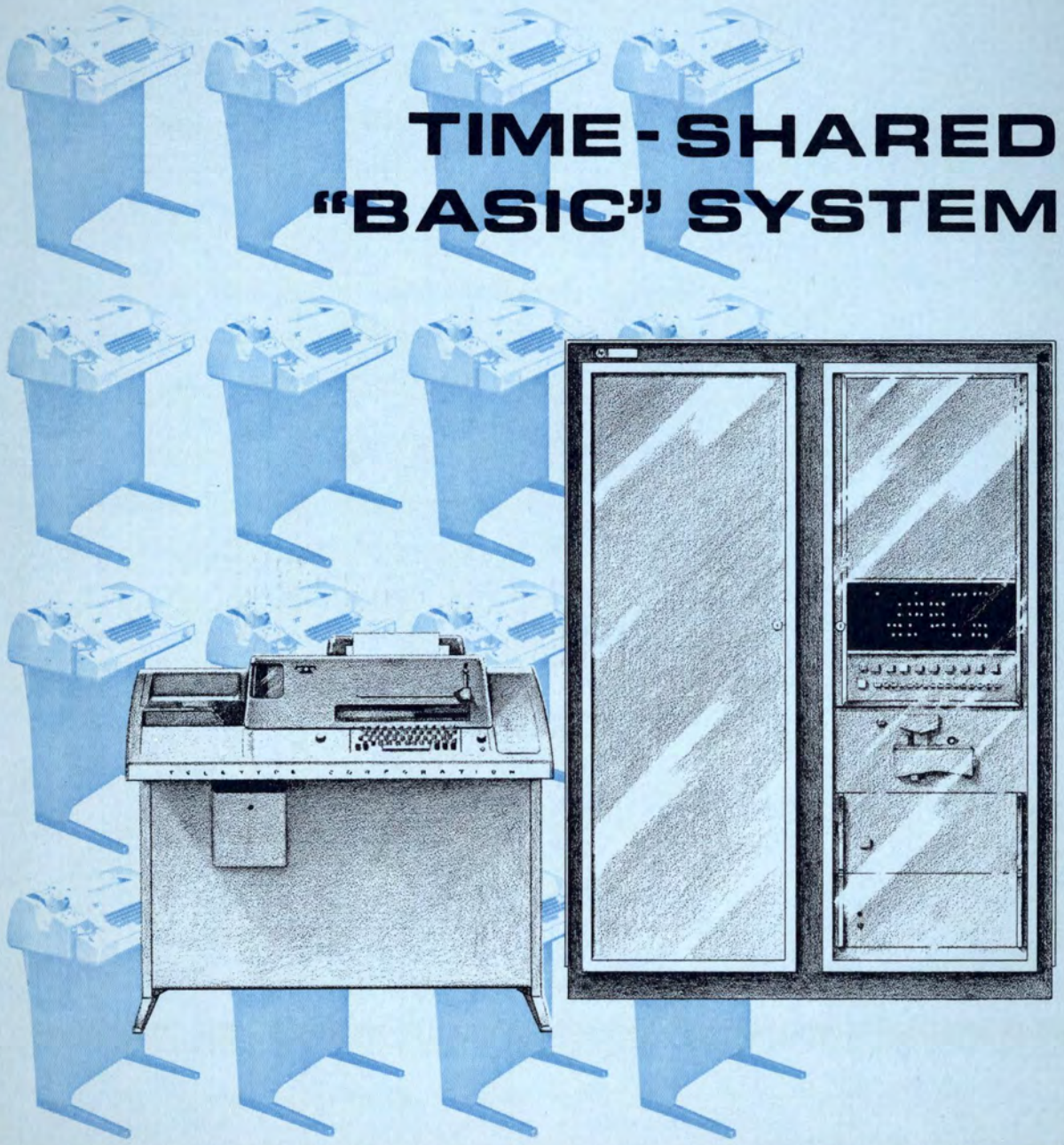
Hewlett Packard

HEWLETT hp PACKARD

digital computers

TIME-SHARED "BASIC" SYSTEM



significant system features

System Capacity — Simultaneous use by up to 16 programmers

Real-Time Service — No batch processing turn-around time

Around-the-clock availability — The more use, the less $/hour

Economic Operation — $7.00 per terminal per working day

Conversational Language — BASIC, a simple, yet powerful tool

Extensive Diagnostics — Compiler and run diagnostics in English

Incremental Compiling — Line-at-a-time compiler diagnostics

Full Duplex with Echo — Automatic error checking

Disc Library — 250,000 words of private and public library

Alternate Modes — Non-time-sharing FORTRAN, ALGOL, and Assembler

Terminal Location Flexibility — Can be located many miles away

Closed System — No line or Data Set charges for local terminals

Privacy — Confidential information safeguarded in owned system

Reliability — All silicon solid-state circuitry

BASIC Texts — Excellent texts available on BASIC

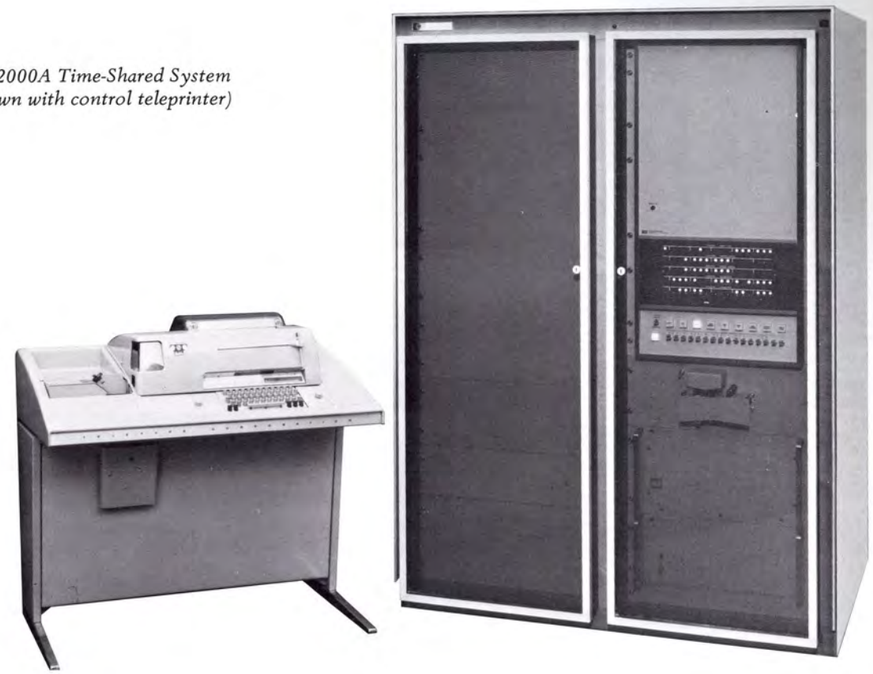
Accounting System — Validating and billing for system use

Support — Sales and service offices throughout the free world

(A technical data sheet providing system and component specifications, model numbers, prices, and ordering information is available on request.)

HEWLETT-PACKARD — Time-Shared "BASIC" System

HP 2000A Time-Shared System
(shown with control teleprinter)



Introduction

The HP 2000A Time-Shared "BASIC" System represents a new philosophy in the design of time-sharing computer systems. Most time-sharing systems have been characterized by their large size, multi-lingual capability, complex executive programs, and high cost. Experience with these systems has shown that most users pay a high price for system features they seldom use. Given a choice, most users prefer a simple, conversational language, usually BASIC. Yet the implementation of BASIC represents a relatively small fraction of the cost of a system.

The HP 2000A, on the other hand, doesn't try to do everything for everybody. What it will do is provide an economical BASIC language time-sharing system capability of efficiently serving up to sixteen users simultaneously. This brochure describes the system, its features, and its applications in research and industry.

a new philosophy in time-sharing

Computer Efficiency

The motivation for time-sharing is increased efficiency, both for the computer and for the user. Today's computers are so much faster than the programmer with his keypunch or typewriter that efficient and economical use of a computer has required new input/output techniques.

Batch Processing

In batch processing the users' programs are prepared off-line and collected in a high speed storage device for sequential execution by the computer. The efficiency of the system depends upon maintaining a queue of programs ready for execution.

Time-Sharing

In time-sharing, the computer's hardware and software is designed to allow simultaneous use by many programmers. This parallel technique also reduces the input/output bottleneck.

Time-Sharing Benefits

In order to understand the utility of time-sharing it is helpful to list some of the features of time-sharing systems that have made them the success they are.

1. Time-sharing systems are *economical* to use; the power of a high speed processor is available to each user at a fraction of the total cost.

2. The user can perform his computations *when he wants to* without waiting for a turn in the batch system queue.

3. Conversational interpretive languages, not economically practical on a single terminal-per-processor basis because of their on-line program preparation and slower execution times, become powerful and practical tools when built into a time-sharing system. These languages, which *can be learned in hours instead of weeks* are perhaps the major factor in the success and growth of time-sharing.

4. Program debugging *is greatly simplified* by the combination of on-line, two-way communication and lower operating cost, which makes it possible for the user to debug a program on-line without repeated cycles through the batch queue.

5. In some applications time-shared operation makes it possible for many users to simultaneously access a large *common data base.*

Batch System Benefits

At the same time there are things that time-sharing systems do not do well:

1. Time-sharing systems are not usually practical in applications requiring the processing of large volumes of data as the terminals are usually slower devices matched to the reading and typing speeds of an operator.

2. Complex problems with long running times or with frequent use may be more economical on a batch basis because of the slower execution times on the time-sharing system.

Time-Sharing Users

The majority of the present time-sharing users fall into one of three catagories.

1. The largest class of users are the *scientists, engineers, and technicians* of industrial and research organizations who are not professional programmers. They use the system as a computational tool because the languages are easy to learn, and because they can develop and debug their programs in the relative quiet of the terminal area without the pressure of debugging in a public and more expensive environment. Since the languages are simpler and easier to learn the occasional user can still maintain adequate proficiency.

2. *Professional programmers,* while not so concerned with the schedule cycle of a batch system (since they typically work on several problems concurrently), nevertheless find the time-sharing systems useful for debugging programs for later batch processing or for simple problems, particularly where programs already exist in the time-sharing library.

3. *Students* make up a third group of users of growing importance. Time-sharing systems provide an excellent tool for the programming student by permitting more hands-on time and greater interaction with the computer. Programming fundamentals can be applied earlier in programming classes because of the simpler languages. Generally, students are finding increasing use for the systems for graduate work and special projects.

Time-Sharing Languages

Although the present commercial time-sharing services collectively offer more than twenty programming languages, the conversational, interpretive languages enjoy the greatest use. Of these, BASIC, developed at Dartmouth College, is the most often used.

A New Philosophy

The HP 2000A is a practical solution, not a total solution. It cannot totally replace a need for a multi-lingual service but it can more economically perform the majority of functions now entrusted to time-sharing services. It uses a smaller, high speed computer, the HP 2116, with a straightforward executive program to direct the computer's support. of input/output demands, program execution, library service, and accounting system.

The HP 2000A is within the reach of many users who cannot justify a conventional time-sharing system.

Besides the time-sharing mode the system can also be used during off hours as a batch processor operating in Assembly language, FORTRAN, or ALGOL.

BASIC - the language of the HP 2000A

The secret to effective computer use is user-computer communication. The description of the HP 2000A therefore logically begins with examples and descriptions of the system's language, BASIC. These examples demonstrate the simplicity and power of BASIC as a computer language and illustrate why it is usually learned in hours instead of weeks.

A computer program written in BASIC consists of numbered statements. The computer executes these statements in sequence unless an instruction within a statement directs otherwise. Let's examine the statements in the first program (see opposite page).

```
10  LET I = 1
```

In the first statement the variable "I" is assigned the value 1. (Note that the typewriter uses the symbol "Ø" in 1Ø to denote zero and distinguish it from the letter "O".)

```
20  IF I > 1000 THEN 50
```

If "I" were larger than 1ØØØ the computer would jump to statement 5Ø for the next instruction. Since it is not larger, the next statement is 3Ø.

```
30  LET I = I + 1
```

Here the computer is instructed to increment the value of "I" by one. I = 1 + 1 = 2.

```
40  GO TO 20
```

Here the computer is instructed to jump back to statement 2Ø, creating a program loop. The computer will cycle around and around this loop until "I" is greater than 1ØØØ at which time statement 2Ø instructs it to jump to statement 5Ø.

```
50  PRINT "PROGRAM COMPLETE"
```

The computer is instructed to print the phrase "PROGRAM COMPLETE".

```
60  END
```

This statement identifies the end of the program.

Instructions printed over blue tone (on opposite page) are system commands. After the program is entered, the command "RUN" tells the computer to execute the program and the computer responds by typing:

```
PROGRAM COMPLETE
```

Suppose that at this point we wished to have the computer print the value of "I" each time around the loop. We add the statement:

```
25  PRINT I;
```

The "LIST" command causes the computer to list the new program with the new statement inserted in its proper place. The ";" in statement 25 tells the computer to space the values of "I" across the line. Without the ";" the computer would use a separate line for each value of "I" and make a vertical column.

The "RUN" command again causes the program to execute, this time printing each value. If we don't want to wait for the computer to type the full series, the command "STOP" will halt the execution.

If we now want the computer to list the value I, the square of I, the cube of I, and 2 to the power I we rewrite statement 25 as shown. The ↑ is used to indicate raising to a power since the teleprinter cannot type subscripts or superscripts. Statement 5 provides column headings and statement 2Ø is rewritten to reduce the maximum value of "I" to 1Ø. The command "RUN" produces the desired results.

```
10  LET I = 1
20  IF I > 1000 THEN 50
30  LET I = I + 1
40  GO TO 20
50  PRINT "PROGRAM COMPLETE"
60  END

RUN

PROGRAM COMPLETE

READY

25  PRINT I;

LIST

10  LET I=1
20  IF I>1000 THEN 50
25  PRINT I;
30  LET I=I+1
40  GOTO 20
50  PRINT "PROGRAM COMPLETE"
60  END

READY

RUN

 1    2    3    4    5    6    7    8    9   10   11   12
 13   14   15   16   17   18   19   20   21   22   23   24
 25   26   27   28   29   30   31   32   33   34   35   36
 37   38   39   40   41   42   43   44   45   46   47   48
STOP

READY

25  PRINT I, I↑2, I↑3, 2↑I
 5  PRINT "VALUE", "SQUARE", "CUBE", "POWER"
20  IF I > 10 THEN 50

RUN

VALUE          SQUARE         CUBE           POWER
 1              1              1              2
 2              4              8              4
 3              9              27             8
 4              16             64             16
 5              25             125            32
 6              36             216            64
 7              49             343            128
 8              64             512            256
 9              81             729            512
 10             100            1000           1024
PROGRAM COMPLETE
```

more about BASIC and BASIC texts

Conversational Programming

The dialogue between the programmer and the computer is a powerful learning tool for the user. All diagnostic messages are in English and they are given to the programmer as early as possible.

With this technique, format mistakes are identified and brought to the programmer's attention when they are made. There is no wait for a program to cycle through a batch computer queue to learn that a simple format error has prevented the execution of the problem.

Diagnostics

The example on the previous page illustrates the simplicity of programming when everything is done correctly. The real test of a language is: what happens when there are bugs in the program?

The computer can be taught to recognize errors of format and syntax in the program and also recognize certain problems that can develop during the execution, such as an attempted division by zero or a result that is too large. The computer, of course, cannot judge whether the program is going to compute what was intended. If the statements furnished to it are legal and meaningful it must assume the programmer knows what he is doing.

The HP 2000A system checks *each statement* for format and syntax *as it is entered.* If an error is found, a diagnostic message is typed at once. The system makes added checks when it is commanded to "RUN" and provides additional diagnostics as required.

If the result of a computation cannot be expressed as a six digit integer, it is automatically converted to a floating point number.

Thus: 1000000000
becomes: 1.00000 E 9
and: -0.000001
becomes: -1.00000 E-6

If an attempt is made to divide by zero, a diagnostic message is typed and the dividend is given the largest value allowed by the system:

1.70141 E 38

Full Duplex

In the HP time-sharing system, the computer immediately confirms data entered at the terminal. With each key stroke, the teleprinter sends a serial binary code to the computer which then echoes the code back to the teleprinter. It is this echo that causes the teleprinter to type the proper character. If there has been an error in the transmission of the character the programmer is alerted immediately because the printed copy is not correct.

Without this technique it is necessary to ask for a listing of all entries and proofread to check for accurate transmission.

Library

Each time a new program is begun, the system asks for a program name. It is possible to store a program, finished or not, with the command "SAVE". With the command "PUBLIC", the saved program is available to any user. There is space on a disc memory for approximately 1000 average size programs (50 statements each).

HP BASIC, A Hewlett-Packard manual on BASIC, as implemented in the time-sharing system, complete with system commands and program examples.

HP 2000A System Training Manual and visual aids are provided with each system. Course material for training users in the language and system commands of the time-sharing system. More than 70 2-by-2 inch color slides are included.

Manuals are also provided for Assembly language, FORTRAN, ALGOL, Basic Control System, and Symbolic Editor, as well as hardware operation and maintenance.

BASIC PROGRAMMING: by John G. Kemeny and Thomas E. Kurtz – John Wiley & Sons (1967)

"BASIC PROGRAMMING is designed as a comprehensive introduction to the art of computer programming." In this text "the reader is introduced to the language at an elementary level and can then study applications to a wide variety of problems, many of them being of significant practical interest."

"The language (BASIC) is so simple and natural that the reader is required to spend a minimum of time mastering it and can concentrate his efforts on learning programming techniques."

BASIC: An Introduction to Computer Programming Using the BASIC Language by William F. Sharpe – The Free Press (1967)

This text is intended primarily for the user who does not have extensive mathematical training. It illustrates the principles of computer programming with extensive examples drawn from business administration and the social sciences.

Organized so that the reader can prepare and run a useful program of his own after the first two chapters, BASIC makes maximum use of accumulated knowledge to do increasingly complex work.

the HP 2000A system

HARDWARE

The HP 2000A time-shared system is built from state-of-the-art components. Integrated circuits and modular printed circuit board construction make the system economical, reliable and easily maintained. The cabinet can be locked, leaving the computer visible through the plexiglass front doors.

The HP 2116 Computer

The time-sharing system uses the HP 2116 Computer with a 16-bit word length (plus parity) and 16,384 words of magnetic core memory. Memory cycle time is 1.6 microseconds. Interface to the required peripherals is through plug-in input/output cards and standard cabling. Seven of the computer's nine registers are displayed on the operator panel and are visible during system operation. For time-sharing system use, the computer is equipped with power fail interrupt, memory parity check, direct memory access, extended arithmetic unit, time base generator and a power supply extender.

The Disc Memory

For bulk high-speed memory, the system uses the HP 2757A-M1 Disc Memory with 348,160 words of storage. The disc is used for storage of active programs (up to 90K words), for storage of the file copy of the system executive (10K words), and for storage of inactive user programs (248K words). The disc's short average access time, 16 milliseconds, coupled with the executive's optimum timing techniques assure the efficiency required for handling the maximum 16 users at once.

For users with exceptionally large storage requirements the disc storage can be expanded.

System Control Teleprinter

The HP 2754A Teleprinter for system control is a modified ASR-35 made by the Teletype Corporation.

The User's Terminals

The teleprinters used as terminals with the system are modified ASR-33's, also made by the Teletype Corporation. Up to 16 can be used with the system at the same time. These teleprinters are available from Hewlett-Packard, from the Teletype Corporation, or through local telephone companies.

System Connection

Connection between the user's teleprinters and the system can be by direct wiring or by telephone lines. With the telephone system any number of users can have access to the system, with up to 16 able to operate simultaneously.

Direct wiring is practical to at least one mile. Connection through telephone lines via Bell System's Data Set 103A is practical nearly anywhere in the country. Acoustic couplers that allow data communications through normal voice telephones are also used for shorter distances. Space is provided in the system cabinet for 16 Data Sets or for other connection apparatus.

Environmental Conditions

The system is designed to operate under demanding environmental conditions: ambient temperatures from 0° to 45°C (32° to 113°F); relative humidity to 80%.

Peripheral Options

For operation during non-time-sharing periods a full range of peripheral devices is available, including: high speed tape punch, magnetic tape recorders, high speed card readers, line printers, oscilloscope displays, and plotters. The system may also be used with a wide variety of measuring instruments including analog-to-digital converters, counters, and many more (see page 14).

SOFTWARE

Provided with the system is the complete system software required for the operation of the HP 2000A in the time-sharing mode, plus a full range of batch mode software.

The time-sharing executive

The executive program directs the computer's support of input/output demands, program execution, library service, and the accounting system. It operates on a priority basis to provide the user of the system with prompt response, creating the illusion for each user that he has the computer to himself.

The accounting system

An accounting system is furnished that can be used to control access to the computer and also accumulate information for statistical studies, or for billing users. When used, the accounting system requires each user to type in his account number and password in order to gain access to the system. The system then records the number of minutes of terminal time used. Data is accumulated by the system until interrogated and reset through the system control teleprinter.

The library system

Two types of libraries are maintained on the disc by the executive program. A public library of programs, available to any user but changeable only by the originator, is maintained by the system on the disc. The system command "LIBRARY" causes the system to list the names of all public programs.

The private library is maintained for each user; the command "FILES" causes the system to list the names of all the user's saved programs.

Other operating modes

The hardware of the time-sharing system can be used for other purposes by putting the time-sharing system to "sleep". A full range of software systems is furnished with the time-sharing system, including the following:

HP Assembler

The assembler processes a machine oriented language providing the full flexibility of hardware instructions. The language includes machine operation codes, assembler-directing pseudo codes, and symbolic addressing. The output may be absolute or relocatable. Relocatable code is linkable to FORTRAN or ALGOL code.

FORTRAN

The FORTRAN compiler system accepts source programs written in ASA Basic FORTRAN with many useful additions. It produces a relocatable machine-language object program which can be loaded under control of the Basic Control System.

ALGOL

The ALGOL compiler system allows programming in this internationally defined algorithmic language and produces a relocatable program in one pass. The compiler incorporates all major elements described in the ALGOL 60 Revised Report, Communications of the ACM, January 1963, plus many additional significant features.

Basic Control System (BCS)

The BCS system handles loading, relocating, and linking of user programs and library subroutines. It simplifies programming and execution of all input/output operations.

optical mark reader

The Hewlett-Packard 2760A Optical Mark Reader can be used as an input device for the time-sharing system. It handles standard tab cards, reading either punched holes or pencil marks. This reader provides a convenient means for collecting and inputting data from remote stations not equipped with terminals. It is also useful for handling and entering large volumes of data for analysis by a BASIC language program.

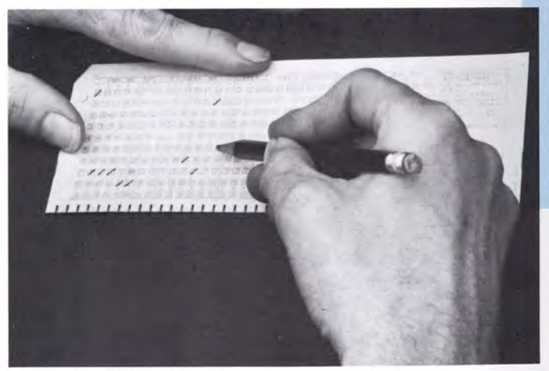
Marking the Cards

Data is entered on the cards by marking the boxes enclosing the characters to be read, using a regular soft black pencil. A black mark across a single box is all that is required to write a numeric character on the card. Letters or punctuation require two marks, one in a numeric position and one at the top of the column. Special symbols may require a maximum of three marks.

Incorrect marks can be removed with an erasure and replaced by new marks in correct locations.

Card Format

The positions of the columns on the cards is determined by the "clock" marks printed in black along the bottom of the card. Spacing of the columns and creation of open areas for non-reading entries is controlled by the locations of the clock marks during the layout of the card. Numerous card manufacturers provide economical services for the layout and printing of such cards.



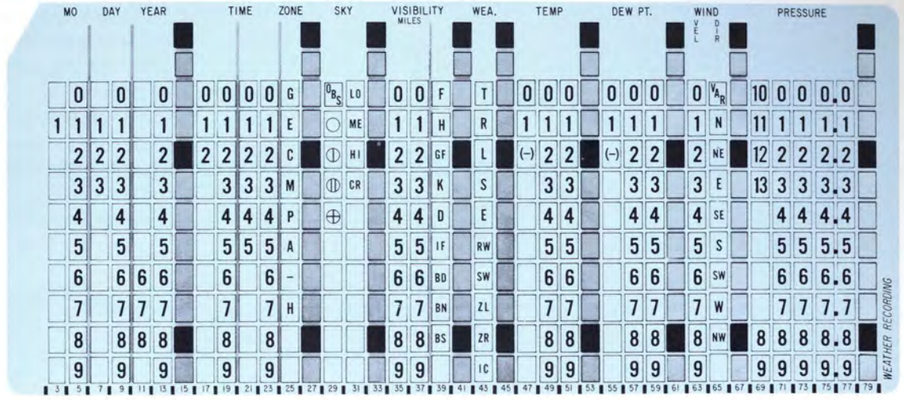
Pre-punched Cards

Control information may be pre-punched into the card to reduce the amount of hand entered data. Sequence, serial or other identification numbers plus any other routine information can be punched into the cards before or after marking to save time or provide an unalterable identification.

Reliability

The mark reading of the 2760A is virtually independent of card base color or variations in lamps or photosensor properties.

- some applications



Weather Recording card

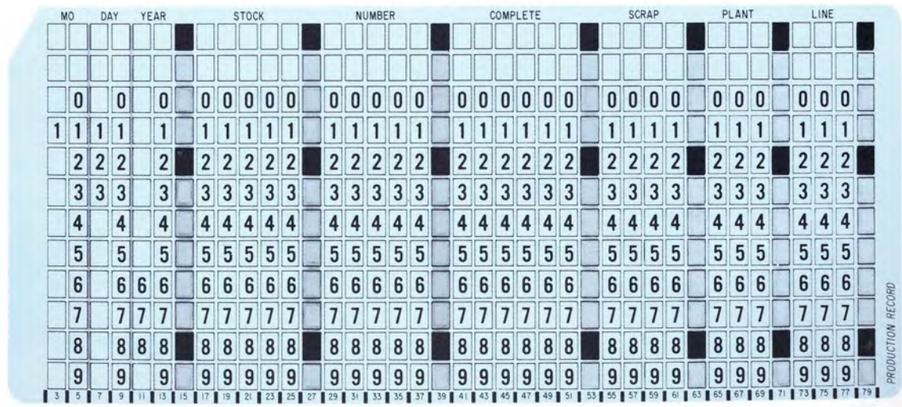
Cards of the format shown above can be read into the HP 2000A system by BASIC language programs for data analysis and collection of statistical information.

The reader is used in combination with the standard teleprinter for input/output. The instruction "INPUT" will accept information from the keyboard or from the card reader.

Cards of the type shown below could be used for daily summarizing of plant production. A BASIC language program could input the data from the cards in various locations and print out a listing and summary for each location, in addition to overall totals.

Other applications include: Sales call reporting, test scoring, attendance reporting, survey analysis etc.

Production Record card



Hewlett-Packard Computers

The HP 2116 Computer used in the 2000A system and the smaller 2115 Computer pictured at left include many features found only in larger machines. Three standard programming languages are available, backed up by an efficient assembler providing 70 basic instructions (including micro-programmable register reference instructions) and 23 assembly-directing pseudo instructions. The compilers and assembler generate relocatable code, which is loaded and linked by the control system loader; the programmer is not concerned with page boundaries. Modular software drivers for peripherals permit device-independent programming. An optional plug-in Extended Arithmetic Unit reduces multiply/divide times and provides valuable long shift and rotate instructions. High-speed (up to 625,000 words/second) Direct Memory Access is also available as a plug-in option.

Hewlett-Packard computers may be operated with a wide range of peripheral Input/Output devices, examples of which are shown below, plus measuring instruments such as Digital Voltmeters, Electronic Counters, Oscilloscopes, Scanners, Quartz Thermometers, and many more. Peripheral devices are interfaced simply through 1 or 2 plug-in cards.

HP 2020

MAGNETIC TAPE
Read/write
6000 or 16,700 char/sec
7-chan, 200 or 556 bpi

SOROBAN ERD

CARD READER

12-bit parallel column,
80-column cards
1000 cards/min

DATA PRODUCTS 4200

LINE PRINTER

300 lines/min
72 to 132 characters/line
ASCII character set

CALCOMP 565

PLOTTER
300 steps/sec
Resolution .01 inch
Plotting width 11 inches

HP 2757A
HP 2756A

DISC MEMORY
(and power supply)
32 tracks, head-per-track
174,080 16-bit words

HP 2753A

TAPE PUNCH
Punches 8-level code
120 char/sec

. . . about Hewlett-Packard

The Hewlett-Packard Company specializes in the manufacture of instruments and systems to satisfy measurement needs of all kinds in science and industry. Today, Hewlett-Packard provides 1500 different products for electronic, chemical and medical instrumentation applications.

Since its founding in Palo Alto almost thirty years ago, Hewlett-Packard has grown from a two-man operation into a world-wide organization of more than 11,000 people, with an annual sales volume exceeding $200 million. The company and its affiliates now have more than a dozen manufacturing plants, including two in Western Europe and one in Japan. Sales and service offices are located in nearly every major city in the free world.

Hewlett-Packard's Entry into the Computer Field

The original Hewlett-Packard products were electronic measuring instruments. With growth, these products increased in scope and sophistication, and spread into other fields, principally those of medical and chemical instrumentation. As the complexity of the measurement tasks undertaken in all areas increased, the need became evident for computational capability integrated into the instrumentation systems to provide more complete solutions to the overall measurement problems.

The key to involvement by Hewlett-Packard in any field of interest is contribution, and this was true of Hewlett-Packard's introduction (in 1966) of the HP 2116A, a general-purpose digital computer designed from the ground up to provide ease of interface, both in hardware and software, with a broad variety of measuring instruments as well as traditional computer peripherals.

More recently, a second computer, the HP 2115A has been introduced. The HP 2115A is a smaller, lower cost computer, yet it offers most of the hardware capabilities of the HP 2116A and the two computers are completely software compatible. Both computers have been designed to provide the user maximum efficiency and convenience in solving his problem.

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