HEWLETT-PACKARD

KEYBOARD

VOL. 6 NO. 2

21

COVER

Our artist, Hal Andersen, has given his impression of the new Model 21 Calculator —– its full number is 9821A —– in a surrounding of perspective depth. The Model 21 has considerable depth, combining the features of the Model 20 with those of the Model 65 Cassette Memory, and more. See the feature article on page 6.

CONTEST: Rationalizing Fractions

The deadline was March 20 for entries in the contest to find the fastest program for rationalizing a decimal fraction by expressing it in the form i_1/i_2, where the i's are integers, and obtaining a specified accuracy.

Several interesting entries were received. These are being judged, and results will be announced in the next *KEYBOARD*. The winner will receive as a prize his choice of any currently available HP software pac.

HP Computer Museum
www.hpmuseum.net

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OVERVIEW

In this *KEYBOARD* issue is an article introducing the new Hewlett-Packard Model 9821A Programmable Desktop Calculator. With its algebraic language and built-in cassette drive, the new Model 21 combines the best features of the Model 20 and the cassette memory. We hope you will enjoy this introduction, starting on page 6.

KEYBOARD Vol. 6 No. 1 described the 9880A/B Mass Memory System and some of its business applications. Described in the current issue are two other important applications of the 9830A in project cost accounting and the 9830A/9880 in management of file systems. The articles are found on pages 2 and 12.

The Crossroads is a new column commencing in this issue to bring you some better understanding of areas in which mathematics and calculators interact, and to bring you some challenges and occasional chuckles. This first article features Boolean algebra. Any suggestions you have for future Crossroads topics will be welcome. See page 15.

Hewlett-Packard has new software listing sheets for each programmable desktop calculator to replace the calculator program catalog. See page 18 for replicas of these listings.

KEYBOARD belongs to you, our valued customer. If you like its contents, write and let us know. Better still, if you have ideas for improving it or for adding information you would like to see in *KEYBOARD*, be sure to let us know!

A B Sperry

Project Cost Accounting

by John G. Herrgott*

The success or failure of an engineering consulting firm depends on both technical expertise and the ability to complete projects on schedule. Most firms prepare project cost reports to allow the project manager to monitor the work completed and cost of each project. The cost reports are also compared with estimates to detect cost overruns. Effective corrective action can be taken to minimize loss only if project overruns are detected at an early stage. Timely, detailed, and accurate project cost reports are the key to project management and maintaining a healthy level of profitability on each job.

Presently, most firms have not automated their project cost accounting. Only the largest firms can afford an in-house computer, and time-shared computers or service bureaus are too expensive for the average firm. One or more skilled administrative employees must be devoted to the tedious job of manual cost accounting.

MANUAL COST ACCOUNTING

Employee time and expenses must be entered into a project journal from time cards and expense records. This is a very time-consuming procedure, as each employee may work on several projects during a week. Periodically, the project records are summarized and cost reports are printed for the project managers. Again, a time-consuming, error-prone process.

Due to the time required for manual cost accounting, most project cost reports lack detail. A page is usually printed for each project. A list of hours each employee worked during the last period (week or month) along with his total hours worked on the project is shown. Project labor cost is simply the sum of each employee's hourly cost rate times his total hours. The expenses charged to the project are added to the labor cost to obtain total project cost. Although preparation of these reports is extremely time consuming, they still lack sufficient detail for an in-depth analysis of project work.

The owner or officers of an engineering consulting firm are faced with an unpleasant tradeoff between the detail and frequency of project cost reports and the workload of the administrative staff. Project managers must have detailed cost reports to analyze job progress and cost. On the other hand, the administrative workload should be kept down to minimize overhead cost. A satisfactory balance between administrative time and reporting requirements is seldom achieved by manual project cost accounting.

COST ACCOUNTING THE HP WAY

Now, Hewlett-Packard offers a highly cost effective method of automated cost accounting with the 9830A Programmable Calculator and the Consultant's Cost Accounting Pac. Employee time and expenses can be entered through the 9830A keyboard and stored in project files on a magnetic tape cassette. Project reports can be printed as frequently as needed; e.g., reports can be printed each week for active projects.

EASY TO USE

The 9830A cost accounting system can be operated by administrative people without prior computer experience. Specific operations such as entering time or printing reports are selected by simply pressing the appropriate Special Function key. Display messages are easy to understand and guide the operator through each program step by step.

Extensive data verification was designed into these programs to prevent invalid data from being stored in the project files or accidental loss of valid data. Incomplete entries, or entries with variables that are out of range, are automatically rejected. Allowable entries are printed for verification by the operator and stored.

*Commercial Market Development, Calculator Products Division, Hewlett-Packard, Loveland, Colorado

USER DEFINED REPORT HEADINGS

The Consultant's Cost Accounting Pac Vol. 1, Part No. 09830-73037, can be used in a wide variety of businesses. A key feature is the ability of each customer to easily define the project phase headings and direct charge (project expense) labels for his own business. Headings are defined during file set up and are stored on a magnetic tape cassette. The headings are recalled and printed on project reports.

DETAILED PROJECT REPORTS

Project Phase Report

Project managers can obtain a great deal more detail in their project cost reports by using the 9830A and the Consultant's Cost Accounting Pac. Project work is subdivided into 7 (maximum) separate activities, called phases. The hours each employee worked on each phase during the current period (month) and total to date are printed on this report. This "explosion" of project hours by employee and by phase gives the project manager a valuable tool. He can now see how many hours an employee charged to specific activities in a project, rather than just the total hours.

The phase report also shows the amount of money charged to each of up to 9 project expenses (direct charges). Amounts are shown for the current period and the total to date. Totals for labor cost, direct charges, and total project cost are printed.

Project Cost/Charge Report

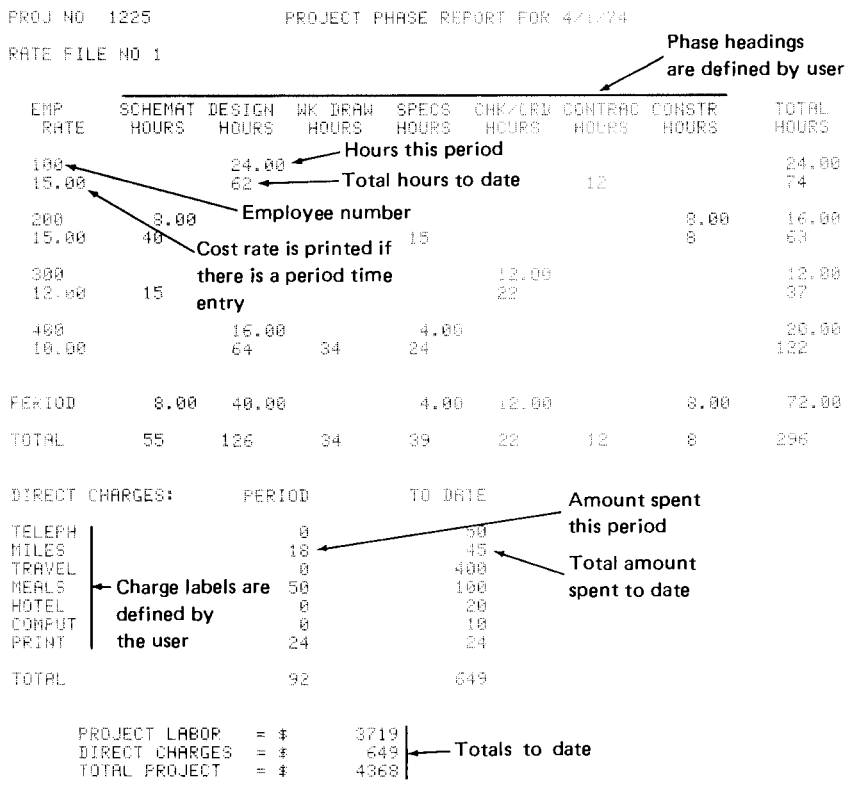
The most comprehensive of the project reports is the cost/charge report. It is designed to assist the project manager in the analysis of current work completed, project cost, anticipated customer billing based on work completed, and project profitability.

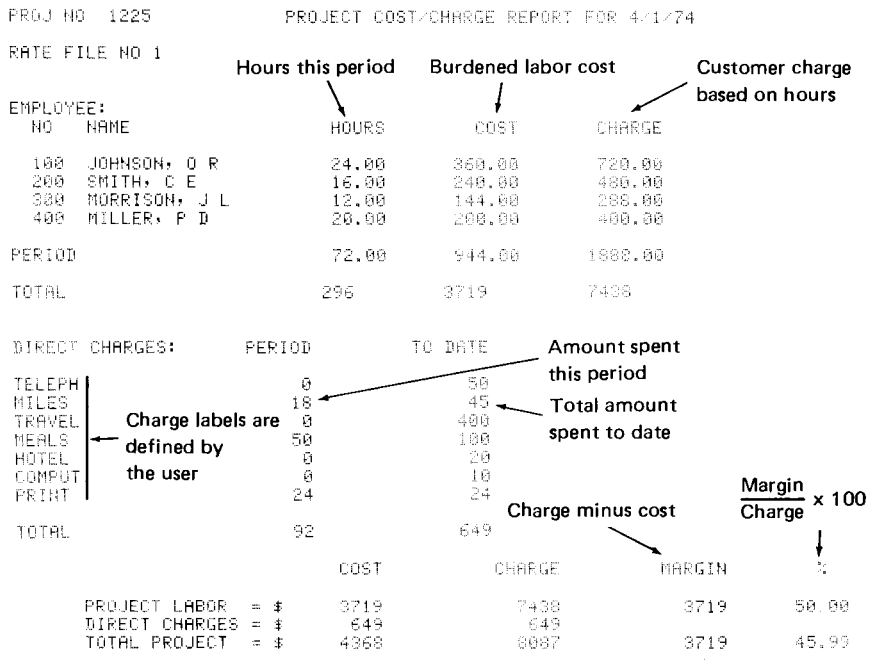
For the current period (month), the hours worked, burdened labor cost, and anticipated customer charge based on hours are printed for each employee. The period totals and totals to date are printed for hours, burdened labor cost, and anticipated customer charge.

Expenses charged to projects are also printed. The amount charged during the current period and total to date is shown, along with the totals.

The last section of the cost/charge report is used for the analysis of project profitability. The total cost, customer charge based on hours, gross margin (charge minus cost), and percent margin are printed.

The customer charge shown on the report may be compared with actual billing to determine if actual billing is current. The percent margin figure can be used to determine if the project is meeting the firm's profit objective.





Project Summary Report

The summary report is designed to provide the project manager with a summary of the completion status of a number of projects. One line is printed for each project showing the estimated completion date, hours and labor cost this period, hours and labor cost to date, budgeted hours and cost, and percent complete. The percent complete is calculated from total hours to date and budget hours. The project manager can quickly review the status of a large number of projects, then select detailed phase or cost/charge reports for projects that require further analysis.

PROJECT SUMMARY REPORT FOR 4/1/74

PROJ NO	EST DATE COMPLETE	THIS PERIOD HOURS	THIS PERIOD COST	TO DATE HOURS	TO DATE COST	% COMP	BUDGET HOURS	BUDGET COST
1225	1- 10- 75	72	944	296	3719	29.6	1000	15000
1230	7- 1- 74	25	350	113	1625	22.6	500	7500
1235	9- 12- 74	48	712	140	2100	23.3	600	8050
1240	1- 1- 75	0	0	75	1125	10.7	700	10500
1245	7- 1- 74	0	0	543	7982	90.5	600	8820
1250	9- 1- 74	24	372	180	2754	72.0	250	3825
1255	6- 1- 74	0	0	405	6278	101.3	400	6200
1260	11- 7- 74	63	945	512	7936	53.9	950	14250
1265	12- 1- 75	0	0	0	0	0.0	600	9000

Entry Summary Reports

A time summary report and a charge summary report are printed after employee time or project charges are entered. They provide the user with a recap of the time and charges entered.

SYSTEM CONFIGURATION

9830A Programmable Calculator
7616 Total Bytes Memory, Option 275
String Variables ROM, Option 274
9866A Thermal Printer or 9861A Typewriter
9865A External Tape Cassette

EASY OPERATION

The Consultant's Cost Accounting Pac is extremely easy to use. All programs required for routine operations or file set up and maintenance are provided on two magnetic tape cassettes. Project files are marked and set up on blank tape cassettes. Project tape labels are provided to attach to these cassettes. Up to 100 project files can be stored on each cassette. The programs allow use of several project file tapes.

To use the pac, the operator simply inserts one of the program cassettes into the tape drive built into the 9830A Calculator. A project file tape is inserted into the external tape drive. A program is executed by simply pressing the appropriate Special Function key, defined by the key template. During execution of each program, the operator selects alternative operations or enters data in response to display messages. All data entries are verified at several stages to preserve the integrity of the project data files.

OPERATING PROGRAMS

All programs for routing operations are contained in this tape cassette.

Print Reports

Project number(s) are first selected by pressing either the ONE OR GROUP or the UPDATED OR ALL key. Then the report to be printed is selected by pressing either the PHASE REPORT or the COST/CHARGE REPORT or the SUMMARY REPORT key. Groups of reports are printed without operator interaction – except to change project file tapes in the external cassette unit.

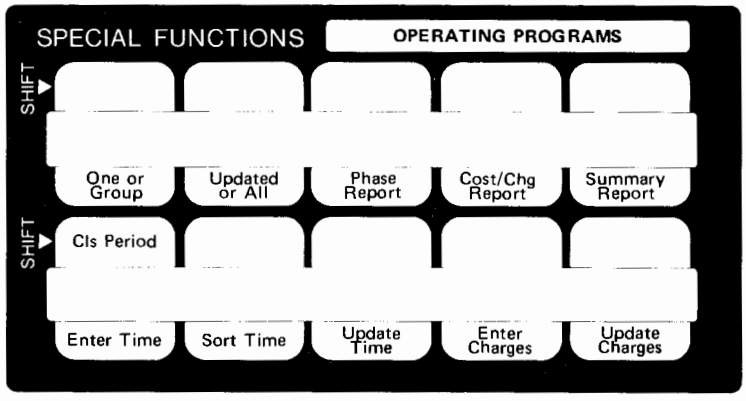
Data Entry and Project File Update

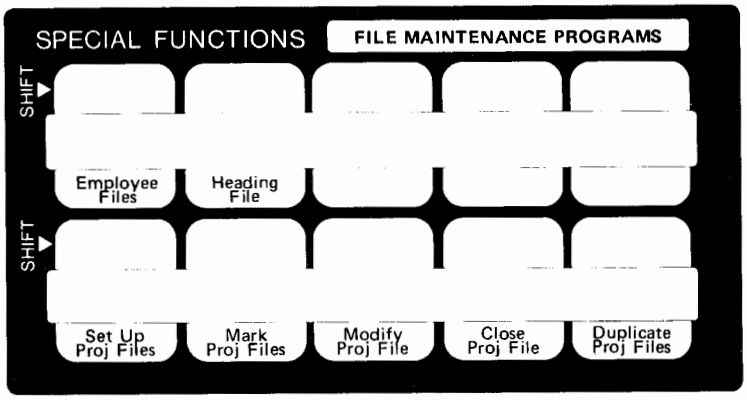
Employee time is entered using the program executed by pressing the ENTER TIME key. After time entry, the employee time entries can be edited. Then, the time summary report is printed. The entries are sorted by project number by pressing the SORT TIME key. The sorted time entries are transferred into the project file tape(s) by pressing the UPDATE TIME key. The sort time and update time programs do not require operator interaction – except to change project file tapes.

Project charges are entered by pressing the ENTER CHARGES key. After entry is complete, the charges can be edited. The entries are automatically sorted by project number and a charge summary report is printed. The sorted charges are transferred to the project file tape(s) by pressing the UPDATE CHARGES key.

New Period

All time and charge entries are added to both the period and total to date records in the project files. After all reports are printed for the current period, the period is closed, and a new period started by simply pressing the CLOSE PERIOD key (pressing the shift key and enter time key simultaneously). This program sets all period time and charge entries in the project files to zero. The total to date records are unchanged.





FILE MAINTENANCE PROGRAMS

All programs for setting up and maintaining the permanent files are contained on this tape cassette.

Set up (and Maintain) Files

The employee name file and the employee rate file(s) are set up by pressing the EMPLOYEE FILES key. These files are also modified by this key program as changes occur in the employee staff.

The 7 phase report headings and 9 direct charge labels are defined by pressing the HEADING FILE key. If necessary, they can be redefined by executing this program again.

Project file tapes are created from blank tape cassettes by simply pressing the MARK PROJECT FILES key to mark the tape. Then, project data is transferred to the project file tapes by pressing the SET UP PROJECT FILES key. As new business is obtained, new projects are added to the tape by executing this program. Data in the project files can be edited by pressing the MODIFY PROJECT FILE key.

Duplicate Project File Tapes

A duplicate set of project file tapes can be obtained for backup by pressing the DUPLICATE PROJECT FILES key. The original project tape must be inserted into the internal tape drive and a (marked) duplicate tape inserted into the external tape cassette. Project file transfer is automatic. A current copy of the project tapes should be stored in a safe place in case of loss or damage to the primary set.

Close Completed Projects

After work has been completed on a large number of projects, a new set of project tapes, with only active projects, can be obtained by pressing the CLOSE PROJECT FILE key. Each project can be closed or moved in response to a display message. Projects that are closed out can be printed for a permanent record. The new set of project tapes should be duplicated immediately.

SOLVE TECHNICAL PROBLEMS

Of course, the 9830A can also be used to solve a variety of technical problems. The HP library of technical programs is growing daily. Special application programs can easily be written in the BASIC language to solve your specific problems. A wide variety of standard peripherals is available for the 9830A.

SUMMARY

The Hewlett-Packard 9830A system is a very cost-effective approach to automated project cost accounting. It is now possible for consulting firms to easily keep track of employee time and expenses charged to a large number of projects. Three project reports are available to help project managers monitor and control project work. Some report headings can easily be defined by the user to 'customize' the reports to his business – the format is not changed. Office personnel can easily learn to operate the system without computer training. It is a very interactive, easy-to-use automated cost accounting system. ■

ERRATA

In the Contest Awards announcement inside the back cover of KEYBOARD Vol. 6, No. 1, seventh line from the bottom, Dr. F.L. Whittaker's name was misspelled. In the fourth line from the bottom, the word 'price' should read 'prize'.

Hewlett-Packard Series 9800
Model 21

ALGEBRAIC PROGRAMMABLE CALCULATOR

The Hewlett-Packard Model 9821A (Model 21) programmable calculator brings together in one package the versatility of a desktop calculator, the ease of the natural algebraic language, and the convenience of the tape cassette for program and data storage. With the Model 21 you can design a system to meet your own specific needs in the business, technical, industrial, or scientific fields. This system allows you to write, edit, and use programs to solve your problems with unprecedented time savings and ease.

The Model 21 allows you to design your own personal computing system. With a choice of internal memory sizes, several plug-in blocks to define up to three keybanks with your selection of functions, and a variety of input and output peripherals, you can specify and purchase only the capabilities you need for your present applications. If your needs increase in the future, the Model 21 system can be quickly expanded to meet them, right in your own office.

As an example of the Model 21's computing power, the basic memory is sufficient to solve 16 simultaneous linear equations in 16 unknowns. The fully expanded optional memory is capable of solving up to 70 equations in 70 unknowns.

Seven major features of the Model 21 Calculator contribute most of its computing power, ease of use, and versatility. These are its:

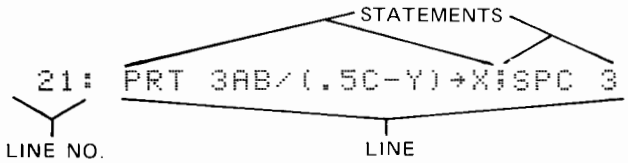
- Natural algebraic language
- Simple programming and editing
- Three special function key banks
- Full alphanumeric display and built-in printer
- Expandability through plug-in blocks, memory, and peripherals
- Built-in tape cassette
- Built-in cassette control ROM

NATURAL ALGEBRAIC LANGUAGE

The Model 21 uses a powerful but natural instruction set which combines the best features of the conventional programmable calculator keyboard language with some of the best features of computer languages like FORTRAN or BASIC. It includes branching and sub-routining, as well as adding many of its own unique features. As a result, the Model 21 uses a language with the same symbols and structure as algebra. It provides a human-oriented, conversational approach to problem solving.

Since the basic calculator's complete alphanumeric capability also appears in the built-in printer and the display, programs can include printed or displayed user instructions, as well as alpha labels for input data and results.

The structural unit of the Model 21 language is a *line* composed of one or more *statements* representing complete activities. Statements are separated by semicolons. Maximum line length can be from 35 to about 68 keystrokes. Here is an example of a line:



In this line, A, B, C, and Y are the contents of the indicated registers. The first statement prints the calculated numerical value of the expression $\frac{3 \cdot AB}{.5C-Y}$ and also places this value in the X storage register. The second statement causes the printer to space three lines after the activity specified by the first statement has been completed. Note that in this line no multiplication instruction is needed, since the Model 21 performs implied multiplication automatically.

You can either execute a line or store it. Pressing [EXECUTE] when there is a line in the display is keyboard operation. This causes all of the operations specified in the line to be performed, and the results to be displayed, printed, or stored, as instructed by the line statements.

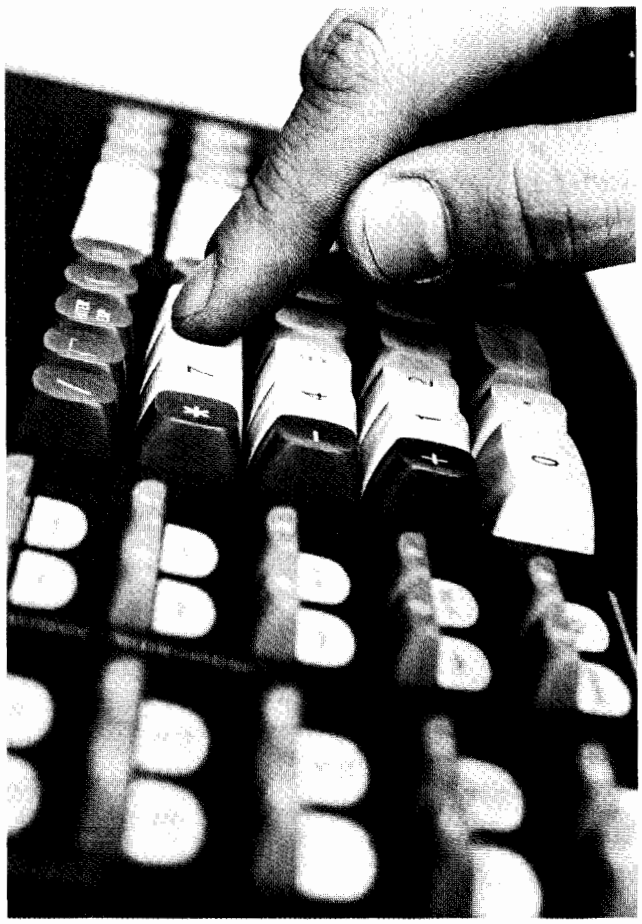
SIMPLE PROGRAMMING AND EDITING

A program is composed of a series of lines which perform activities in a logical sequence. To place a line in the read/write memory as a program line, you merely press [STORE] . The lines are automatically assigned sequential numbers (0, 1, 2, . . .n) as they are stored.

The Model 21 provides unprecedented ease of programming and program editing. Some of the unique features helping to attain this ease are discussed here.

A NOTE (N) appears in the display immediately when a language syntax error occurs, referring to a table identifying the type of error. For example, omitting a closing parenthesis causes NOTE 03 to appear. Pressing [BACK] replaces the line in the display, so that you can insert the missing parenthesis and continue entering additional characters. A pull-out card below the Model 21 keyboard provides a handy list of the various error diagnostic notes. In addition, a soft tone sounds when a note is displayed to alert you to the fact that an error has occurred. This tone is also programmable, so that you may use it to monitor the progress of long programs or alert you when a program is completed.

To help in editing or verifying a program you can obtain a listing such as the one shown below at the touch of a key. You can list either the entire program or any selected part of it. The listing serves as a permanent file



record, as well as an editing aid. At the end of the listing, the number of available R( ) registers and a verification number are also printed. This verification number serves as a check to assure you that the proper program is in the memory.

```
0:
FXD 3;ENT "ALPHA
",A,"LOAD RESIST
ANCE",B,"INPUT R
ESISTANCE",C⊢
1:
PRT (A/(1-A))(A/
(1-A))B/C⊢
2:
GTO 0⊢
3:
END ⊢
Σ840
R1410
```

PROGRAM LISTING

In the TRACE mode, the Model 21 prints each line of the program as it is being stored; or during program execution, it lists the number of each line and any quantities it stores. This helps you verify intermediate results and detect logic errors.

The TRACE mode is an excellent tool in debugging programs. You can select it either from the keyboard or by a program statement to examine part of the program's activity, then cancel it with a NORMAL statement following the suspected part of the program.

For most efficient use of the read/write memory, the Model 21 stores program lines sequentially without gaps. It also allows additions, insertions, and corrections to be made simply. Whenever an additional character, statement or line is inserted, or one is deleted, the balance of the program adjusts to occupy the minimum required memory, and lines are automatically renumbered if required.

You can add a line to a program simply by addressing the line number, entering the line through the keyboard, and pressing INSERT STORE .

Similarly, you delete a line by addressing the line number and pressing RECALL DELETE . This avoids any need for rerecording or rekeying large sections of a program to make corrections.

You can add, change, or delete program statements or characters (a character results from each keystroke) using the editing keys. Recall the line to the display. Then simply back space to the position of the character to be changed, make the change and restore the modified line.

The Model 21 includes powerful branching capability. Branching can be unconditional, with a GO TO instruction, or conditional, dependent upon numeric or FLAG status. The target branching address can be a specific line number, a relative line number, or a label independent of line numbers. Some examples of branching statements are shown below.

`GTO 10` is an unconditional statement which will cause the program to branch to line 10, a specific address.

`GTO +5` or `GTO -4` will cause branching ahead five lines or back four lines.

`IF A=0;GTO "DOT"` is a conditional statement causing branching to the label address "DOT" if the condition A = 0 is met; otherwise the program ignores the rest of that program line and proceeds with the next sequential line.

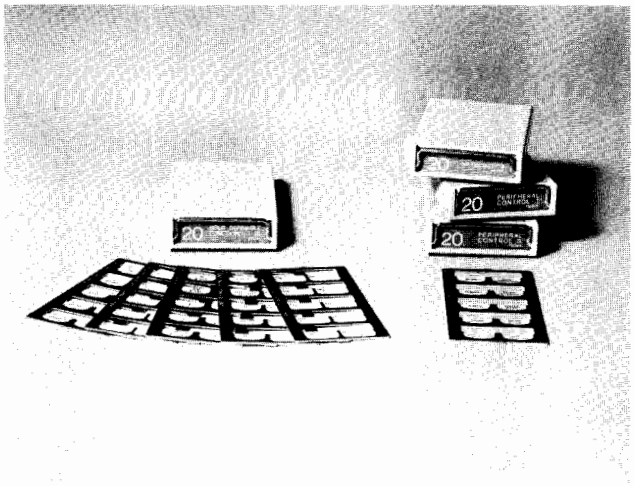
`IF FLG 0; JMP (A+2B)` will cause jumping ahead or back the computed number of lines if Flag 0 is set; otherwise the program proceeds with the next line.

A logical statement such as A = 0 will be assigned a value of 0 if the statement is false, or 1 if the statement is true. In addition to being a powerful branching tool, this Boolean capability has many other uses. (For a fuller discussion, see the related Crossroads article in this issue.).

Subroutines can be nested up to 30 deep, adding greatly to the calculator's power.

The Model 21 has 16 flags. Any flag can be set or cleared either from the keyboard or by a program statement.

Data storage, other than in the dedicated Alpha registers, is in the available R ( ) registers (R0, R1, . . .). The R-register address can be computed, such as R(A + B/2 - 4), or it can be nested, such as R(R(R(R24))) , for indirect addressing. Nesting can be to any depth within the allowable program line length.



THREE SPECIAL FUNCTION KEY BANKS

Up to three 10-key keybanks of the Model 21 can be assigned special functions by plugging a powerful read-only-memory (ROM) block into one of the numbered slots in the top of the calculator. An overlay marked with the special functions assigned to each key snaps into place over the proper key bank.

Four plug-in blocks are now available.

The Model 11220A *Peripheral Control I* block provides general-purpose control of most Model 21 peripherals. It is especially powerful in controlling the Model 9862A Plotter and the Model 9861A Typewriter. With the plotter, the Model 11220A allows scaling of your problem in *user units*, plotting axes with tic marks, and labeling with words and numbers. With the typewriter, you can choose either a four-column format with the simplest command set, or a fully-formatted output allowing typing of standard forms, tables, and letters.

The Peripheral Control I block also includes READ, WRITE, and TRANSFER statements to facilitate data input, output, and transfer among peripherals in a Model 21-based system.

The Model 11221A *Mathematics* block provides mathematical functions such as sine, cosine, tangent, log x, ln x and inverses of these functions. It also allows you to raise a number or expression to a non-integer power, and to set your arguments to degrees, radians, or grads. In addition, it gives the value of pi in one keystroke. Also provided are the integer part and absolute value of a given number.

The Model 11222A *User Definable Functions* block allows you to define up to 25 of the keys in the left-hand keyblocks with special functions and subprograms. With one other block in place, 15 keys are available. Five keys can be defined if all the plug-in slots are filled.

All subprograms are stored in a protected part of the memory, so they cannot be changed accidentally while mainline programs are being edited or stored.

Three types of subprograms can be used with the Model 11222A:

Immediate Execute routines or functions are available at a touch of the definable key. These routines may be any programs solving your repetitive problems, such as impedance, loan interest, economic order quantity, and many others. They have the advantage of not requiring any skill on the user's part; they are instantly accessible, independent programs.

Subroutines with parameters are those normally called by the mainline program several times in the solution of a problem, but with different input quantities involved each time. The subroutine is written in terms of unknown parameters P1, P2, P3 . . . These parameters are assigned specific values by the main program, including the values of algebraic expressions, whenever the subroutine is called. You can assign a name or mnemonic to your subroutine, such as N! to identify it in mainline program listings or displays.

Defined functions may also use parameters, as in the N! function below. A defined function is used in the same way as a key in the basic calculator, such as [√‾] . Note in the N! example that the defined function mnemonic appears in the program just as it would be used in a mathematical expression on paper.

```
0:
"N!";P1→P2;1→P3⊢
1:
IF P2=0;P3→F ;
GTO 3⊢
2:
P2P3→P3;P2-1→P2;
GTO 1⊢
3:
END ⊢
```

N! AS A DEFINED FUNCTION

```
0:
ENT "N",A,"K",B⊢
1:
N!A/N!BN!(A-B)→C
⊢
2:
FXD 0;SPC 2;PRT
"N=",A,"K=",B,"C
=",C⊢
3:
END ⊢
```

COMBINATION PROGRAM

The combinations program calls N! three times in each solution with different parameter values, saving considerable memory space.

Although any of the plug-in blocks can be placed in any slot in the Model 21, programs written by Hewlett-Packard use this configuration:

Definable Function Block	Slot No. 1 (left)
Mathematics Block	Slot No. 2 (center)
Peripheral Control Block	Slot No. 3 (right)

Users are encouraged to employ this same configuration for consistency. The slot for any unused plug-in unit is left empty.

The Model 11224A *Peripheral Control II* block provides general-purpose control of most Model 21 peripherals, with special emphasis on input/output control. Special commands make it possible to directly read and write 8-bit bytes to communicate with ASCII and other byte-oriented peripheral devices.

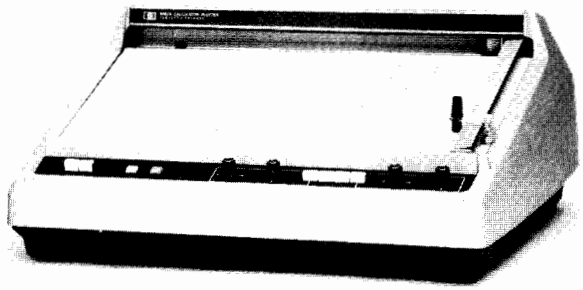
ALPHANUMERIC DISPLAY

Because of the Model 21's alphanumeric output algebraic language, only a single display is required. This uses light-emitting diodes in a 16-character display, which is easy to read over a wide range of angles and distances. Each of the 9/32 inch (0,71 cm) high characters uses a 7 x 5 dot matrix of light-emitting diodes to provide naturally-shaped numbers, letters, and symbols .

ALPHANUMERIC PRINTER

A quiet, thermal printer built into the basic Model 21 Calculator provides permanent records of programs and data. It can print the same numbers, symbols, and letters that are displayed, as well as user instructions, alpha labels for program results, and other alphanumeric messages.

The maximum printer and display line length is 16 spaces. However, this does not limit the program line length, which can be from about 35 to 68 keystrokes, depending on its composition.

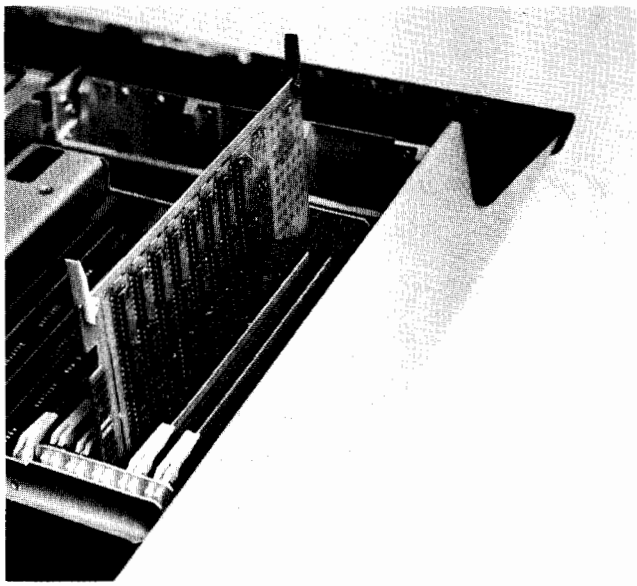


PERIPHERAL AND MEMORY EXPANDABILITY

The Model 21 is expandable through plug-in ROM's, added internal memory, and external peripherals, providing capabilities to match any type of application. The basic calculator has 167 R( ) registers which can be used for program or data storage. Other factory options include 423, 935, or 1447 R( ) registers; or memory may be added in increments of 512 registers by HP service personnel in your own office.

The Model 21 accepts up to four peripherals at one time, allowing you to assemble a personalized system for your particular applications. An input/output expander allows the use of up to 13 peripherals simultaneously. The peripherals available for use with the Model 21 are:

Model 9861A Typewriter Output
Model 9862A Plotter
Model 9863A Paper Tape Reader
Model 9864A Digitizer
Model 9865A Tape Cassette
Model 9866A Thermal Pagewidth Printer
Model 9868A Input/Output Expander
Model 9869A Hopper Card Reader
Model 9870A Marked Card Reader
Model 2570A Coupler/Controller
Model 2575A Coupler/Controller



BUILT-IN TAPE CASSETTE UNIT

Program and data storage is made particularly convenient by the use of a built-in tape cassette unit. Each 300-foot (91.4 m) cassette has a capacity equivalent to approximately 8000 registers. A built-in cassette control ROM makes this tape cassette as easy to use as it is powerful. Programs and data may be stored on the same cassette. You decide the size of each file on the tape for maximum packing, or leave room for future expansion. Programs and data may be loaded manually, or under program control for running longer programs or handling larger amounts of data than will fit at one time in the memory of the Model 21.

Other features of the built-in cassette control ROM include the ability to locate any file on the tape and identify its contents. Another key allows you to use this same built-in ROM to address up to nine peripheral cassettes as well as the built-in unit. And a special-program feature allows you to load and run special machine-language software provided by Hewlett-Packard for expanding the capability of your Model 21. Also, cassettes may be protected against accidental rerecording and/or secured against unauthorized use and duplication. The built-in cassette ROM provides all of this control without taking up any of the three ROM slots or their associated keys.

OTHER FEATURES

You can specify the format of numbers to be displayed and printed as either fixed point or floating point, with any number of digits up to 9 to the right of the decimal point. The commands are given either in a program or from the keyboard. The last displayed digit is automatically rounded. For example, 705.51554 may appear in one of these sample formats:

FIXED (3)	705.516
FLOAT (9)	7.055155400E 02
FLOAT (3)	7.055E 02

The Model 21 handles any number in the range $-9.99999999999 \times 10^{99}$ to -10^{-99}, 0, and $+10^{-99}$ to $+9.99999999999 \times 10^{99}$ with 12 significant digits. The ten most significant digits are displayed; the other two are guard digits, which prevent rounding errors.

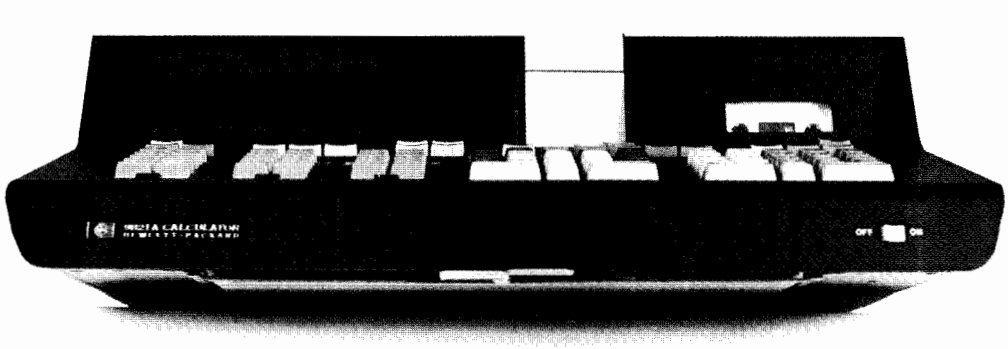
In addition to the R ( ) registers, the Model 21 has six built-in, dedicated data registers. These six registers, A,B,C,X,Y, and Z, have their own keys. The Z-register performs the special function of automatically storing the numerical result of executing a line if no other storage register is designated.

The Model 21 keyboard is human engineered. It has fingertip-fitting keys, which are functionally grouped, as well as color coded. Often-used keys such as [RUN PROGRAM], [0] and [EXECUTE] are oversize for convenience. Half-size keys in the three left-hand key banks allow room for overlays to label their special functions assigned by the plug-in blocks.

MATHEMATICS PROGRAM LIBRARY

A library of powerful mathematics programs (Model 21 Math Pac, HP Part No. 09821-70401) is supplied with each 9821A Calculator. It contains 26 programs, prerecorded on a tape cassette, which will solve about 60 types of mathematics problems. In addition, the complete library of programs developed for the Model 20 Calculator will operate with the Model 21. Many of these programs are available now in cassette format for Model 21 users.

If the combined versatility of a desktop calculator, the ease of the natural algebraic language, and the convenience of the tape cassette are best for your application, contact the Hewlett-Packard sales office in your area or fill out and mail the reply card in this issue for a demonstration of the Model 9821A Calculator. ●



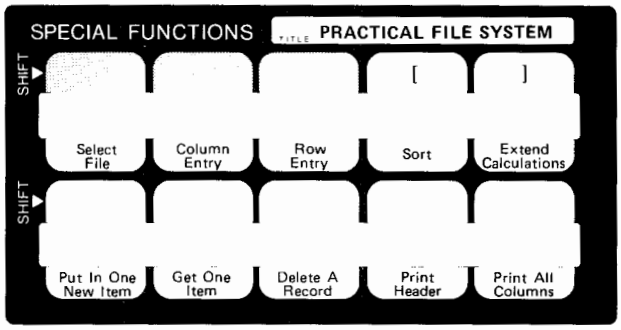
Practical Files System Programs

by Donna Kimble*

The Practical Files System programs, contained in the Data Base Routines Pac supplied with the HP 9880A/B Mass Memory subsystem, are a comprehensive group of interactive programs designed to allow the user to store and retrieve data from the mass memory without knowledge of the BASIC language statements and commands.

Also, with a minimum amount of programming skill, highly specialized calculations and reports can be made with the use of subroutines available in the system.

The Practical Files System interprets typical data base problems, automatically performing all housekeeping functions required, so that, after answering no more than seven different questions, the file exists on the mass memory platter. After the file is created, data entry from the keyboard is simplified by data entry prompts which fit the particular application, such as PRICE?, TOTAL WEIGHT?, etc. .which are the specific row and column names just entered.



One possible use of the Practical Files System is in a laboratory situation; for example, a dietitian must keep percentage breakdowns of protein, fat and carbohydrates for various common foods. The data on a report such as the one shown in Figure 1 can easily be stored on the mass memory.

*Calculator Products Division, Hewlett-Packard Company, Loveland, Colorado

NUTRITIVE ANALYSIS — Dietitian Williams — Date 6/30/73

Sample	Calories	Total Weight (gms)	Weight Protein (gms)	% Protein	Weight CHO (gms)	% CHO	Weight Fat (gms)	% Fat	Remarks
whole milk	174	244	9	21	12	28	10	52	1 cup
skim milk	88	246	9	41	13	59	0	0	1 cup
buttermilk	88	246	9	41	13	59	0	0	1 cup
cottage cheese	243	225	30	49	6	10	11	41	1 cup, creamed
cocoa	239	242	9	15	26	44	11	41	1 cup, made with whole milk
yoghurt	120	246	8	27	13	43	4	30	1 cup, made with nonfat milk
eggs	78	50	6	31	0	0	6	69	1 large egg, raw or cooked, without shell
ground beef	182	85	23	51	0	0	10	49	3 oz., lean, broiled
chicken	173	85	23	53	0	0	9	47	3 oz., broiled, without bone
tuna	46	85	7	61	0	0	2	39	canned, 3 oz., drained, oil pack
asparagus	40	175	4	40	6	60	0	0	1 cup, cooked
carrots	24	50	1	17	5	83	0	0	1 raw whole carrot, 5½ by 1 inch
lettuce	8	50	1	50	1	50	0	0	2 large or 4 small leaves
tomato	32	150	2	25	6	75	0	0	1 raw tomato, about 3/16.
apple	72	150	0	0	18	100	0	0	1 raw medium apple, about 3/16.
orange juice	108	248	1	4	26	96	0	0	1 cup, reconstituted frozen concentrate
pineapple	80	140	1	5	19	95	0	0	1 cup, raw, diced
coconut	343	97	3	3	13	15	31	82	1 cup, fresh, shredded
peanut butter	100	16	4	16	3	12	8	72	1 Tablespoon
butter	99	14	0	0	0	0	11	100	1 Tablespoon
mayonnaise	108	15	0	0	0	0	12	100	1 Tablespoon
jelly	52	20	0	0	13	100	0	0	1 Tablespoon, grape jelly
sugar	48	12	0	0	12	100	0	0	1 Tablespoon, cane or beet
beer	48	240	1	9	11	91	0	0	8 oz., 3.2% alcohol
chocolate	148	28	1	2	18	49	8	49	1 oz., semisweet chocolate

Figure 1 Analysis of Foods

The file created on the mass memory to hold the data is summarized in the header information stored for that file. This information is stored in the file automatically at the time the file is created. See Fig. 2.

```
HEADER RECORDS = 1
NO. OF ROWS IN FILE 50
RECORDS PER ROW 1

COLUMN 0    ROW NAME                        15   CHARACTERS
COLUMN 1    CALORIES                         NUMERIC
COLUMN 2    TOTAL WT. (GMS)                  NUMERIC
COLUMN 3    WT. PROTEIN (GMS)                NUMERIC
COLUMN 4    % PROTEIN / CALORIES             NUMERIC
COLUMN 5    WT. CARBOHYDRATE (GMS)           NUMERIC
COLUMN 6    % CARBOHYDRATE / CALORIES        NUMERIC
COLUMN 7    WT. FAT (GMS)                    NUMERIC
COLUMN 8    % FAT / CALORIES                 NUMERIC
COLUMN 1    REMARKS                         80   CHARACTERS
```

Figure 2 Header Information

Once the data file is created, data entry may be made row by row, column by column, or each individual item may be entered separately. Below is an example of the questions asked when ROW ENTRY is selected.

```
ENTER ROW NAME OR DONE?     1. COTTAGE CHEESE
CALORIES?                   0  (will be calculated)
TOTAL WT.?                  225
WT. PROTEIN (GMS)?          30
% PROTEIN                   0    (will be calculated)
WT. CARBOHYDRATE (GMS)?     6
% CARBOHYDRATE?             0    (will be calculated)
WT. FAT (GMS)?              11
% FAT?                      0    (will be calculated)
REMARKS                     1 CUP, CREAMED
```

Notice that some data can be obtained by performing calculations on the given data. For example, calories can be calculated as follows:

Calories = Gms Protein * 4 cals/gm protein + Gms CHO * 4 cals/gm CHO + Gms Fat * 9 cals/gm fat

The calculations required in the above example can be obtained by using the Special Function program, EXTEND CALCULATIONS, to perform the individual steps required, column by column, or the calculations can be performed in a special program written for that purpose (a specialized program can often be completed more quickly). Here is an example of the questions asked when EXTEND CALCULATIONS is selected.

```
NUMERIC DATA IN COLUMN?                  3
OPERATION: + – * OR/?                    *
NUMERIC DATA IN COLUMN?                  0  (0 indicates use
ENTER CONSTANT?                          4   of a constant)
RESULTS IN COLUMN NUMBER?                4
WT. PROTEIN (GMS) * CONSTANT = % PROTEIN
READY TO CALCULATE Y OR N?               Y
```

One feature of the EXTEND CALCULATIONS program is that it allows the use of either a column of data or a constant in the calculations. Also, results of calculations may be stored in any column in the file, including the ones from which the calculations are made.

Here is an example of a special program written especially to calculate the calories for the 50 food samples in the file.

```
10 FOR R = 1 TO 50      For each food,
20 C-3                  Get column 3, gms. protein
30 D=FNR(0)             from file in W.
40 A=W*4                Multiply by 4 calories/gm. protein
50 C=5                  Get column 5, gms carbohydrate,
60 D=FNR(0)             from file in W.
70 A=A+W*4              Add 4 calories/gm. CHO
80 C=7                  Get column 7, gms. Fat,
90 D=FNR(0)             from file in W.
100 A=A+W*9             9 cals./gm. Fat; add to calories
110 C=1                 Put into file, column 1,
120 D=FNP(0)            total calories, from A.
130 NEXT R              Get next food
140 END                 END
```

The above program uses the function subroutines provided with the Practical Files System: FNRead, to put the data from row R and column C in the variable W, and FNPut, to store the variable from A to the file row R and column C. These same function subroutines can be used to create any kind of formatted report necessary, or to perform searches of the data for specific values. In the example below, a report is made of all foods having more than 30% protein and less than 30% carbohydrate.

```
10 FOR R = 1 TO 50      For each food,
20 C=4                  Get W, the % Protein from
30 D=FNR(0)             file column 4.
40 IF W<30 THEN 130     If protein is less than 30%, get next food
50 C=6                  Get W, the % CHO from
60 D=FNR(0)             file column 6.
70 IF W>30 THEN 130     If CHO is greater than 30%, get next food
80 C=0                  Get W$, the food name, column 0,
90 D=FNR(0)             and print it;
100 PRINT W$;           Get W$, the remarks from
110 C=9                 column 9, and print.
120 D=FNR(0)            Get next food.
130 PRINT W$            END
140 NEXT R
150 END
```

Even the most complicated calculations and reports can easily be made with knowledge of just a few conventions associated with the functions, FNR and FNP.

Many kinds of problems can be solved with the Practical Files System, since it has been designed to be as general in scope as possible. Also, the programs are designed to be as easy to understand as possible, so that the user may also use them to assist him in learning programming techniques that will help him to take advantage of the powerful 9830 Calculator-Mass Memory system.

Letters To The Editor

Gentlemen:

When our 9810A developed a minor problem we handled it as shown on the enclosed. (Fig. 1)

At schoolyear's end last May we sent it (along with our special instruction to users) to Toronto for repair.

When we got it back, the cartoon addressed to myself (Fig. 2) accompanied it.

Just thought you'd like to know there's lots of good natured humor left kicking around in the business world. Makes life pleasant!

A.D. Brophy,
Math & Physics Department
Cambrian College
of Applied Arts and Technology
Sudbury, Ontario

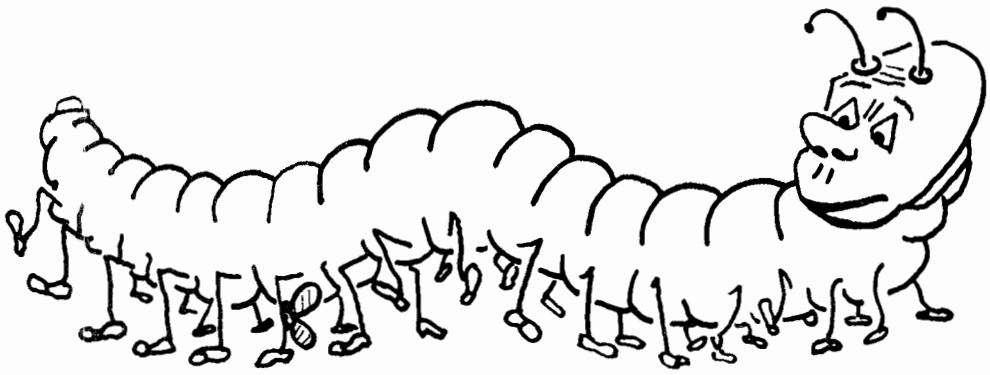


Fig. 1 Step 0185 has a bug!

Fig. 2 Step 0185 all fixed up.

THE Crossroads

Boolean Algebra

by John Nairn, Ph.D.

"The idea that aptitude for mathematics is rarer than aptitude for other subjects is merely an illusion which is caused by belated or neglected beginners." —
J.F. HERBART

The mathematical abilities of calculator users cover the entire spectrum from novice to expert. To those who manipulate the keys of these machines, mathematics may be a profession, a tool, a curiosity, or simply a necessary evil. But unless your use for a calculator is limited entirely to running "canned software", you are inevitably involved, to a greater or lesser degree, in the art of programming. And programming is inevitably involved, to a greater or lesser degree, in the science of mathematics. And that brings us to the crossroads — the place where mathematics and calculators meet, interact, and provide mutual benefit.

In the coming issues of *KEYBOARD*, The Crossroads will be a regular feature that will attempt to explore this intersection. Each article will touch on a particular point of mathematics which has application in programming and solving problems on calculators. Also topics on mathematical recreations, puzzles, and games will be included when they offer insights into the use of calculators. It is our intention to present these articles in a way that will be interesting, informative, and (from time to time) entertaining. Since the professional mathematician has at his disposal books which treat these subjects rigorously, our approach will be one of an overview. Many users who do not have time to study these topics in detail will find these articles useful in obtaining a quick introduction to tools and techniques which may be unfamiliar but useful to programming and calculating.

The format of The Crossroads will be to present a new mathematical topic in each issue, explore its application to calculators, and at times pose related problems to which we invite readers to submit solutions. Later issues will also include reader's comments on earlier articles and publication of the best solutions to the posed problems. Since the success of this column will depend on reader interest we invite your comments, problems and solutions to problems, and suggestions on topics for further articles.

The first topic to be covered in this issue is Boolean algebra. The HP Models 20, 21, and 30 all have Boolean capability which can be a powerful tool in writing more efficient programs as we shall see later.

BOOLEAN ALGEBRA

George Boole was a 19th century English mathematician who devoted much of his time to the study of logic. He believed that most of the mistakes and confusion could be removed from Aristotelian logic if it could somehow be subjected to the same rules that make mathematics a rigorous discipline.

For example, everyone is familiar with the classical example of Aristotelian syllogism: all men are mortal; John is a man; therefore, John is mortal. This presents no difficulty, since the premises are simple and the conclusion is immediately obvious. Not so simple is the syllogism: John is a grog; the only way not to be immortal is to have been a grog and not now be a grog; therefore . . ? It takes considerable mental gymnastics to determine what (if any) conclusion can be drawn from these premises. Or what about the paradox: (the statement within these parentheses is false!)? If it is true it is false, and if it is false it is true. In the first case we get lost in even trying to decide what the second premise is saying. In the second case, it seems clear what is said, but no path to the resolution of the paradox seems to exist.

In order to analyze such difficult logic, Boole developed a symbolic logic in which sentences were replaced by single letters (p, q, etc.) and connectives (AND, OR, NOT) replaced by algebraic symbols. He then developed a set of rules by which these symbols and connectives could be manipulated in an algebra-like fashion to reduce complex statements to simpler ones, much the same way that the algebraic expression $4(x+y) - 3x = 9x + 4$ can be reduced to $y = 2x + 1$.

In the last century, Boole's original work has been developed into many esoteric branches of mathematics such as the propositional calculus which finds application in the theory of probability. But it also has application in more easily understood fields such as switching theory, computer design, and even programming. It is in these areas that it is commonly known as Boolean algebra, and it is here that we will confine our discussion.

In the world of Boolean algebra, there are only two numbers, zero and everything else (represented by 1). Logically, these are associated with true (= 1) and false (= 0). For example, the statement $2 < 1$ is false and has a value or result of 0. Symbols may be linked by operations

such as AND, OR, and NOT symbolized by p*q, P+q, and p respectively. The entire statement, p*q, is true only if both p and q are true; whereas p+q is true if either p or q (or both) is true. Notice that if * and + are associated with the normal arithmetic multiplication and addition respectively, the usual rules of arithmetic hold with one seeming exception. If p and q are both true (i.e., p=1, q=1) then p+q = 2 (by normal arithmetic) and p+q = 1 (by Boolean algebra). However, since all non-zero numbers are represented by one in Boolean algebra, there is no contradiction.

Consider the case of a committee of two men (a and b) who each cast a vote (1=yes, 0=no) on a resolution. If it takes a unanimous vote to pass a resolution, then the vote of the committee can be represented by a*b. If only one out of two votes is required, then a+b would represent the committee's vote. Or consider the United Nations where a no vote by any of the five major powers is enough to veto a resolution. The collective vote could be represented by a*b*c*d*e. If any of the five votes was no (=0), the overall vote would be no. Can the reader discover the representation of the vote of a three-man committee where at least a two-out-of-three majority is required? The solution will be given next time.

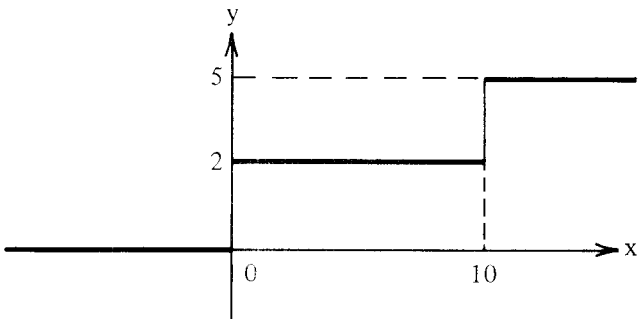


Figure 1

How does all of this relate to programming calculators? Some specific examples will serve to illustrate the use of Boolean algebra. Figure 1 shows a step function — one that is constant over a given range and then jumps to a different constant over another range. These functions are encountered in such examples as tax brackets, quantity discounts, etc. It is amazing how many times step functions crop up in everyday programming. Figure 2 shows portions of a 9820 (or 9821) and a 9830 program which calculate Y for a given value of X using the step function in Figure 1. Notice that each requires 5 separate statements (3 assignments and 2 tests). The same results could be achieved using Boolean algebra by the single assignment: Y = 2*(X>0) + 3*(X>10). If X≤0, both Boolean statements are false (=0) and we have Y = 2*0 + 3*0 = 0. If 0<X≤10, then X>0 is true (=1) giving Y = 2*1 + 3*0 = 2. If X>10, both statements are true and Y = 2*1 + 3*1 = 5. The same logic could be applied to any number of steps.†

†Our thanks go to Robert Campanini, BHP Central Research Laboratories, Shortland, N.S.W., Australia for submitting a 9830A programming idea using Boolean statements for either evaluating a step function or multiple branching.

Model 20:

```
0→Y; IF X>0;2→Y;IF X>10;5→Y
```

Model 30:

```
100 Y = 0
110 IF X<=0 then 150
120 Y = 2
130 IF X<=10 then 150
140 Y = 5
150
```

Figure 2

In geometry, we often need to convert between polar (R,A) and rectangular (X,Y) coordinates. The conversions are given by:

$$X = R*COS(A) \qquad R = SQR(X^2 + Y^2)$$
$$Y = R*SIN(A) \qquad A = ATN(Y/X).$$

All of these are straightforward except calculating the polar angle, A. Since the arctangent function operates on the ratio Y/X, the result is always in the range -90° to +90°, which is in quadrant I or IV. If the point is in quadrant II or III, (X<0), we need to make a correction to the value calculated by the arctangent function. Figure 3 shows the required corrections for the various cases.

Quadrant	X	Y	Correction
I,IV	≥0	–	none
II	<0	≥0	+180°
III	<0	<0	−180°

Figure 3

To do this without Boolean algebra would require many tests and branches. With Boolean algebra we simply set

$$A = ATN(Y/X) + 180 * (X<0) * (2 * (Y\geq 0)-1).$$

The reader should convince himself that this indeed gives the correct result in all three cases.

In commercial applications, it is often necessary to calculate the number of days between two dates. To do this we can calculate the 'day number' of each of the two dates in the year (i.e. .January 1 = 1, June 16 = 167, December 31 = 365) and subtract the two day numbers. This day number can be calculated by adding the number of days from all the prior months and then adding the number of days in the given month. For example, from Figure 4 we see that the number of days prior to June is 151. Thus, the day number of June 16 is 151 + 16 = 167. If we needed to program a days-between-dates calculation, we could store the table in Figure 4 in the calculator. However, it would be more convenient to calculate the number of days, (D(M), prior to a given month, M, whenever it was needed. Using regression analysis, we find that the function

$$D(M) = 31 * (M-1) - INT(2.2 - 0.4*M)$$

returns the proper value except for January and February for which it gives D(1) = -2 and D(2) = 28. Shall we give

up on our function and go back to storing the table? Not at all; let's fix the function. Notice that when M = 1 and 2, D(M) gives the correct values (0 and 31) if only the first term is kept. Therefore, we let

D(M) = 31*(M-1) - INT(2.2 - 0.4*M)*(M>2).

The function is now good for all months since when M is 1 or 2, (M>2) is false (=0) and the entire second term is zero. You might try to discover how to correct this function (using Boolean algebra) to make it apply to leap years as well. A future article will be devoted entirely to calendar calculations.

JAN	0	JUL	181
FEB	31	AUG	212
MAR	59	SEP	243
APR	90	OCT	273
MAY	120	NOV	304
JUN	151	DEC	334

Figure 4

Many computer languages provide a function MIN(X,Y) which takes two numbers, X and Y, and returns the smaller (minimum) of the two. Can the reader discover how to construct such a routine (and also the related MAX(X,Y) function) before it is given next time? Using Boolean algebra, it only requires a single statement.

We have seen several examples where Boolean algebra can be used to simplify programs. In general, whenever several tests and branches to accomplish one task are found in a program, it is likely that some Boolean capability can be used to simplify this segment of the program. ■

MODEL 21 HARDWARE

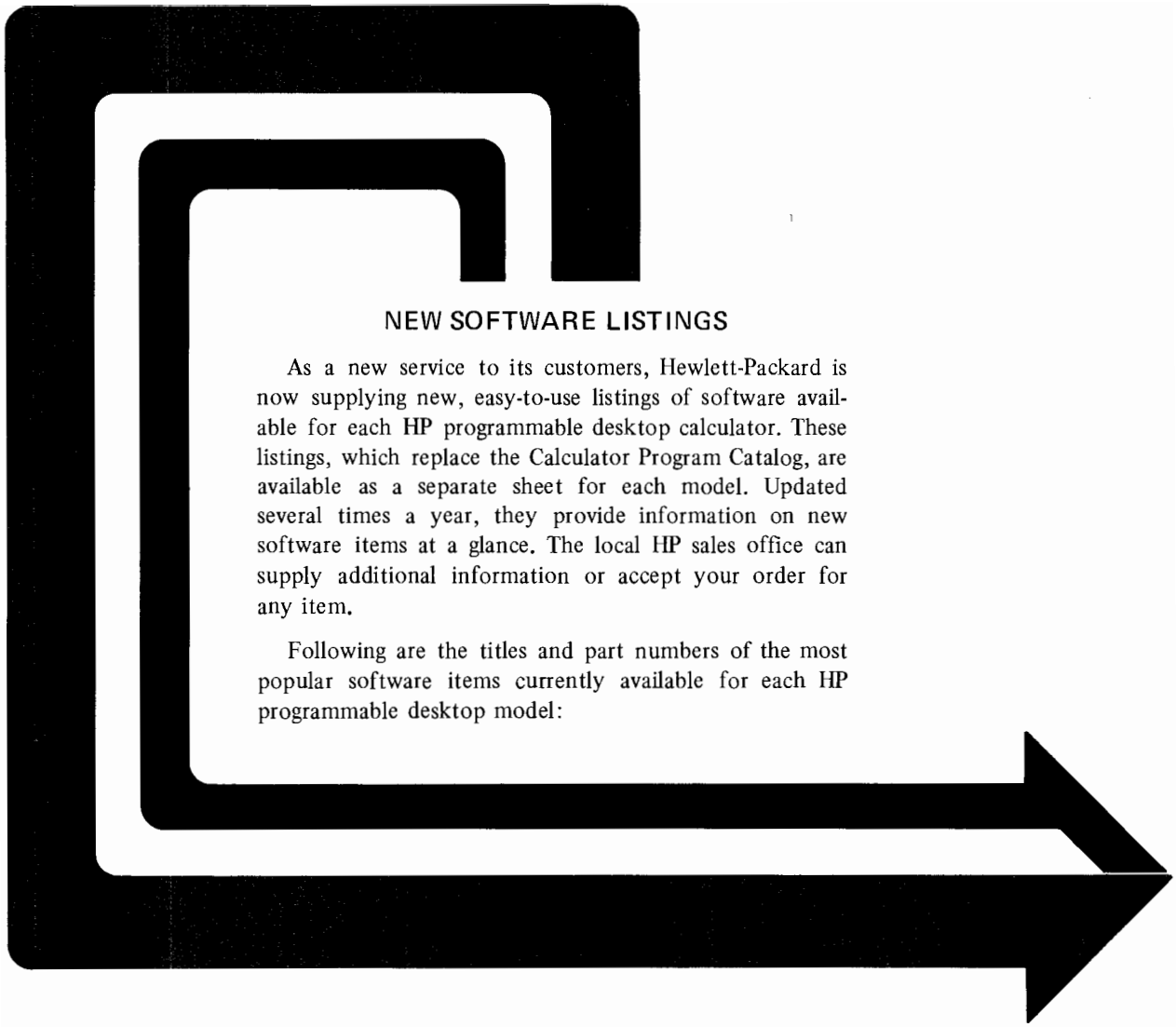
The following hardware options and accessories are available. Additional information can be obtained through your local Hewlett-Packard sales office, or by mailing the inquiry card in this KEYBOARD.

DESCRIPTION	PRODUCT NUMBER
BASIC MODEL 21 CALCULATOR, including 167 registers . . .	9821A
FACTORY INSTALLED OPTION	
423 Total Data Registers	Opt. 001
935 Total Data Registers	Opt. 002
1447 Total Data Registers	Opt. 003
FIELD INSTALLATION KITS	
512 Additional Data Registers	11225A
PLUG-IN FUNCTION BLOCKS	
Peripheral Control I	11220A
Mathematics	11221A
User Definable	11222A
Peripheral Control II	11224A
PERIPHERALS (order Option 20)	
Mark-Sense Card Reader (no ROM required)	9860A
Typewriter (requires 11220A or 11224A)	9861A
Plotter (requires 11220A)	9862A
Paper Tape Reader (requires 11220A or 11224A)	9863A
Digitizer (requires 11220A or 11224A)	9864A
Tape Cassette	9865A
Thermal Page Printer (requires 11220A or 11224A)	9866A
I/O Expander	9868A
Calculator Card Reader (requires 11220A or 11224A)	9870A

NEW SOFTWARE LISTINGS

As a new service to its customers, Hewlett-Packard is now supplying new, easy-to-use listings of software available for each HP programmable desktop calculator. These listings, which replace the Calculator Program Catalog, are available as a separate sheet for each model. Updated several times a year, they provide information on new software items at a glance. The local HP sales office can supply additional information or accept your order for any item.

Following are the titles and part numbers of the most popular software items currently available for each HP programmable desktop model:



HEWLETT hp PACKARD

SOFTWARE INFORMATION

MODEL 9100

EFFECTIVE APRIL, 1974

DESCRIPTION	PART NUMBER	
ENGINEERING		
HYDRAULIC ENGINEERING PAC (a/b, c)		
Manual	09100-75100	
MICROWAVE CIRCUIT DESIGN PAC (a, b, c, d, f)		
Manual	09100-71200	
Recorded Magnetic Cards	09119-71200	
STRUCTURES PAC (a/b, c, d)		
Manual	09100-74200	
Recorded Magnetic Cards	09119-74200	
Wye to Delta or Delta to Wye Conversion (a/b)	09100-71010	
MATHEMATICS		
Dashed & Dotted Curve Plot With Equal Arc Length Segments For Arbitrary Spaced Data (a/b, d)	09100-70091	
Fast Fourier Transform Routines (b, d, f, g)	09100-70419	
Interpolation Using a Sixth Power Polynomial (a/b)	09100-70090	
Multiple 2-Point Gaussian Integration (b)	09100-70092	
Roots of a Quartic Equation (b)	09100-70031	
Simultaneous Solution $\leqslant$ 25 Linear Equations, $\leqslant$ 25 Unknowns (a/b, f)	09100-70039	
MISCELLANEOUS		
Lunar Module Landing Simulator (b, d)	09100-76504	
STATISTICS		
ANALYSIS OF VARIANCE PAC (a/b, c)		
Manual	09100-70900	
Recorded Magnetic Cards	09119-70900	
EXTENDED MEMORY STAT PAC (a/b, c, d, f)		
Manual	09100-70875	
Hyperbolic Regression (b, f)	09100-70863	
Point Plot Programs With Symbols (a/b, f)	09100-70865	
QUALITY ASSURANCE PAC (a/b, c, d)		
Manual	09100-70950	
Recorded Magnetic Cards	09119-70950	
Slope and Intercept Errors of a Straight Line (a/b)	09100-70862	
STAT PAC VOL. 1 (a/b, c, d)		
Manual	09100-70800	
Recorded Magnetic Cards	09119-70800	

EQUIPMENT CODE KEY

a = 9100A Calculator
b = 9100B Calculator
c = 9120A Printer
d = 9125A/B Plotter
e = 9160A Marked Card Reader
f = 9101A Extended Memory
g = 9102A Buffer Box

REMARKS

Single programs normally include prerecorded magnetic cards as well as printed material.

ORDER INFORMATION

All software orders and further information requests should be placed through your local HP sales office.

HEWLETT hp PACKARD

MODEL 10

SOFTWARE INFORMATION

EFFECTIVE APRIL, 1974

DESCRIPTION	PART NUMBER	
COMMERCIAL		
Amortization Analysis (b, d, e)	09810-73409	
Amortization Schedule (b, d, e)	09810-73408	
BUSINESS ROUTINES PAC (d, f)		
Manual	09810-73000	
Recorded Magnetic Cards	09819-73000	
Installment Loan – Add On Interest (b, d, f)	09810-73401	
Inventory Control Program (c, h, q, r, s, w)	09810-73011	
Payroll (Version A) (a, c, d, f)	09810-73003	
Payroll (Version C) (a, c, h, s)	09810-73005	
Payroll (Version E)	09810-73007	
ENGINEERING		
Active Filter Design (c, d, e, f, t)	09810-71002	
CETUS: Ge (li) Gamma Spectrum Program for Environmental Sample Analysis (a, c, d, e, f, r)	09810-71701	
HVAC PAC (a, b, c, d, e, f)		
Manual	09810-74500	
Recorded Magnetic Cards	09819-74500	
Line Sag Calculations (b, c, d, s, t)	09810-71376	
Pipe Network Balancing (a, c, d, e, f,)	09810-75001	
SURVEYING PAC VOL. 2 (a, b, c, d, e, f, s, t)		
Manual	09810-74150	
Recorded Magnetic Cards	09819-74150	
SURVEYOR I (d)		
Manual	09810-74031	
Recorded Magnetic Cards	09819-74031	
SURVEYOR II (d, e)		
Manual	09810-74032	
Recorded Magnetic Cards	09819-74032	
SURVEYOR III (a, c, d, e, f)		
Manual	09810-74033	
Recorded Magnetic Cards	09819-74033	
INTERFACING & SYSTEMS		
CASSETTE MEMORY PAC (a, b, c, d, f, s, t)		
Manual	09865-70000	
Recorded Magnetic Cards	09865-70009	
DIGITIZER PAC (c, d, t, v)		
Manual	09810-76050	
Recorded Magnetic Cards	09819-76050	
Plotter Routine (c, f, j, t)	09810-76002	
Tape Operating System (a, b, c, d, f, o)	09810-76503	
MATHEMATICS		
Bessel Functions (d, e)	09810-70005	
MATH PAC (a, b, d, e, f, i)		
Manual	09810-70000	
Recorded Magnetic Cards	09819-70000	

DESCRIPTION	PART NUMBER	
MATHEMATICS (continued)		
MATH SUBROUTINE PAC (opt. h)		
Manual	09810-70100	
Recorded Magnetic Cards	09819-70100	
Numerical Integration Using Gaussian Quadrature (d)	09810-70007	
The Number π Determined by Monte Carlo Method (e)	09810-75901	
Three Dimensional Transformation Subroutines (c,d,t)	09810-76003	
MEDICAL		
CARDIO-PULMONARY PAC (b, c, d, e, f)		
Manual	09810-75325	
Recorded Magnetic Cards	09819-75325	
CLINICAL LAB RIA PAC (a, c, d, f, i, j, opt. l & t, u)		
Complete Pac	09810-75262	
Manual	09810-75263	
Recorded Magnetic Cards	09819-75263	
Clin Lab Programming Manual	09810-75340	
CLINICAL PATHOLOGY PAC (b, d, e, f, i)		
Manual	09810-75350	
Recorded Magnetic Cards	09819-75350	
Programming Manual for the Clinical Laboratory	09810-75340	
STATISTICS		
Blackhat Sorter (a, d)	09810-70805	
N^{th} Order Polynomial Regression $N \leqslant 9$ with Plot (a,c,e,f)	09810-70806	
NON-PARAMETRIC STAT PAC (a, b, d, e, f, j)		
Manual	09810-70825	
Recorded Magnetic Cards	09819-70825	
QUALITY ASSURANCE PAC (a, b, d, e, f, j, t)		
Manual	09810-70875	
Recorded Magnetic Cards	09819-70875	
RELIABILITY PAC (a, c, d, e/i, t)		
Manual	09810-70950	
Recorded Magnetic Card	09819-70950	
STAT PAC VOL. 1 (c, d, i)		
Manual	09810-70800	
Recorded Magnetic Cards	09819-70800	
STAT PAC VOL. 2 (a, b, c, d, f, i, j, t)		
Manual	09810-70850	
Recorded Magnetic Cards	09819-70850	
TYPEWRITER STAT PAC (a, c, e, s, t)		
Manual	09810-70900	
Recorded Magnetic Cards	09819-70900	

EQUIPMENT CODE KEY

a = Opt. 001 (111 Data Registers)
b = Opt. 002 (1012 Program Steps)
c = Opt. 003 (2036 Program Steps)
d = Opt. 004 Printer
e = 11210A Math ROM
f = 11211A Printer Alpha ROM
h = 11213A User Definable ROM
i = 11214A Statistics ROM
j = 11215A Plotter ROM
l = 11261A Plotter/Printer Alpha Comb. ROM
o = 11265A Cassette Memory ROM
q = 11267A Typewriter/Cassette Comb. ROM
r = 9860A Mark-Sense Card Reader
s = 9861A Typewriter
t = 9862A Plotter
u = 9863A Paper Tape Reader
v = 9864A Digitizer
w = 9865A Tape Cassette

REMARKS

Single programs normally include prerecorded magnetic cards as well as printed material.

ORDER INFORMATION

All software orders and further information requests should be placed through your local HP sales office.

HEWLETT hp PACKARD

MODEL 20

SOFTWARE INFORMATION

EFFECTIVE APRIL, 1974

DESCRIPTION	PART NUMBER	
COMMERCIAL		
PAYROLL PAC (a, f, g, i, m)		
Complete Pac	09820-73002	
Manual	09820-73003	
Recorded Magnetic Cards	09829-73003	
Recorded Cassette	09829-73002	
ENGINEERING		
Active Filter Design (a, c, d, i)	09820-71002	
Band Pass Filter Design (a, d)	09820-71001	
Chebyshev Low-Pass Filter Design, Unequal Terminations (d)	09820-71004	
CNAP Network Analysis (a, c, d, j)	09820-71003	
ELECTRICAL ENGINEERING PAC VOL. 1		
Manual	09820-71000	
Recorded Magnetic Cards	09829-71000	
MICROWAVE PAC VOL. 1		
Manual	09820-71200	
Recorded Magnetic Cards	09819-71200	
NUMERICAL CONTROL PAC (a, d, g, j, q, r, s)		
Complete Pac	09820-72050	
INTERFACE & SYSTEMS		
DIGITIZER PAC (a, c, d, j, l)		
Manual	09820-76000	
Recorded Magnetic Cards	09829-76000	
Tape Operating System (a, e, f, m)	09820-76502	
User Definable Program Set for Control of 3480/3485 DVM (a, d, e, g, s, t, u, v)	09820-76501	
MATHEMATICS		
Complex Number Arithmetic (a, d, e)	09820-75801	
Fast Fourier Transform (a, d)	09820-70008	
Least Squares Solution of m Equations in n Unknowns	09820-70004	
MATH PAC		
Manual	09820-70000	
Recorded Magnetic Cards	09829-70000	
Matrix Inversion for a Positive Definite Symmetric Matrix	09820-70003	
MISCELLANEOUS		
Model 20 Basic Features Demo (a)	09820-76002	
Model 20 T List	09820-76008	
The Game of Life (a, c, d, j)	09820-76005	
STATISTICS		
STAT PAC VOL. 1 (a, c, d, j)		
Manual	09820-70800	
Recorded Magnetic Cards	09829-70800	
STAT PAC VOL. 2 (a, c, j)		
Manual	09820-70825	
Recorded Magnetic Cards	09829-70825	

EQUIPMENT CODE KEY

a = Opt. 001 (429 registers)
c = 11220A Peripheral Control I ROM
d = 11221A Mathematics ROM
e = 11222A User Definable ROM
f = 11223A Cassette ROM
g = 11224A Peripheral Control II ROM
i = 9861A Typewriter
j = 9862A Plotter
l = 9864A Digitizer
m = 9865A Tape Cassette
q = 2895B Tape Punch
r = 2748B Tape Reader
s = 11202A General Interface
t = 11203A BCD Interface
u = 3480A/B Digital Voltmeter
v = 3485A Scanning Unit

REMARKS

Single programs normally include prerecorded magnetic cards as well as printed material.

ORDER INFORMATION

All software orders and further information requests should be placed through your local HP sales office.

HEWLETT hp PACKARD

MODEL 21

SOFTWARE INFORMATION

EFFECTIVE APRIL, 1974

DESCRIPTION	PART NUMBER	
COMMERCIAL		
PAYROLL PAC (a, g, i)		
Complete Pac	09821-73002	
Manual	09820-73003	
Supplement	09821-73003	
Utility Cassette	09829-73005	
Program/Data Cassette	09829-73004	
ENGINEERING		
ELECTRICAL ENGINEERING PAC VOL. 1 (a, d, e, j)		
Complete Pac	09821-71101	
Manual	09820-71000	
Supplement	09821-71000	
Recorded Cassette	09829-71101	
MICROWAVE PAC VOL. 1 (a, d, e, f, j)		
Complete Pac	09821-71251	
Manual	09820-71200	
Supplement	09821-71200	
Recorded Cassette	09829-71251	
MATHEMATICS		
MATH PAC (a, d, e, j)		
Complete Pac	09821-70401	
Manual	09820-70000	
Supplement	09821-70000	
Recorded Cassette	09829-70401	

EQUIPMENT CODE KEY

a = Option 001 (423 total registers)
d = 11220A Peripheral Control I ROM
e = 11221A Mathematics ROM
f = 11222A User Definable ROM
g = 11224A Peripheral Control II ROM
i = 9861A Typewriter
j = 9862A Plotter

REMARKS

A complete pac includes all printed material and recorded cassettes associated with the software. Each sub-item (manual, supplement, cassette) should be purchased only as a replacement item or as an extra copy.

ORDER INFORMATION

All software orders and further information requests should be placed through your local HP sales office.

HEWLETT hp PACKARD

MODEL 30

SOFTWARE INFORMATION

EFFECTIVE APRIL, 1974

DESCRIPTION	PART NUMBER	
COMMERCIAL		
ACCOUNTING SYSTEMS/ACCOUNTS PAYABLE (a, f, s, k or p)		
Complete Pac	09830-73020	
Manual	09830-73021	
Recorded Cassette 1	09839-73020	
Recorded Cassette 2	09839-73021	
ACCOUNTING SYSTEMS/ACCOUNTS RECEIVABLE-BILLING PAC (a, f, s, k or p)		
Complete Pac	09830-73025	
Manual	09830-73024	
Recorded Cassette 1	09839-73024	
Recorded Cassette 2	09839-73025	
ACCOUNTING SYSTEMS/INVENTORY CONTROL PAC (a, f, s, k or p)		
Complete Pac	09830-73030	
Manual	09830-73031	
Recorded Cassette	09839-73030	
CONSULTANT'S COST ACCOUNTING PAC (a, f, o, p)		
Complete Pac	09830-73037	
Manual	09830-73036	
Operating Programs Cassette	09839-73036	
File Maintenance Cassette	09839-73037	
EXPENSE/BUDGET MONITOR PROGRAM (a, f, k or p)		
Complete Pac	09830-73051	
Manual	09830-73050	
Recorded Cassette	09839-73051	
REAL ESTATE MULTIPLE REGRESSION PROGRAM PAC (p)		
Complete Pac (5 cassettes)	09830-73003	
Manual	09830-73002	
Recorded Cassette	09839-73003	
REAL ESTATE PAC VOL. 1 (k or p)		
Complete Pac	09830-73011	
Manual	09830-73010	
Recorded Cassette	09839-73010	
REAL ESTATE PAC VOL. 2 (b, f, k or p)		
Complete Pac	09830-73005	
Manual	09830-73004	
Recorded Cassette	09839-73004	
Data Cassette	09839-73005	
ENGINEERING		
HVAC PAC (a, p)		
Complete Pac	09830-74500	
Manual	09830-74501	
Recorded Cassette	09839-74501	
MAGNETICS PAC VOL. 1 (a or b, k or p)		
Complete Pac	09830-71001	
Manual	09830-71000	
Recorded Cassette	09839-71000	

DESCRIPTION	PART NUMBER	
ENGINEERING (Continued)		
MODIFIED MOMENT DISTRIBUTION (a, k or p, c, f, opt. d & l)		
Complete Pac	09830-74210	
Manual	09830-74208	
Recorded Cassette	09839-74210	
MODIFIED MOMENT DISTRIBUTION (a, k or p, c, f, o, opt. d & l)		
Complete Pac	09830-74211	
Manual	09830-74209	
Recorded Cassette	09839-74211	
MULTI-STORY MOMENT DISTRIBUTION (a, k or p, c, f)		
Complete Pac	09830-74220	
Manual	09830-74217	
Recorded Cassette	09839-74220	
MULTI-STORY MOMENT DISTRIBUTION (a, k or p, c, f, o)		
Complete Pac	09830-74221	
Manual	09830-74218	
Recorded Cassette	09839-74221	
MULTI-STORY MOMENT DISTRIBUTION (a, k or p, c, f, o)		
Complete Pac	09830-74222	
Manual	09830-74219	
Recorded Cassette	09839-74222	
PIPE NETWORK BALANCING (2k or 4k, k or p)		
Complete Pac	09830-75001	
Manual	09830-75000	
Recorded Cassette	09839-75001	
REINFORCED CONCRETE BEAM DESIGN (a, c, k or p)		
Complete Pac	09830-74255	
Manual	09830-74254	
Recorded Cassette	09839-74255	
REINFORCED CONCRETE COLUMN DESIGN (a, c, k or p, opt. d & l)		
Complete Pac	09830-74250	
Manual	09830-74249	
Recorded Cassette	09839-74250	
RING FRAME ANALYSIS (a, k or p, c, f, opt. d & l)		
Complete Pac	09830-74230	
Manual	09830-74229	
Recorded Cassette	09839-74230	
STEEL BEAM COLUMNS (a, c, f, k or p)		
Complete Pac	09830-74240	
Manual	09830-74239	
Recorded Cassette	09839-74240	
3-D BEAM ANALYSIS (a, k or p, c, f, opt. d & l)		
Complete Pac	09830-74235	
Manual	09830-74234	
Recorded Cassette	09839-74235	
MATHEMATICS		
MATH PAC (k or p)		
Complete Pac	09830-70001	
Manual	09830-70000	
Recorded Cassette	09839-70000	
MEDICAL		
CLINICAL LAB RADIOIMMUNOASSAY PAC (a, e, f, p, opt. m, l, d)		
Complete Pac	09830-75330	
Manual	09830-75329	
Recorded Cassette	09839-75329	
MISCELLANEOUS		
PLOTTER PAC (d, l, k or p)		
Complete Pac	09830-76001	
Manual	09830-76000	
Recorded Cassette	09839-76000	

DESCRIPTION	PART NUMBER	
STATISTICS		
STAT PAC VOL. 1 (a, k or p)		
Complete Pac	09830-70801	
Manual	09830-70800	
Recorded Cassette	09839-70800	
STAT PAC VOL. 2 (a, k or p)		
Complete Pac	09830-70826	
Manual	09830-70825	
Recorded Cassette	09839-70825	

EQUIPMENT CODE KEY

a = Opt. 275 4K R/W
b = Opt. 276 8K R/W
c = Opt. 270 Matrix ROM
d = Opt. 271 Plotter ROM
e = Opt. 272 Extended I/O ROM
f = Opt. 274 String Variables ROM
k = 9861A Typewriter
l = 9862A Plotter
m = 9863A Paper Tape Reader
o = 9865A External Tape Cassette
p = 9866A Thermal Page Printer
s = 9867A Mass Memory (Single)

REMARKS

A complete pac includes all printed material and recorded cassettes associated with the software. Each sub-item (manual, recorded cassette, data cassette) should be purchased only as a replacement item or as an extra copy.

ORDER INFORMATION

All software orders and further information requests should be placed through your local HP sales office.

programming tips

We are indebted to Dr. J.N. Shapiro and Captain R.J. Woodward of Texas A&M University, College of Geosciences, College Station, Texas for this programming tip.

Hewlett-Packard's routine for making dashed plots with the 9862A (page 3-6 of the 11220A Peripheral Control I Operating Manual) alternates solid lines a preselected number of x units long with spaces a preselected number of x units long. If the function being plotted has a small slope, the resulting plot can be made to consist of dashes (and spaces) of about the same length, as desired. However, if the function has steep parts, the length of the dashes (and spaces) can get very long, theoretically approaching infinity for a function of infinite slope; for example, ln x as $x \rightarrow 0$. See Figure 3.9 on page 3-6 of the above references for an example using cos 3x.

The reason for this is very simple. Equal increments in the independent variable, x, are not generally equal increments in arc length, s. For plotting purposes, it is equal increments in s which are desirable.

Mathematically speaking, the effects of a changing slope may be taken into account quite easily. One simply uses the definition of, ds, a differential element of arc length.

$$ds = \sqrt{dx^2 + dy^2}$$

$$ds = dx\sqrt{1 + (dy/dx)^2}$$

Here dy/dx may be calculated for each point, or the finite difference $\Delta y/\Delta x$ between adjacent points may be calculated.

In practice two other effects must be considered. First, both y and x must be scaled by the total number of units of each covered by the plot. That is, a line corresponding to .1 y units will cover .1/10 = .01 of the graph's height if y goes from 0 to 10 (or -5 to 5, etc.), whereas the same .1 units will plot twice as long if y goes instead from 0 to 5.

A second effect is the physical size of the graph. The appropriate coordinates should be multiplied by the length of the graph in their direction. In terms of units along the x axis, and including both of the above effects ds is given by

$$ds = dx\sqrt{1 + (A\ dy\&dx)^2}$$

$$\text{where } A = \frac{(x \text{ max} - x \text{ min})}{(y \text{ max} - y \text{ min})} \bullet \frac{(\text{height of graph})}{(\text{length of graph})}$$

The program (Figure 1) generates equal length dashes as shown in the two plots of ln x, one with equal size dashes and one without (Figure 2). Note that the x increment should be small and the number of increments per dash should be large for best dash equality.

This suggestion is interesting because of its utility, but perhaps even more so because it illustrates very simply an elementary concept of calculus.

```
0:
ENT "X MIN",R0,"
X MAX",R1⊢
1:
ENT "Y MIN",R2,"
Y MAX",R3⊢
2:
ENT "LENGTH/HEIG
HT",R4⊢
3:
(R1-R0)/(R3-R2)R
4→A⊢
4:
0→Z;SCL R0,R1,R2
,R3⊢
5:
ENT "X INCREMENT
",B⊢
6:
ENT "INCR. PER D
ASH",C⊢
7:
R0-B→X⊢
8:
GSB "*"⊢
```

```
9:
PLT X,LN X⊢
10:
IF Z≤C;GTO -2⊢
11:
PEN ⊢
12:
GSB "*"⊢
13:
IF Z≤2C;GTO -1⊢
14:
0→Z;GTO -6⊢
15:
GTO +3⊢
16:
"*";X+B→X;IF X>R
1;GTO +3⊢
17:
Z+r(1+AA/XX)→Z⊢
18:
RET ⊢
19:
END ⊢
R366
```

Figure 1 Routine for equal dash length.

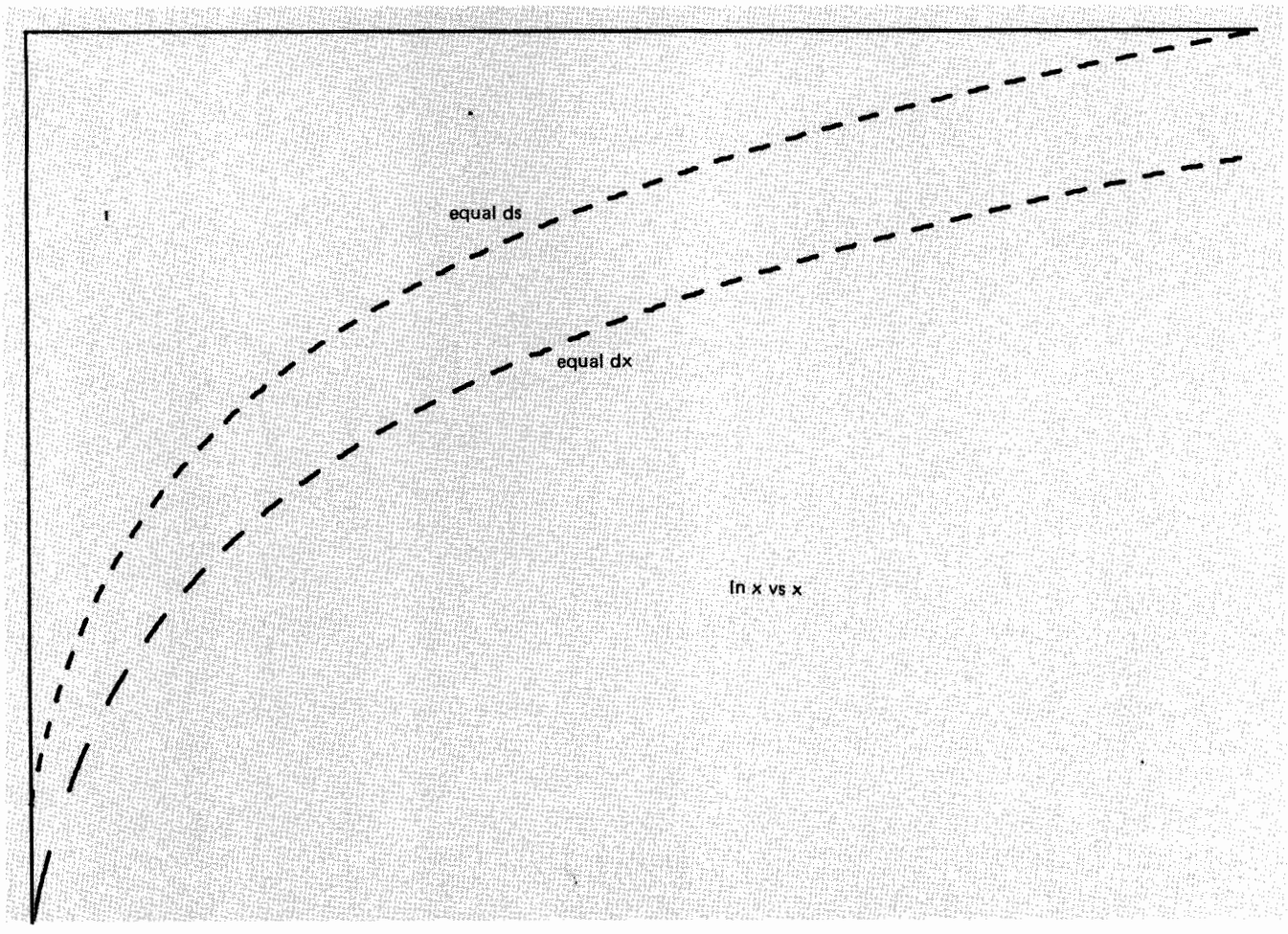


Figure 2 Comparison between using equal x increments and equal arc increments for dash length.

Win an HP-45 or HP-80

1974
CALCULATOR SYSTEM APPLICATION CONTEST

KEYBOARD is conducting a new contest for unusual applications of HP programmable desktop calculator systems. To allow the greatest opportunity for equipment diversity, as well as variety of applications, this contest will include 9100A/B systems in addition to the 9800 series.

Two branches of the contest are being held with different time limits to allow equal opportunities for participation by calculator users in all countries. The U.S.A. branch of the contest will run until June 15, 1974. The branch for all other countries will run until August 15, 1974.

The winner of each branch of the contest will receive his choice of an HP-45 or an HP-80 Pocket Calculator, or an equivalent value prize in the form of a 9800 series plug-in Read-Only Memory or HP calculator software. Additional rules are:

1. Each entry shall be in the form of an article suitable for publication in *KEYBOARD*, and a publication release shall be included.

2. The inclusion of programs used in the contest application is desirable but not essential to win. Each program submitted shall be fully documented and include a program submittal form found in the back of most HP software pacs.

3. Entries shall be typed double-spaced on paper approximately 8½ by 11 inches (21,6 cm by 27,9 cm).

4. Pertinent photographs, charts, and other illustrations shall be included. Photographs must be good contrast black-and-white prints between 4 by 5 inches (10,1 cm by 12,7 cm) and 8 by 10 inches (20,3 cm by 25,4 cm). The author's photograph and curriculum vitae should be included.

5. Entries shall be submitted to either a field editor or directly to HP *KEYBOARD*, P.O. Box 301, Loveland, Colorado 80537, U.S.A., postmarked not later than the deadline date.

6. Entries become the property of Hewlett-Packard and cannot be returned.

7. A proof copy of any article to be published will be submitted to the author for approval prior to publication.

8. Employees of Hewlett-Packard Company, its affiliates and subsidiaries are not eligible to compete.