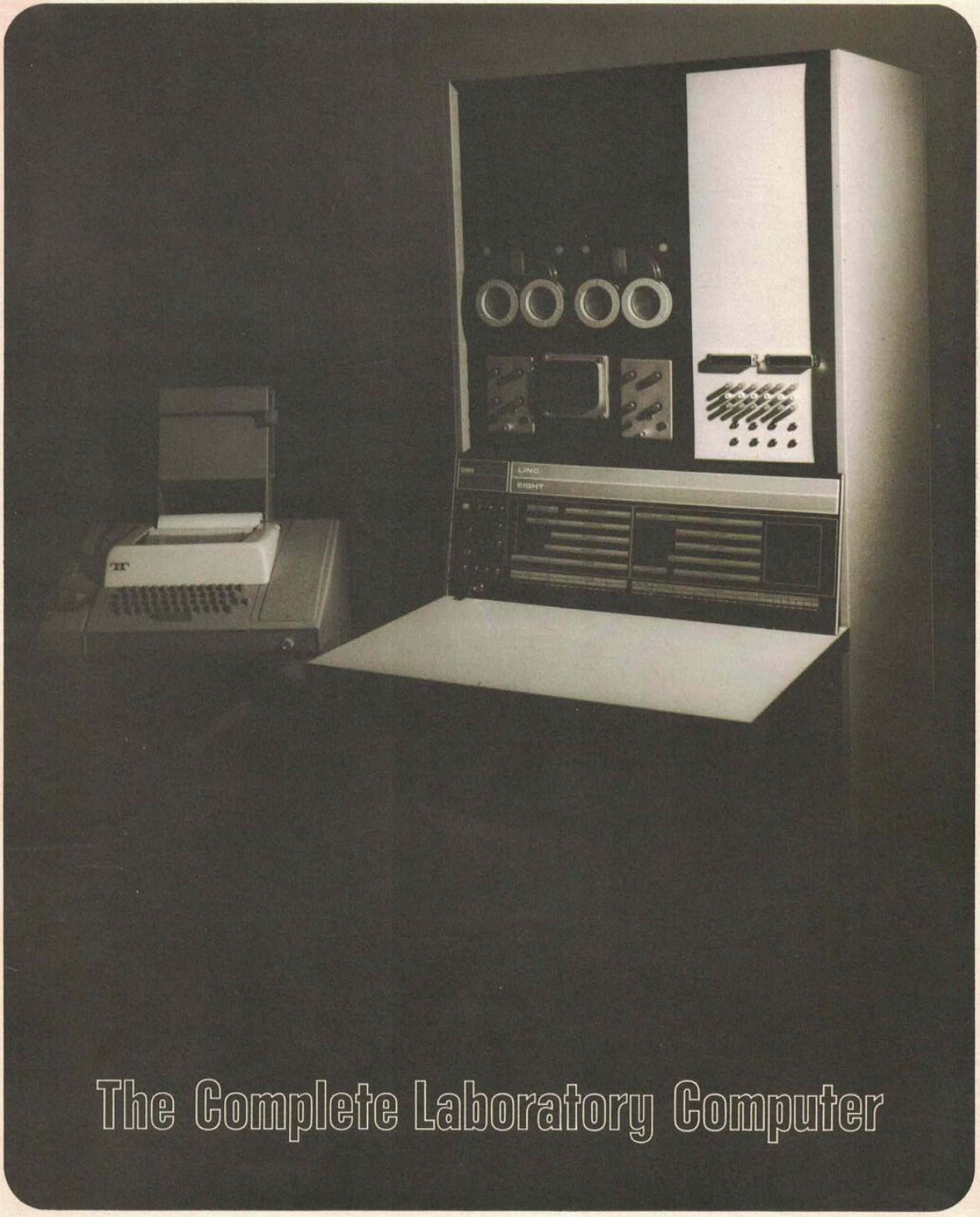
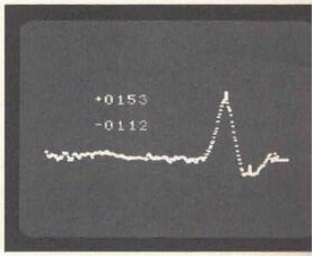
LINC8



The Complete Laboratory Computer

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

Computers In The Laboratory



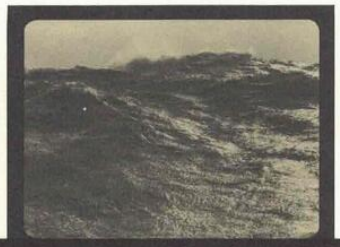
The general purpose laboratory computer becomes a powerful partner in research. Storing, collating, combining, and analyzing research data. Talking directly to the researcher while experiments take place. Displaying results in time for him to vary experiment sequences based on emerging results. Giving him power for creative problem solving, not mere data shuffling.

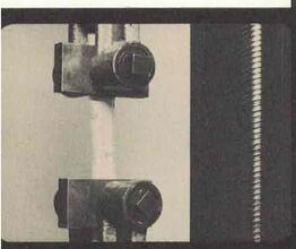
The researcher also gets long-term instrumentation economy. Economy in the ability to change data instrumentation tasks without changing the instrument. Economy in the ability to expand (including the size of the computer itself) by plugging in modular options.

There is an investment to be made. A few weeks diligent study of computer fundamentals to start. But the pay-off is great. Dividends come in terms of an entire career. In adding the computer discipline to your own. In ability to do more and better quantitative research.

Digital Equipment Corporation has played a pioneering role in developing general purpose computers particularly suited for laboratory research. Hundreds of DEC's computers are being used at Universities, in government research centers and in industry. In pure and applied research. In physical, life, and behavioral sciences.

With the development of the LINC-8, DEC has combined the features of two successful general purpose laboratory computers, the LINC, developed under National Institutes of Health and NASA grants and the popular PDP-8 into a single complete data handling facility. And believes the LINC-8 will become the standard in its field.





DEC computers are being used:

In Biomedical Research for:

Arterial shock wave measurements, in-phase triggering of stimuli from EEG alpha waves, processing of single-unit data from the nervous system, EKG processing and average response computation.

In Physics Research for:

Multiparameter pulse height and time of flight analysis. Bubble chamber measurements.

In Industrial Research for:

Tensile strength tests. Electronic component testing. Data transmission analysis.

In Behavioral Research for:

Pattern recognition response analysis. Operant conditioning.

In Earth Sciences for:

Seismic array monitoring. On-board oceanographic data analysis and navigation.

Write for application literature.

LINC-8 AS A TRAINING COMPUTER

LINC-8 is the ideal system on which to teach engineering and science students the use of the full-scale computer in their discipline. It is a complete training system including built-in facilities for input and output of data. The outstanding accessibility of the system — the ease with which the novice can communicate with it make it the ideal training computer. Use the LINC-8 for training either full time or in combination with research activities.

LINC-8: $38,500

COMPLETE SYSTEM

LINC-8 is complete. It is designed to be used as a total computer-based laboratory data handling facility. Added to the power of a full-scale computer facility are a built-in analog-to-digital converter, oscilloscope display, dual magnetic tape unit, relay buffer, buffered input-output lines, and a teletypewriter with paper tape reader and punch. The parts of the LINC-8 system are so combined that they complement each other. The computer facility collects experimental data directly through the analog-to-digital converter. The relays and output system allow direct control of the experiment. The researcher communicates directly with the computer through the scope and teletypewriter. The built-in magnetic tape stores experimental results and the researcher's instructions and makes it easy to use the computer to change or modify these instructions. LINC-8 has everything needed to plug in an experiment and go.

POWERFUL

LINC-8 is powerful. The full-scale LINC-8 computer facility includes a fast memory (1.5 microsecond cycle). And it's expandable. (The 4096 word core expands to 32,768 words.) The combined computation power of two successful general purpose laboratory computers is combined with complete laboratory data handling.

FLEXIBLE

LINC is easily connected to the experiment and puts the researcher in direct creative control of his research. He can vary experimental sequences based on emerging results, or have the LINC-8 vary experiments automatically. And with the LINC-8 the researcher has his choice of two research computers, LINC (for Laboratory INstrument Computer) and the popular PDP-8. The researcher picks the computer better suited to the job at hand. With each computer he has the full input-output facility of the complete LINC-8 system. An almost unlimited number of other laboratory instruments may be simply and directly plugged into the LINC-8. And the researcher can choose from a long list of standard cataloged DEC options.

EASY TO LEARN COMPUTING POWER

The LINC-8 is designed to be operated by laboratory personnel. Special features have been incorporated that make it easy to learn how to use the system. English language displayed on the LINC-8 oscilloscope helps teach the basic fundamentals. A few weeks' diligent study and the researcher is ready to begin using the power and flexibility of a full-scale general purpose computer for the rest of his research career.

TRAINING

Digital Equipment Corporation offers free courses in programming and maintaining each of its computers. These courses are conducted by experienced DEC teachers and comprehensive training manuals are provided. Classes are kept small to insure adequate attention and to give each student as much time as possible on the computer. DEC assists with specific programming problems before, during, and after installation of the LINC-8.

EASY TO MAINTAIN

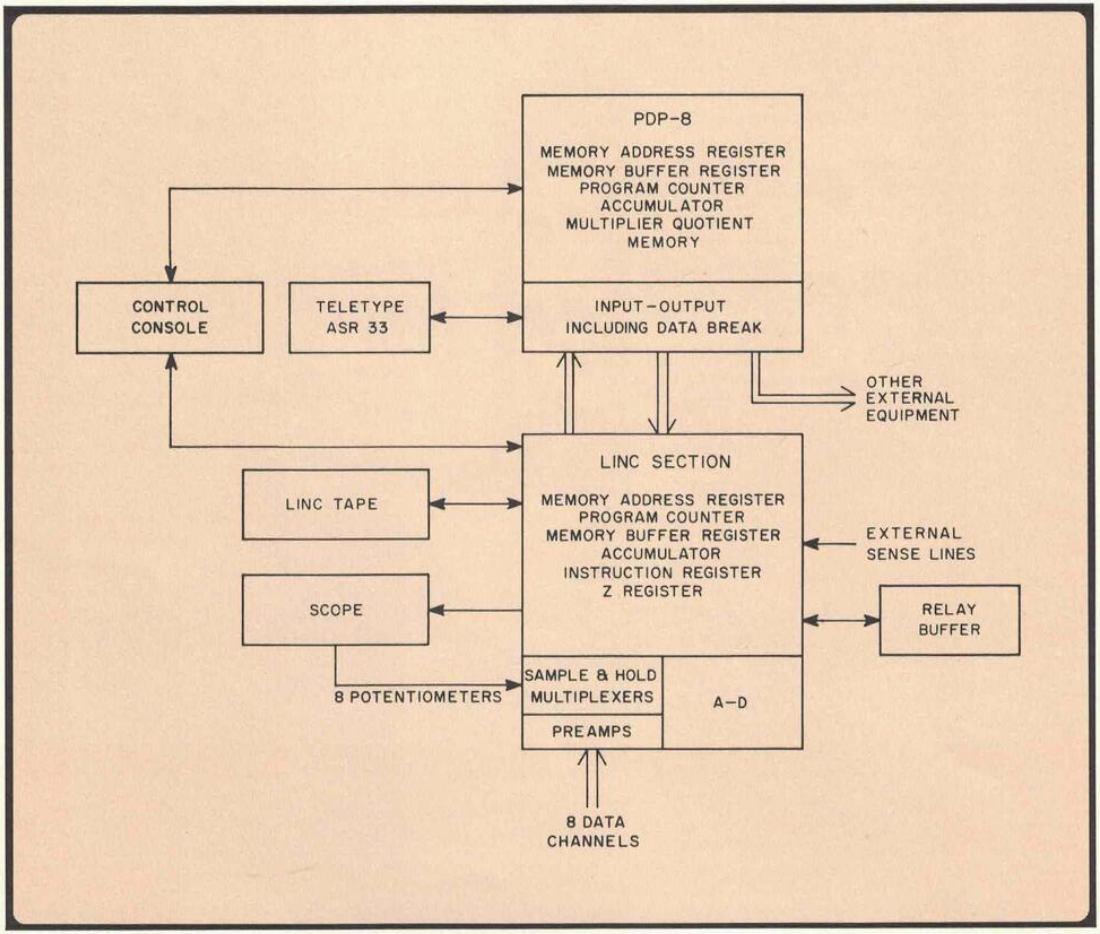
The LINC-8 is designed to be maintained by laboratory personnel. The system is used to check out itself. For example, one computer mode can check out the other; the scope is used to rapidly check out the analog-to-digital converter, and relay buffer. Complete marginal checking features are provided to insure extremely reliable operation.

DEC COMMUNITY OF COMPUTER USERS

Users of DEC computers share in DECUS (Digital Equipment Corporation User's Society). DECUS was formed to promote a free and effective exchange of information between computer users with similar problems. DECUSCOPE, a monthly technical newsletter is used to distribute programming techniques, routines, and program summaries contributed by members. The DECUS Library distributes program descriptions and the corresponding program tapes and listings to members. Certification of these materials is under the direction of the DECUS programming committee, which also guides the operation of the Library. DECUS also publishes the proceedings of its annual symposiums and conducts frequent seminars.


LINC
EIGHT

THE LINC-8 SYSTEM



LINC-8 SYSTEM CONFIGURATION

LINC-8 COMPUTER

The LINC-8 system is comprised of two subsystems:

1. A standard PDP-8
2. The LINC subsystem consisting of a LINC central processor portion, a display scope, a dual tape transport, relay register, analog-to-digital, external sense lines, and data terminal panel.

The two subsystems share a dual console and are connected by means of a special interface section which mediates the exchange of data and control. The LINC-8 is designed to operate in one of two modes. In the first mode, it operates as a standard basic PDP-8 computer system. In the second, it operates as a LINC having certain special in-out and speed characteristics but otherwise functionally identical to the original LINC. LINC development was supported by National Institutes of Health and NASA.

The LINC and the PDP-8 are both single address, fixed word length, parallel computers using 12-bit binary arithmetic. Cycle time of the 4096-word random access magnetic-core memory, which is shared by both computers, is 1.5 microseconds. Standard features of the LINC-8 include indexing and indirect addressing, and facilities for sensing a wide variety of external signals, and program interruption as functions of input-output device conditions.

The 1.5 microsecond cycle time in either PDP-8 or LINC mode provides a computation rate of 333,333 additions per second. In the LINC mode, multiplication is performed in approximately 32 microseconds and forms the 22-bit product of two signed 11-bit numbers. Division is accomplished by means of a subroutine that produces a 12-bit quotient in the accumulator and a 12-bit remainder in memory.

LINC CONTROL PANEL

The LINC control panel contains the lights, switches, and knobs used to operate the LINC-8 in the LINC mode. The toggle switches present digital information to the system. The levers and rotary switches are for controlling computer tasks. The indicator lights show the state of the computer while it is operating.

Some of the special controls on the LINC panel are described below.

LOAD — By pressing the load lever the basic operating program is automatically loaded into memory from magnetic tape.

MARK BUTTON — Used with the MARK program to place the timing and mark information on new tape.

CLEAR BUTTON — Clears the computer memory and performs a simple hardware test.

DO LEVER — Allows the researcher to execute instructions manually at the console, including magnetic tape instructions.

E-STOP, F-STOP — These two levers are used to stop the computer whenever a reference is made to a preselected memory location. This is extremely useful for debugging programs.

AUTO RESTART AND DELAY — By means of these controls, the LINC can be made to pause at predetermined memory locations for a variable length of time.

AUDIO CONTROL — The Audio Control is used for monitoring the operation of an experiment by means on an audible signal while the computer is running.

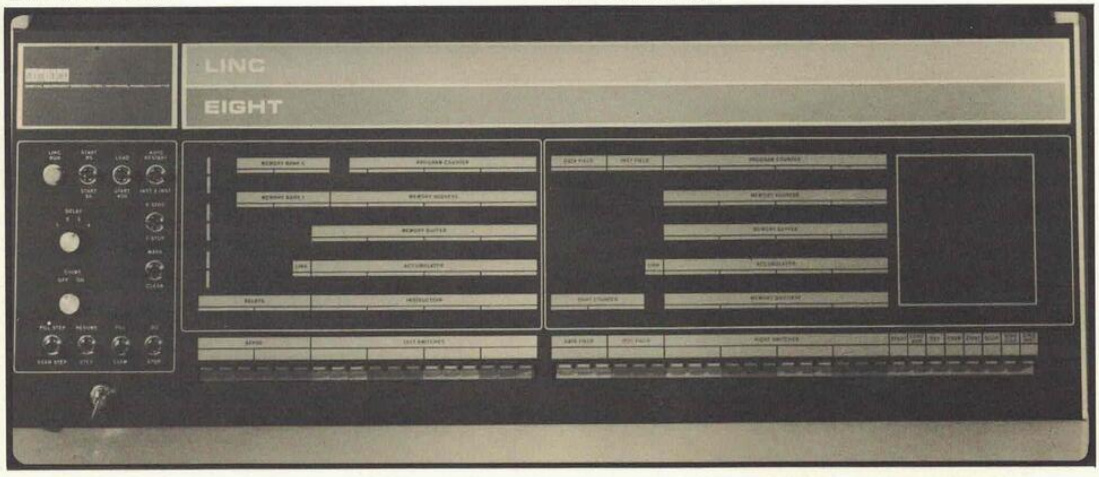
SENSE SWITCHES — Six switches are provided for easy control of program operation. Programs can sense the state of the switches and branch accordingly.

PDP-8 CONTROL PANEL

The PDP-8 control panel contains the keys, indicator lights, and switches used to operate the LINC-8 in the PDP-8 mode. As with the LINC panel, the PDP-8 is used to manually control the computer. The panel is used for data storage, core memory examination, normal start/stop continue control, and single step or single instruction operation. Each step or each instruction of the program may be monitored visually for demonstration, program check-out, or maintenance.

LINC Control Panel

PDP-8 Control Panel



LINC-8 MAGNETIC TAPE UNITS

The dual magnetic tape system can be used to store programs, numerical data and results on 3½ inch reels of ¾ inch-wide tape which contain 512 consecutively numbered blocks, each capable of storing 256 12-bit numbers (total of 262,144 twelve bit words). The tape moves at approximately 60 inches per second in either direction and information is recorded at a track density of about 400 bits per inch. A block occupies 2.5 inches of tape and can, therefore, be scanned in about 1/25 of a second.

The entire process of searching the selected tape for a desired block, transferring information between the block on tape and the core memory of the computer, and checking the transfer is controlled by a single computer instruction. A variant of this instruction permits transfers involving as many as eight consecutive blocks (2048 words) to be made. All operations of the magnetic tape units may be initiated from the console, providing a convenient way of changing programs.

SIX BIT RELAY REGISTER

Relays: A built-in relay register in the LINC mode is used for direct control of other existing laboratory equipment.

LINC-8 ANALOG-TO-DIGITAL CONVERTER

The LINC-8 contains an internal 9-bit analog-to-digital converter which includes sample and hold and sixteen input channels. Eight of the input channels have input amplifiers and accept ±1v input signals. The remaining eight channels are normally connected to potentiometers which can be used as manual program controls or parameter inputs.

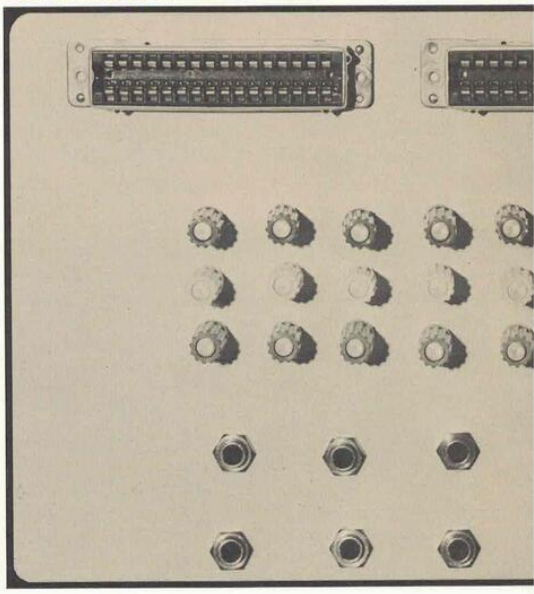
DATA TERMINAL PANEL

The Data Terminal Panel provides a convenient means of connecting to various input-output lines as well as a location for special interface logic. The hinged Data Terminal Panel immediately to the right of the scope and tape units has analog input jacks, relay terminals, and spare connectors. Mounted behind the panel are provisions for mounting some 60 FLIP CHIP modules as well as all the input-output signal lines to the LINC-8 system. By using standard DEC FLIP CHIP modules, it is convenient to interface most special laboratory equipment. FLIP CHIP modules are also used to build digital counters, timers, etc., for unique laboratory applications.

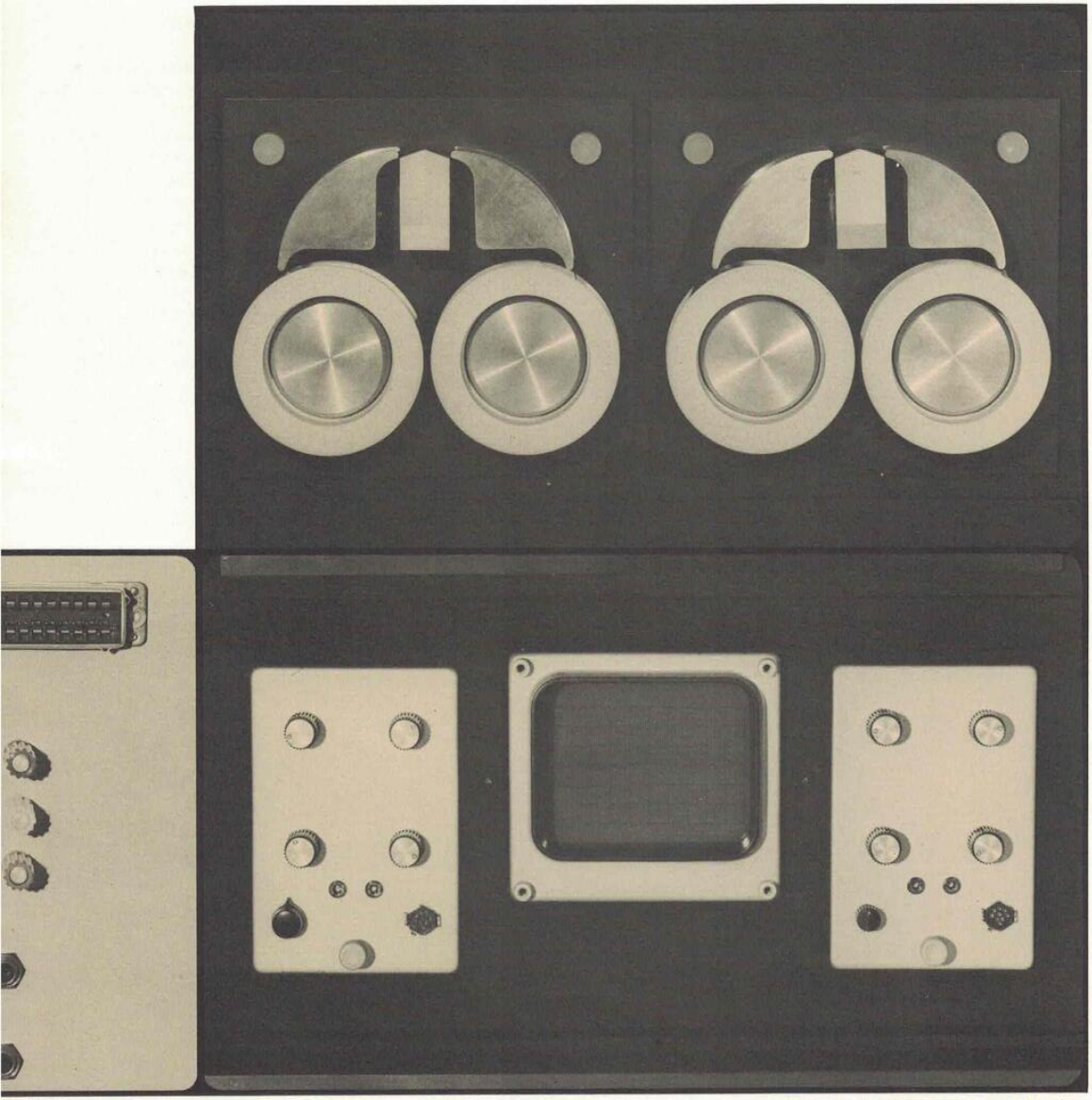
LINC-8 OSCILLOSCOPE DISPLAY

The principal output of the LINC-8 is the oscilloscope display which can be viewed directly or photographed. Displays of programs, data, and results of calculations can be generated point-by-point in graphic form or through numbers and letters of the alphabet at rates of up to 35,000 points per second. Letters of the alphabet or digits are displayed with a point plotting matrix (4x6 points) by a special hardware character generator at a rate of up to 5,000 characters per second. There are two distinct channels which may be connected either to the display scope mounted at the console or to additional remote standard oscilloscopes with special plug-in units. The LINC provides X and Y axis deflection signals which position the spot with a precision of one part in 512 along each coordinate.

Data Terminal Panel



LINC-8 Magnetic Tape Units



LINC-8 Oscilloscope Display

PROGRAMMING THE LINC-8

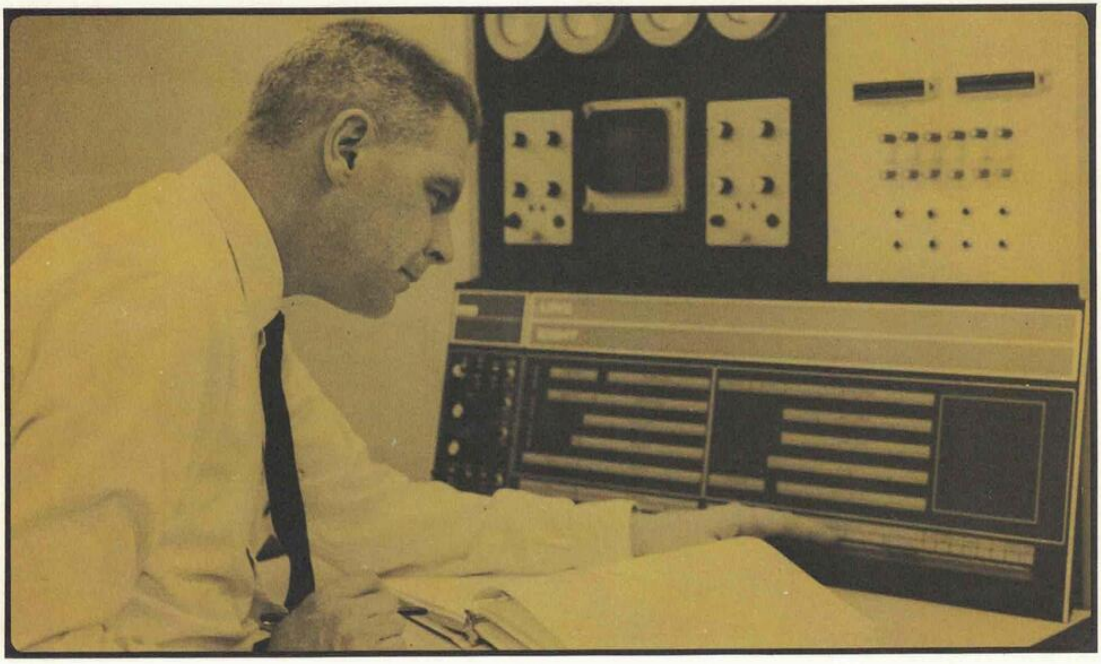
Because the LINC-8 makes high-speed computing available to many new computer users, the LINC-8 programming system was designed to simplify and accelerate the process of learning to program. The LINC-8 programming system makes immediately available to each user the full, general-purpose data processing capability of the PDP-8 and the LINC. In addition, the programming system serves as the operating nucleus for the growing library of programs and routines. New techniques, routines, and programs are constantly being developed, field-tested, and documented in the DEC Program Library for incorporation in users' systems. The programming system and collected programs for a computer system, called "software", often determine the usefulness of the computer to the researcher.

In the LINC mode, the LINC section is controlled by an ordinary LINC program held in the upper half of the PDP-8 memory (which is arranged to correspond exactly to the standard LINC memory of 2048 words). The LINC section is designed to call and carry out all instructions of the LINC program except magnetic tape, operate, and a new instruction called 8 Execute. Instructions of this excepted class, called the Execute Class, are carried out by interpretive routines held in the lower half of the PDP-8 memory. These routines also include programs for Teletype input to LINC, the operation of the LINC console functions, and some special input-output functions. The interpretive program is automatically read into the PDP-8 memory from magnetic tape by the wired-in LOAD mode initiated at the console. The interpretative routines occupy approximately 1000 words of the PDP-8 memory. The LINC can make use of all the remaining memory for program operation.

In both LINC and PDP-8 modes the following software is provided:

FLOATING POINT — The LINC-8 floating point software permits the LINC-8 to perform arithmetic operations that many other computers can perform only after the addition of costly optional hardware. Floating point retains the maximum precision available by discarding leading zeros. In addition to increase accuracy, floating point operations relieve the programmer of problems common in fixed point arithmetic operations. This is of particular advantage to the inexperienced programmer.

MATHEMATICAL FUNCTIONS — The LINC-8 programming system also includes a set of mathematical routines to perform the following operations in both single and double precision: addition, subtraction, multiplication, division, square root, sine, cosine, arctangent, natural logarithm, and exponential.

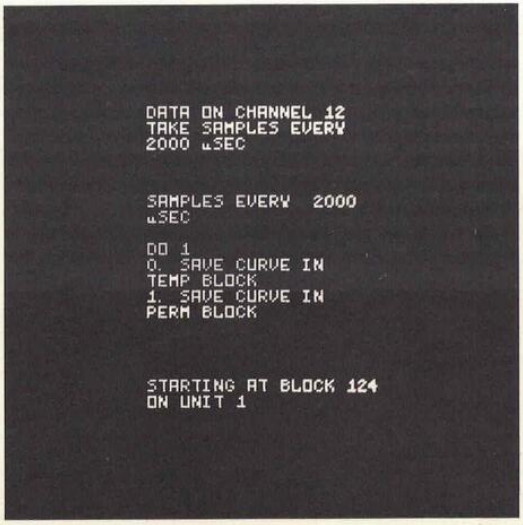


UTILITY AND MAINTENANCE PROGRAMS — Utility programs provide printouts or punchouts of core memory content as specified by the user. Subroutines are provided for octal or decimal data transfer and binary-to-decimal, decimal-to-binary, and Teletype tape conversion.

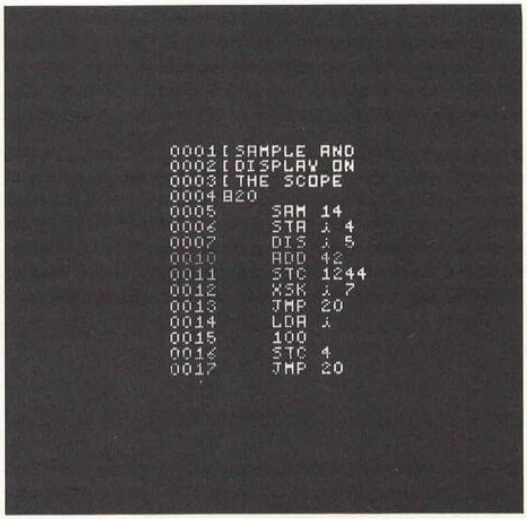
A complete set of standard diagnostic programs is provided to simplify and expedite system maintenance. Program descriptions and manuals permit the user to test the operation of the computer for proper core memory functioning and proper execution of instructions. In addition, diagnostic programs to check the performance of standard and optional peripheral devices are provided with these devices.

PROGRAMMING IN THE LINC MODE

The LINC software was developed for on-line, real-time experimental research under grants from the National Institutes of Health and the National Aeronautics and Space Administration. Development began at Massachusetts Institute of Technology and continued at Washington University in St. Louis.

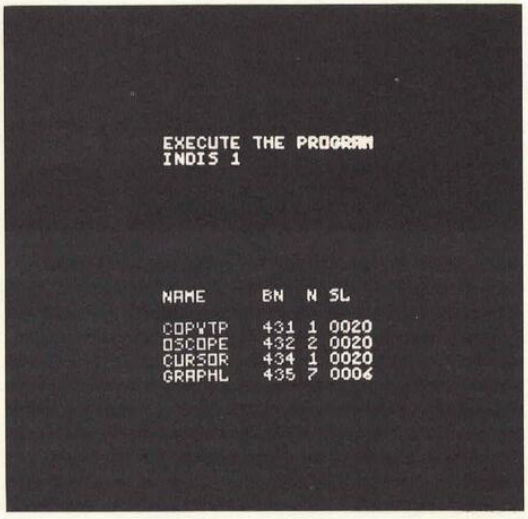


The LINC software includes an "assembler program" which allows the researcher to talk directly with the LINC (via teletypewriter and scope display) while preparing programs or collecting and analyzing data. The researcher types his program in at the console, and the display shows him each completed instruction before it is stored. The LINC Assembler then converts his program into a binary (machine language) program which will actually control the system during his experiment. Writing of programs is made considerably easier by the extensive use of the LINC display and tape units.



The LINC assembly language also provides twelve commands for changing, and converting stored programs. These commands permit insertion and deletion of instructions, scope display of instructions, storage and recall of programs, and copying programs on magnetic tape.

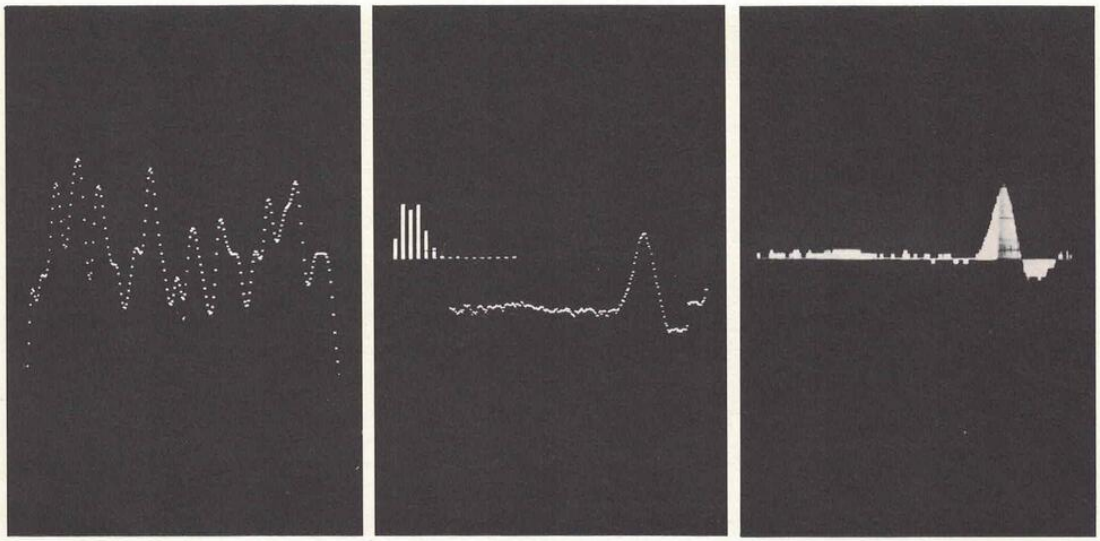
Another LINC system software program is GUIDE. GUIDE is a system of routines to control other programs stored on the LINC tape. It lets the user easily retrieve and execute other programs, delete old programs, and add new ones. A significant characteristic of GUIDE, as well as of the other LINC programming aids, is that oscilloscope displays of alphanumeric information provide a rapid, direct interaction between the user and the machine to speed and simplify program manipulation.



The following instructions are used with the LINC. The LINC performs all its experiment control, data taking, reduction and analysis by means of these instructions.

The LINC Order Code is built on eleven basic functions as shown in the list that follows

Mnemonic	Function	Time (μsec)
	ADD	
ADD	Add memory to AC (full address)	3
ADA	Add memory to AC (full address)	3-4.5
ADM	Add AC to memory (sum also in AC)	6-7.5
LAM	Add link and AC to memory (sum also in AC)	6-7.5
	MULTIPLY	
MUL	Signed multiply	33-34.5
	LOAD	
LDA	Load AC, full register	3-4.5
LDH	Load AC, half register	3-4.5
	STORE	
STC	Store and clear AC (full address)	3
STA	Store AC (Index Class)	4.5-6
STH	Store half AC	4.5-6
	SHIFT/ROTATE	
ROLN	Rotate left N places	3-13.0
RORN	Rotate right N places	3-13.5
SCRN	Scale right N places	3-13.5
	OPERATE	
HLT	Halt	3
NOP	No operation	3
CLR	Clear AC and Link	3
SET	Set register N to contents of register Y	6
JMP	Jmp to register Y	1.5-3
	LOGICAL OPERATIONS	
BCL	Bit clear (any combination of 12-bits)	3-4.5
BSE	Bit set (any combination of 12-bits)	4.5-6
BCO	Bit complement (any combination of 12-bits)	3-4.5
COM	Complement AC	3
	SKIP	
	Skip next instruction if:	
SAE	AC equals memory register Y	4.5-6
SHD	Right half AC unequal to specified half of memory register Y	4.5-6
SNS N	Sense switch N is set	3
AZE	AC equals zero	3
APO	AC contains positive number	3
LZE	Link bit equals 0	3
SXL N	External level N is present	3
KST	Keyboard has been struck	3
FLO	Add overflow is set	3
ZZZ	Bit 11 of Z register equals 1	3
SRO	Rotate memory register right one place, then if bit 0 of Y equals 0 skip next instruction	4.5-6
IBZ	Between blocks on mag tape	3
SKP	Unconditional skip	3
XSK	Index memory register Y, skip when contents of Y equal 1777.	4.5
	INPUT-OUTPUT	
ATR	AC to relay buffer	3
RTA	Relay buffer to AC	3
SAM N	Sample analog chan N	21
DIS	Display point on oscilloscope	18
DSC	Display character on oscilloscope (2x6 matrix)	75-140
RSW	Right switch register to AC	<200
LSW	Left switch register to AC	<200
KBD	Keyboard to AC	<200
EXC	Transfer to PDP-8 program control	>75
OPR	Execute input-output control	>75
	MEMORY	
UMB	Change upper memory bank	3
LMB	Change lower memory bank	3
	LINC TAPE	
RDE	Read one block into memory	times
RDC	Read and check one block	depend
RCG	Read and check N consecutive	on tape
WRI	Write one block on tape	position
WRC	Write and check one block	
WCG	Write and check N blocks	
CHK	Check one block of tape	
MTB	Move tape toward selected block	



Data manipulation in the LINC mode.

PROGRAMMING IN THE PDP-8 MODE

The programming system for the PDP-8 consists of the MACRO-8 Symbolic Assembler, FORTRAN System compiler, Symbolic On-Line Debugging Program, Symbolic Tape Editor, Floating Point Package, mathematical function subroutines, and utility and maintenance programs. All operate with the basic computer.

MACRO-8 ASSEMBLER — The MACRO-8 Symbolic Assembler accepts source programs written in the symbolic language and converts core memory locations, computer instructions, and operand addresses from the symbolic to the binary form. It produces an object program tape, a symbol table defining memory allocations, and useful diagnostic messages.

FORTRAN COMPILER — The FORTRAN (for FORmula TRANslation) System compiler for the PDP-8 lets the researcher express his problem in a mixture of English words and mathematical statements. The FORTRAN Compiler contains the instructions the computer requires to perform the clerical work of translating the FORTRAN version of the problem statement into programs in machine language. In addition to reducing the time needed for program preparation, the Compiler enables computer users with little or no knowledge of the computer's organization and machine language to write his own programs.

DEBUGGING PROGRAM — On-line debugging with DDT-8 gives the user dynamic printed program status information. It gives him close control over program execution, preventing errors from destroying other portions of his program. He can monitor the execution of single instructions or subsections, change instructions or data in any format, and output a corrected program at the end of the debugging session.

TAPE EDITOR — The Symbolic Tape Editor program is used to edit, correct, and update symbolic program tapes using the PDP-8 and the Teletype unit. With the editor in core memory, the user reads in protions to his symbolic tape, removes, changes, or adds instructions or operands, and gets back a complete new symbolic tape with errors removed. He can work through the program instruction by instruction, spot-check it, or concentrate on new sections.

OPTIONAL EQUIPMENT

LINC-8 includes options for expanding the processor, reading and punching devices, plotting, CRT displays, analog-to-digital conversion equipment, magnetic drum and tape storage devices, data communication equipment, and additional cabinets.

PROCESSOR OPTIONS

MEMORY EXTENSION CONTROL TYPE 183 — Allows addition of up to seven fields of 4096 words, or up to a total of 32,768 words.

MEMORY MODULE TYPE 184 — From one to seven Type 184 Memory Modules can be added to a LINC-8 containing a Memory Extension Control Type 183.

MEMORY PARITY TYPE 188 — Automatic checking of each word between the processor and core memory is provided by this option.

POWER FAILURE OPTION TYPE KR01 — This option allows the contents of live registers to be stored in core memory when power begins to fail and restarts the program when power returns.

DATA CHANNEL MULTIPLEXER TYPE DM01 — The Type DM01 option expands the data break facilities of the computer to allow up to seven input-output devices to transfer data directly with the core memory, via the computer's block transfer control.

READERS AND PUNCHES

High Speed Perforated Tape Reader and Control Type 750C
High Speed Perforated Tape Punch and Control Type 75E
Card Reader and Control Type CR01

PLOTTER AND PRINTER

Incremental Plotter Control Type 350
Automatic Line Printer Type 64

CATHODE RAY TUBE DISPLAYS

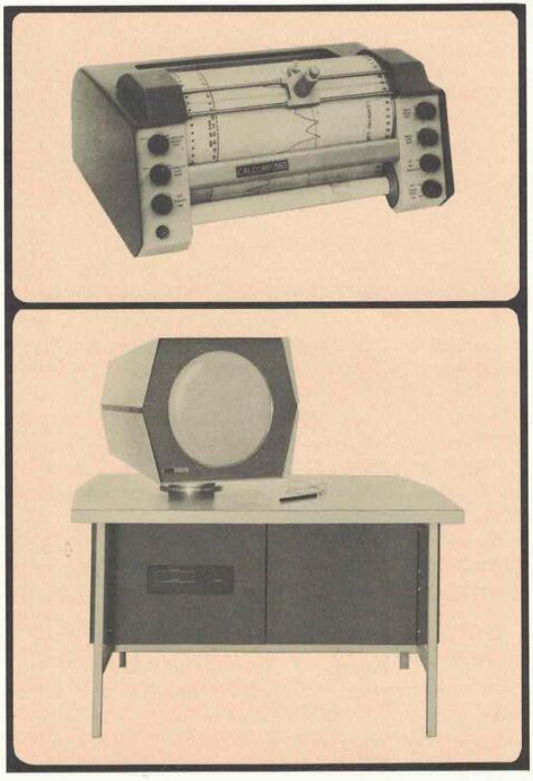
Oscilloscope Display Type 34D
Precision CRT Display Type 30N
Photomultiplier Light Pen Type 370

ANALOG-TO-DIGITAL CONVERTERS

Analog-to-Digital Converter Type 189
General Purpose Analog-to-Digital Converter Type 138E
General Purpose Multiplexer and Control Type 139E

MASS STORAGE

Serial Magnetic Drum System Type RM08
DECtape Transport Type TU55 and Automatic Control Type TC01
Magnetic Tape System Type 580
Automatic Magnetic Tape Control Type 57A
Magnetic Tape Transport Type 50



SPECIFICATIONS

Standard Equipment — LINC-8

4096 words, 12 bit memory (approximately 3,000 programmable)
ASR-33 teletypewriter, with paper tape punch and reader
Six sense switches
Twelve sense switches
Audio control
Cathode Ray Oscilloscope — 2 separate intensifications channels
Dual Magnetic tape unit
Six bit Relay Register
LINC Mode
  Automatic multiply
  16 controllable index registers (memory)
Marginal Checking Features
Analog-to-Digital Converter
  16 Multiplexed channels
  8 accept ±1v
  8 controllable potentiometers
  Sample and Hold
  16 additional channels optional
Data Terminal Panel
  Relay outputs
  Analog input connectors
  Mounting hardware for special interfaces
  Swings open for easy access

Physical

Standard Cabinet Size — 69⅛ inches high, 32½ inches wide (with end panels), and 33 inches deep (without table).

Teletype Size (on stand): 33 inches high to top of console, 44¼ inches high to top of copy holder, 22¼ inches wide, 18½ inches deep.

Electrical

Power Requirements: 115v, 60 cycles, 1 phase, 20 amp (can be constructed for 220v or 50 cycles upon request).

Power Dissipation: 2000 watts.

Digital Signal Levels: Ground and −3v.

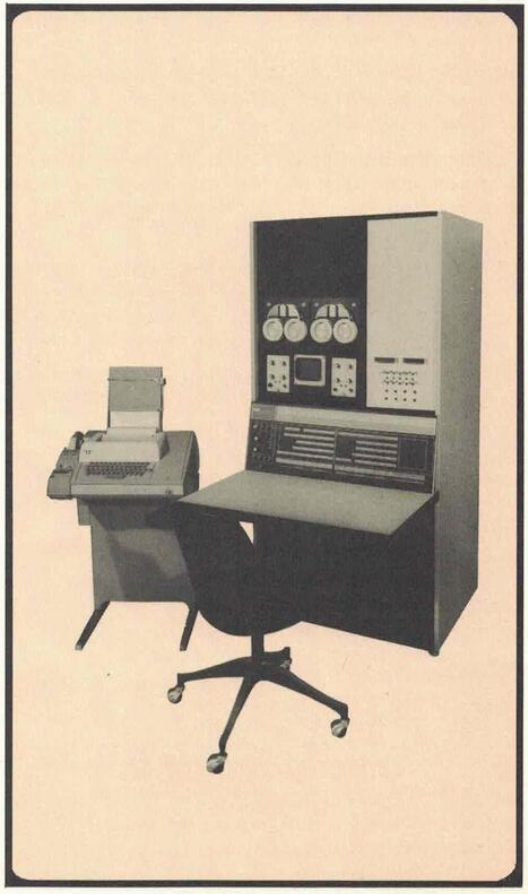
Internal Circuit Potentials: +10, −10, and −15v.

Functional Cycle Time: 1.5 μsec.

Word Length: 12 bits.

Core Memory Size: 4096 words expandable to 32,768 in fields of 4096 words.

Input-Output Capability: 60 different devices can be individually selected and addressed by 3 command pulses.



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