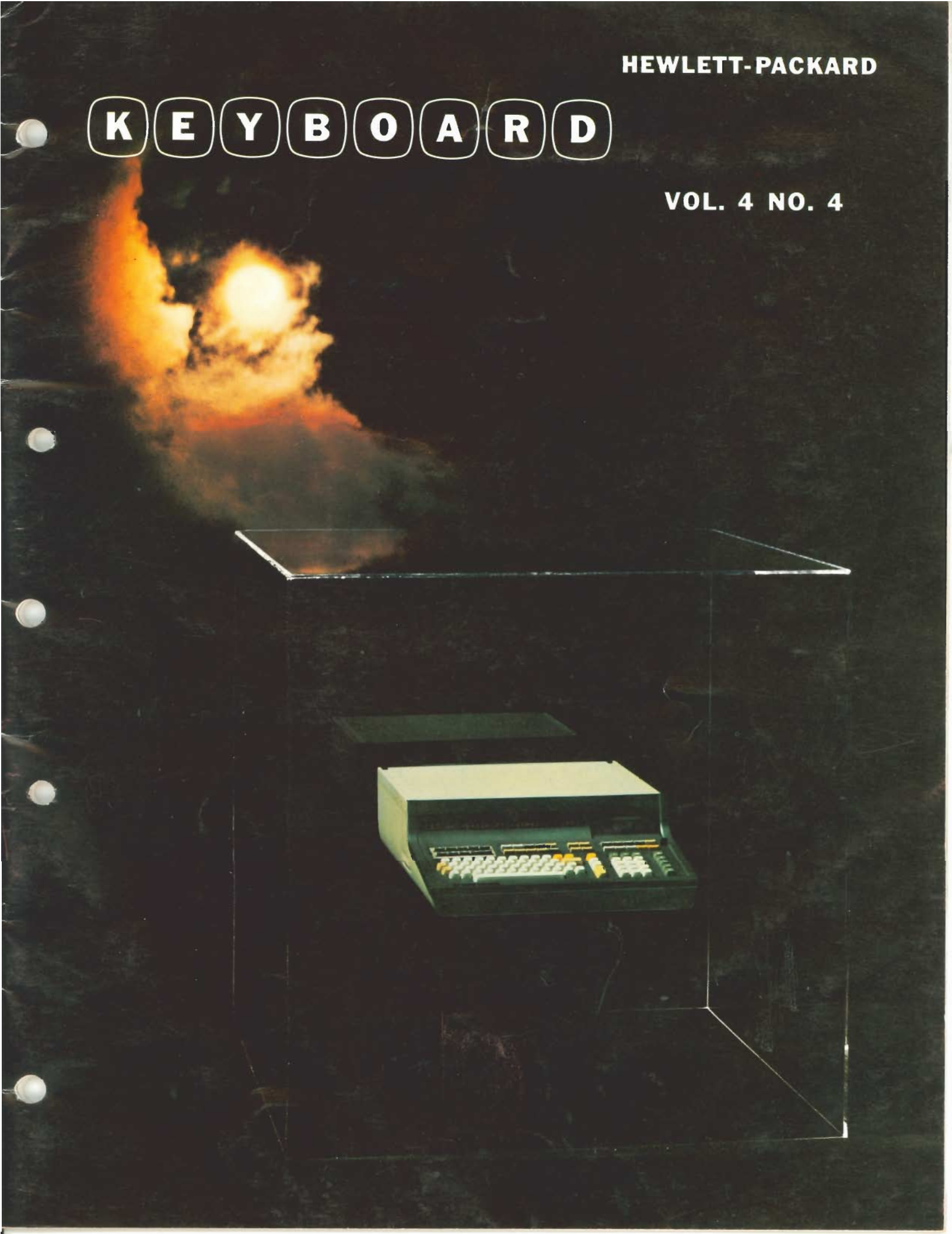
HEWLETT-PACKARD

KEYBOARD

VOL. 4 NO. 4



HP Computer Museum
www.hpmuseum.net

For research and education purposes only.

APPLICATIONS INFORMATION
FOR HEWLETT-PACKARD CALCULATORS
PUBLISHED AT P.O. BOX 301, LOVELAND, COLORADO 80537

Editor: A.B.SPERRY
Art Director: L.E.BRADEN
Artist/Illustrator: H.V.ANDERSEN

Field Editors: **AUSTRALASIA**--Bill Thomas, Hewlett-Packard Australia Pty. Ltd., 22-26 Weir Street, Glen Iris, 3146, Victoria; **CANADA**--Brian Wiley, Hewlett-Packard Canada Ltd., 275 Hymus Blvd., Pointe Claire, Quebec; **EUROPE**--Christian Langfelder, Hewlett-Packard GmbH, Herrenberger Strasse 110, 703 Boblingen, West Germany; **JAPAN**--Akira Saito, Yokogawa-Hewlett-Packard Ltd., 59-1, Yoyogi 1-chrome, Shibuya-ku, Tokyo 151; **LATIN AMERICA**--Daniel Mazar Barnett, Hewlett-Packard Intercontinental , 3200 Hillview Avenue, Palo Alto, California 94304; **SOUTH AFRICA**--Dennis du Buisson, Hewlett-Packard South Africa (Pty.) Ltd., 30 de Beer Street, Braamfontein; **EASTERN U.S.A.**--Stan Kowalewski, Hewlett-Packard Co., W120 Century Road, Paramus, New Jersey 07652; **MIDWESTERN U.S.A.**--Jerry Reinker, Hewlett-Packard Co., 3460 South Dixie Drive, Dayton, Ohio 45439; **SOUTHERN U.S.A.**--Bob McCoy, Hewlett-Packard Co., Post Office Box 28234, Atlanta, Georgia 30328; **WESTERN U.S.A.**--Robert C. Reade, Hewlett-Packard Co., 3939 Lankershim Boulevard, North Hollywood, California 91604.

TABLE OF CONTENTS

Letters to the Editor

Dear Sir,

The programming tip for INTEGER X published in "*KEYBOARD*" Vol. 4 No. 2 fails with the Model 20 when X is in the range 1 to 1.4999, apparently because the machine will not round a number like 100000000000.8 to 100000000001, though it will round 100000000001.8 to 100000000002. It is therefore necessary to add a small program segment which supplies 1 for integer X if X is in the failure range.

Yours faithfully,

A. L. Andrews
Edwards, Clendon & Partners
48 Hobson Street
Wellington, N.Z.

Dear Mr. Sperry:

I was very interested to see Carl Smolka's one line N! program for the HP 9820 on page 4 of the latest KEYBOARD. However, I noticed two minor errors in it, specifically that the last GTO 0 statement and the second assignment of 1 into Z are both unnecessary. The same results will be obtained with these statements deleted.

I enclose a similar one line N! program written along the lines of Smolka's but using fewer registers. It also gives the correct answer for 0!.

```
0:
AZ→Z;A-1→A;GTO 0
;IF A≤1;PRT Z;
ENT "N=?",A+(A=0
)→A;1→Z;GTO 0⊢
1:
END ⊢
```

Sincerely,

Frank J. Bruni
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

TO HP *KEYBOARD* READERS

The new Model 9830A Calculator with its BASIC language, built-in tape cassette drive, and powerful definable keys was shown at the Fall Joint Computer Conference in Anaheim, California. The Model 30 is featured in this issue, along with the new page-width Thermal Printer, Model 9866A. A list of presently available and upcoming Model 30 programs appears on page 18.

A contest for the most unusual applications of HP 9800 calculator systems was announced in *KEYBOARD* Vol. 4, No. 3. The rules are repeated on page 14 of this issue for users who may not have seen the original announcement.

A B Sperry

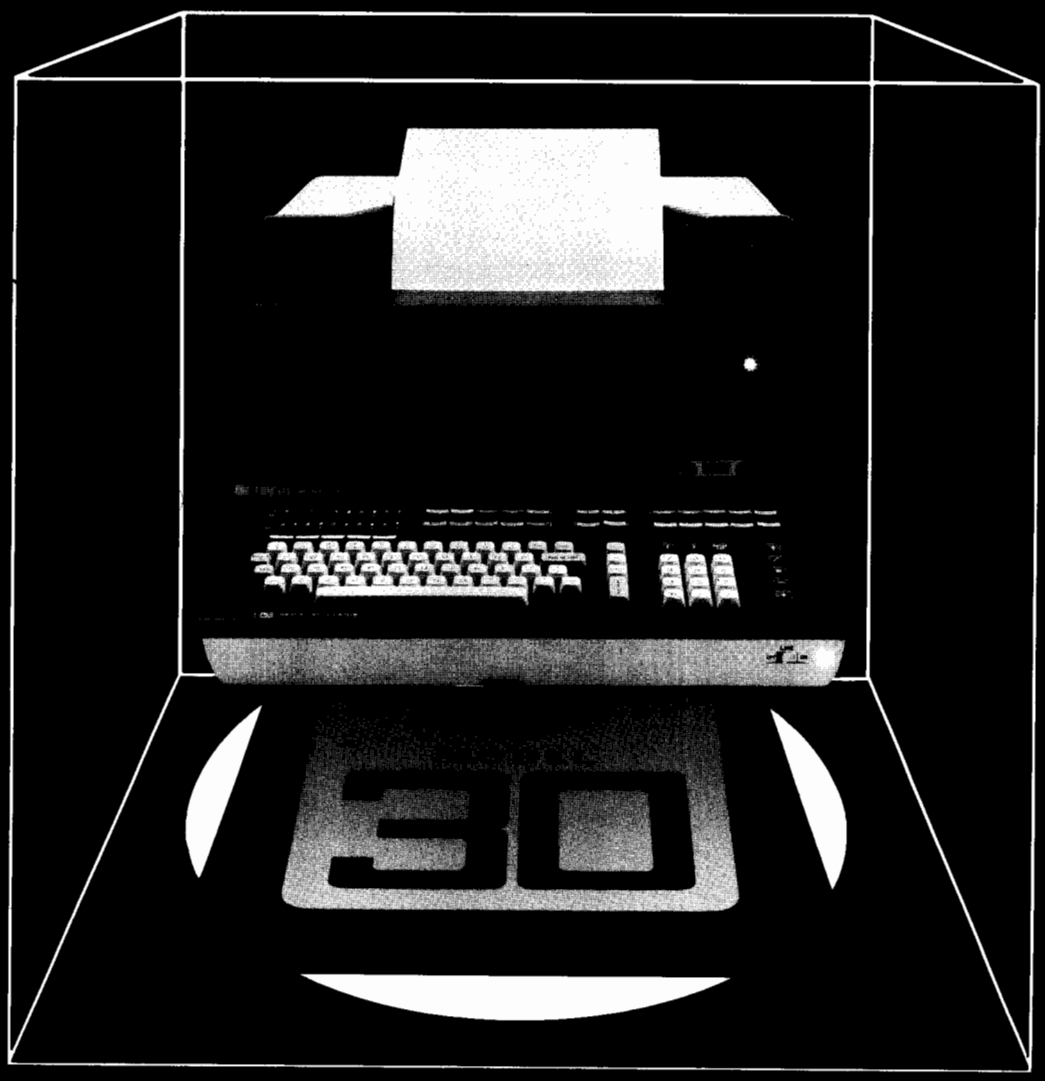
TO MEDICAL USERS

Many doctors, technologists, and researchers have related to us their enthusiasm over the versatility of programmable calculators.

In response to these inputs, Hewlett-Packard's Calculator Division has formed a group specifically dedicated to serving the needs of users in the domains of:

- Clinical Pathology Laboratories
- Nuclear Medicine/Radiology
- Cardiopulmonary Studies

KEYBOARD is seeking articles describing applications of HP desk-top computers in these areas. If you feel that programs you have developed might benefit others in your profession, please let us know. Your work deserves special attention due to the unique way in which calculators contribute to health care.


30

Introducing the BASIC-Language Calculator

Computer power with calculator convenience characterizes the new Hewlett-Packard Series 9800, Model 30 Calculator. As the top of the HP Calculator line the 40 K byte system is the largest and most powerful member of the 9800 family.

Its keyboard design, memory size, programming language, and flexibility make the Model 30 more like a desktop computer than a calculator. Yet it maintains the convenience and user interaction that makes a programmable calculator so easy to use. The operating system is built-in. Turn the power on, type in 2 + 2, EXECUTE, and see 4 on the display.

The Model 30's programming language is BASIC. This easy-to-use language couples simplicity with power and appeals to the new calculator owner as well as the experienced programmer. The Model 30 automatically inherits a comprehensive range of proven software packages, including finance, mathematics, statistics, and education.

The broad range of memory options and peripherals available with the Model 30 gives you maximum flexibility in putting together the specific system required to solve your problem. The result is a cost-effective calculator that can meet your calculator problems today and continue to meet them as your needs expand.

FEATURES

* Alphameric Keyboard
* 32 Character LED Alphameric Display
* BASIC Language
* Easy Editing
* Built-in Tape Cassette
* Special Function Keys
* Expandable User Memory
* Add-On Read-Only Memory
* Formatted Output
* Broad Range of Peripherals

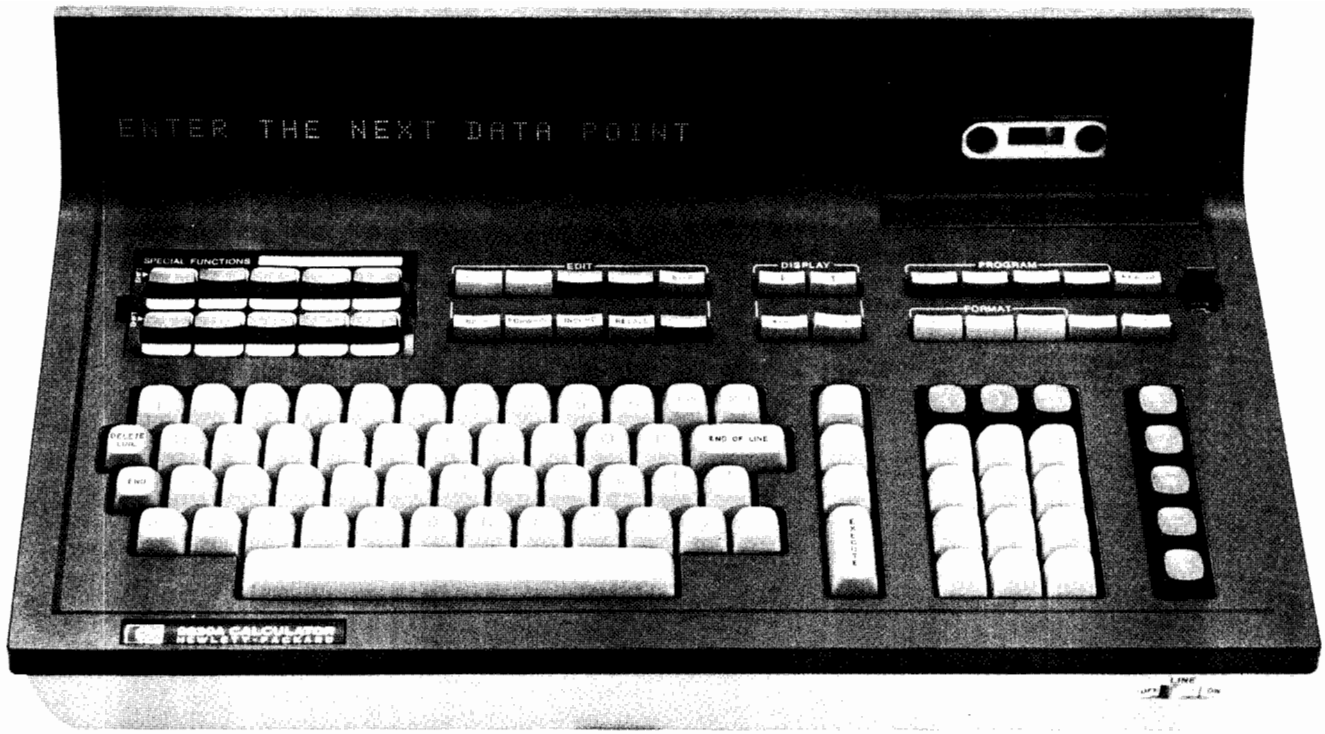
ALPHAMERIC DISPLAY

Light-emitting diodes provide a bright, 32-character display, which is easy to read over a wide range of angles and distances. Each of the 9/32 inch (.714 cm) high characters uses a 7 x 5 dot matrix to provide naturally-shaped numbers, letters, and symbols in this size:

(ACTUAL SIZE)

When greater than 32 characters are being input, the characters will automatically shift to the left to allow room for the additional characters being keyed in. To view the beginning of the input, press [→] ; this moves the characters in the display to the right. Pressing [←] performs the reverse operation.

Although the display is 32 characters, an 80-character line can be keyed in with the automatic scrolling both for program lines and keyboard operations.



ALPHAMERIC KEYBOARD

The keyboard of the 9830A represents its most significant departure from the traditional concept of a programmable calculator. It is not a key-per-function keyboard, but rather an alphameric keyboard like that of a typewriter.

The use of an alphameric keyboard rather than a key-per-function keyboard removes the major restriction to programming language definition and language expandability. It is not necessary to add a new key to the keyboard whenever a new function is added to the language. Rather, a new function is assigned a mnemonic which can be entered as a sequence of alpha characters.

Besides the alpha section of the keyboard, there are three groups of special keys that facilitate use of the 9830A. The first group is a calculator section, which contains the digits and the most commonly used arithmetic operators. The second group contains special control keys used in operating, editing, and debugging programs. The keys in the third group are definable by the user.

PROGRAMMING IN BASIC

In developing the Model 30, it was decided not to define another new and unique programming language. BASIC, which is well known among users of small computer and time-shared systems, was selected. All of the changes that have been made in BASIC in the Model 30 are additions to standard BASIC, so programs written in versions of BASIC that are close to the standard version will run with little or no modification on the Model 30. This means that a tremendous program library is already available.

Besides being well known and used extensively, BASIC has several other characteristics which make it well-suited for a programmable calculator. Since the language was originally designed for use in time-sharing environments, it is interactive and conversational. The Model 30 fully exploits these characteristics by communicating through the 32-character alphameric display and the Model 66 thermal line printer.

BASIC is easy to learn because the commands closely resemble English and there are very few tricky syntax rules to memorize. Each statement in a program is given a line number by the programmer, and the BASIC operating system automatically places the statements in order.

Here is a program written on the Model 30 to input a set of numbers and print their average:

```
10 REM  THIS PROGRAM AVERAGES
12 REM  A SET OF VALUES.
14 REM  "N" = NO. OF VALUES
16 REM  "S" = SUM OF VALUES
18 S=0
20 INPUT N
22 FOR I=1 TO N
24 INPUT X
26 S=S+X
28 NEXT I
30 PRINT "NO. OF VALUES ="N
32 PRINT "SUM OF VALUES ="S
34 PRINT "THE AVERAGE IS"S/N
36 END
```

EDITING

A program line is keyed into the Model 30 display. Pressing END OF LINE places the line in the calculator's read/write memory as a program line. As individual lines are placed into memory or after the entire program has been placed into memory it may be necessary to perform some editing.

Program editing is usually accomplished by retyping any incorrect statement or assigning a line number between two existing lines to a statement to be inserted in a program. The 9830A has expanded on this editing capability by providing complete character-by-character editing.

1. Characters can be inserted.
2. Characters can be changed by overscoring with other characters.
3. Characters can be deleted.

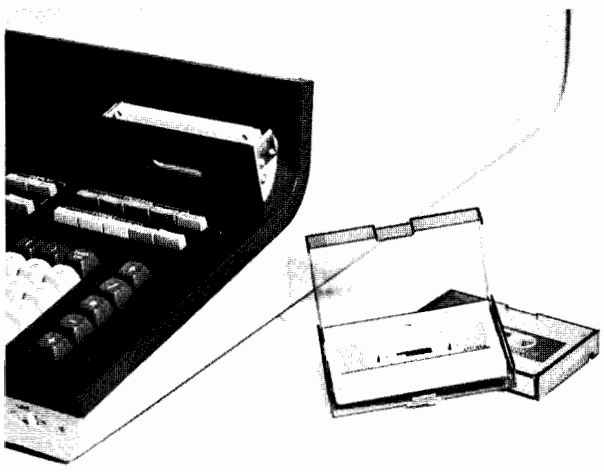
The user may recall a line of program to the display, edit the characters within that line, and store the corrected line without retyping the whole line. If an error is made while typing a statement, the incorrect line can be recalled and edited.

With the Model 30's editing and debugging features the user can quickly and easily insert or delete individual characters or program lines. The calculator does all the necessary bookkeeping.

CASSETTE MEMORY

The Model 30 calculator features a built-in cassette for program, data, or special function key storage. In addition to the internal cassette the Model 30 can operate with up to nine peripheral cassettes (HP Model 9865A).

A series of tape operating commands has been added to 9830A BASIC to control the built-in tape cassette. A command called MARK is used to initialize a cassette and set up a structure of fixed length files. These files can then be accessed randomly by file number. The tape command syntax is simple but flexible.



Model 30 Calculator Tape Cassette and Cartridges

Tape and data manipulations not usually available on large computer magnetic tape systems are easily performed on the 9830. Files may be recalled from the cassette, modified, and restored in the same location, thus eliminating the need for a second tape unit. All files are numbered sequentially and a high-speed bi-directional search is used to locate a specified file from any point on the tape; program execution times are significantly reduced by eliminating the need for tape rewind in order to begin searching for a file.

Cassette storage may be optimized by selecting different file sizes which correspond to the program length and/or data storage of the program. Several Cassette Memories may be used in a system and each can be selectively addressed.

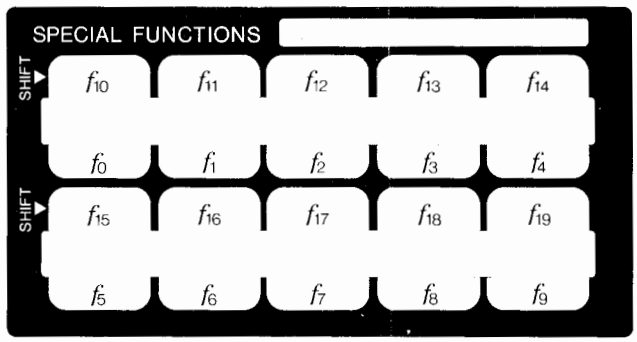
The cassette system has an interrupt mode for simultaneous calculator operation and cassette file search. A single tape cassette can hold up to 80,000 bytes (40,000 words) depending on the file structure set up by the user.

SPECIAL FUNCTION KEYS

There are ten special function keys in the upper-left keyboard area of the Model 30. Each key can have two functions or programs assigned to it for a maximum of twenty.

The special function keys can be used effectively in three different ways:

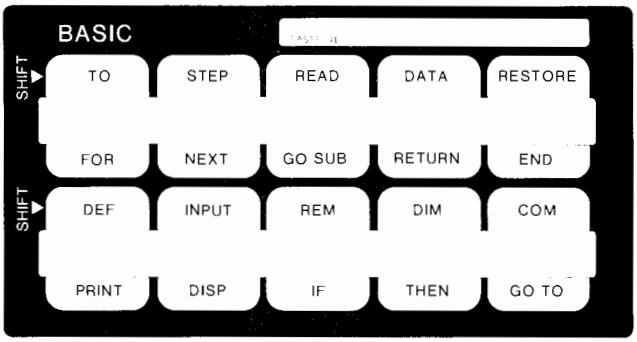
1. To represent text where text is used as a typing aid.
2. To represent functions. The functions can be single or multi-line functions and different parameters can be passed to the function from the mainline program or between functions.
3. To represent an entire program.



Programming and editing rules for the special function keys are the same as those for normal programming.

To assign a function or an entire program to a special function key, the user presses the key labeled FETCH and then presses any of the ten keys. This puts the calculator into the key-definition mode. The user then enters his function or program. Now whenever he presses that particular key, the calculator responds with the name of the function, or in the case of a program, begins execution of the program immediately.

The special function keys can be utilized to make the Model 30 act more like a traditional calculator.



MEMORY EXPANDABILITY

The memory of the Model 30 is expandable in two separate ways. The user read/write memory is expandable from 3520 bytes (1760 words) to 7616 bytes (3808 words). Add-on read-only-memory (ROM) can be added in 2 K byte increments to a total of 16 K bytes.

These add-on ROM modules, each containing 2048 bytes, are available both in small plastic cases and as printed-circuit modules that can be plugged inside the 9830A. After a ROM is in place, the calculator can understand the commands implemented by that ROM and can jump to the execution routines stored in it.

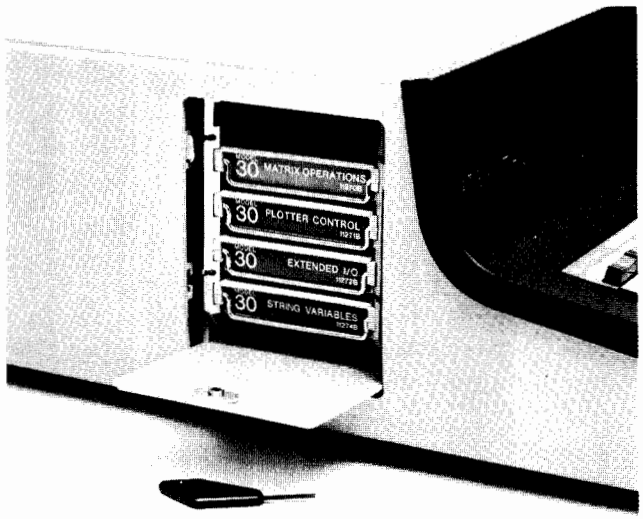
Five add-on ROM's are now available. The Matrix and String Variable ROM's include commands that are part of many BASIC systems, but are not needed by all BASIC users. The MAT commands on the Matrix ROM allow initialization of an array to all ones, all zeroes, or the identity matrix, or reading of the values for an array from DATA statements. Matrix arithmetic functions--addition, subtraction, multiplication, and multiplication by a scalar--are easily called, and functions to take the inverse and transpose are also included. This ROM also includes two commands that are not common in BASIC. They are a REDIM statement to redimension an array without changing the values of any elements, and a DET function for taking the determinant of a matrix.

The String Variable ROM allows the BASIC program to handle strings of alphameric characters. The program can initialize, change, examine, and test these strings, and it can ask the operator to input character strings through the keyboard. The simplest example of the value of string variables is an operator typing "YES" or "NO" in response to a question posed by the program. This add-on ROM makes the 9830A truly conversational.

The Plotter ROM adds several new statements to the 9830A language and provides the drivers needed to control the 9862A X-Y Plotter. Some of the most significant capabilities added are automatic scaling, convenient axis drawing, absolute and incremental plotting, and plotting relative to any origin. Labeling plots and axes has been made simple by a LABEL statement. This statement allows the user to draw alphameric characters of any height and width, at any angle of rotation. The LABEL statement has all the capability of a PRINT statement, that is, labels can be numeric constants, variables, or expressions, or alphameric strings or string variables. LABEL also has all the formatting capability of the 9830A WRITE statement.

The Extended I/O ROM adds statements and functions which provide convenience and flexibility in controlling input and output peripherals. The two most important features in this block are an ENTER statement that is used to input data from a peripheral in either free field or formatted form, and an automatic code conversion capability which allows the 9830A to communicate with peripherals using character codes other than ASCII. The Extended I/O ROM communicates through the standard interface scheme of the 9800 Series, and uses the standard interface cards.

The most unique feature underlying the add-on ROM scheme is the expandability of the Model 30 operating system and the "unlimited" keyboard. Together they make possible the modular or building block firmware (machine language programs) stored in ROM.



Model 30 Calculator With Matrix and Plotter ROM's Installed

TERMINAL CAPABILITY

The fifth ROM that is presently available with the 9830A is a Terminal ROM. This ROM gives the 9830A the unique capability to act as a time-share terminal. It can communicate with a time-sharing service through a modem at any speed from 3 to 300 baud. This optional ROM overrides the standard keyboard input routine and bypasses the syntax routines so that lines of free text can be stored in memory. For example, a FORTRAN program may be entered into the 9830A, edited, and saved on cassette. After a program has been entered and edited, the user can call up his time-sharing service and have the 9830A transmit the program automatically. The user may also have his time-sharing service transmit a program to be saved in the memory of the 9830A. The editing, execution, and storage capabilities of the 9830A make it a very powerful time-share terminal.

MODEL 66 PRINTER

The new Model 9866A Page-Width Printer was designed by HP specifically for the Model 30. It is a quiet, thermal printer capable of printing 80 alphameric characters per line at 250 lines per minute. (That's better than 330 characters per second--compared to a teletypewriter at 10 characters per second, or a typewriter at 15.) Characters are generated from a 5 x 7 dot matrix.

The Model 66 Printer provides the Model 30 calculator with optimum print capability in terms of speed, line length, and character set. The integrated product design and quiet operation make it ideal for laboratory or office use.

See the article on page 8 for more information on the Model 66.

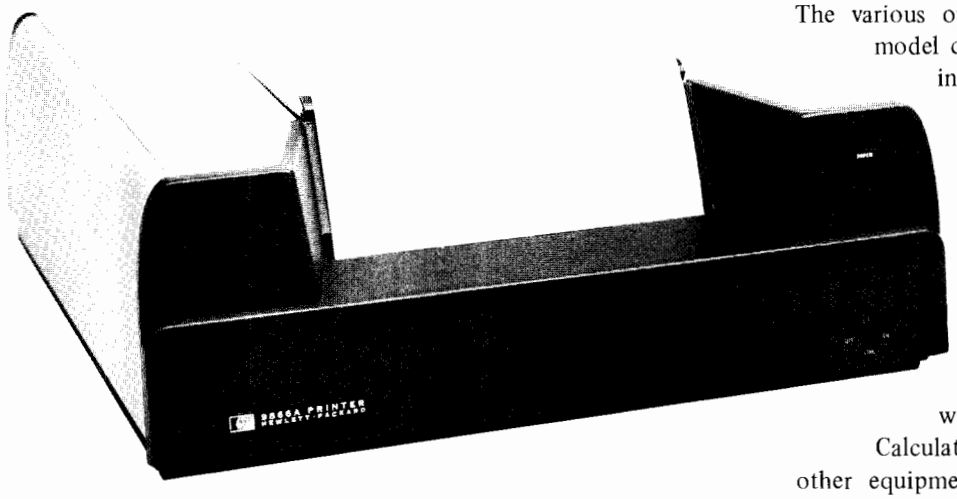
PERIPHERALS

The Model 30 accepts up to four peripherals at one time (up to five if the Model 9866 Printer is included). This can be expanded to 13 peripherals with the use of the Model 9868 I/O Expander. This broad I/O capability coupled with the wide range of 9800 series peripherals allows the user to configure the exact system necessary for his application.

The peripherals now available for use with the Model 30 are:

Model 9860A	Marked Card Reader
Model 9861A	Output Typewriter
Model 9862A	X-Y Plotter
Model 9863A	Paper Tape Reader
Model 9864A	Digitizer
Model 9865A	Tape Cassette
Model 9866A	Page Width Printer
Model 9868A	I/O Expander
Model 9869A	Hopper Card Reader
ASR Model 38	Teletype
Model 2895A	Paper Tape Punch
Model 2748A	Paper Tape Photo Reader

Introducing A Full-Page Printer For Your Calculator



A new printer is available for 9800 Series calculators. The 9866A Printer is fast, quiet, and versatile. The Model 66 uses the same proven thermal printing technique used by the smaller strip printers for the Models 10 and 20 Calculators, while providing many of the desirable characteristics of a line printer.

- 64 characters (see Fig. 1)
- 80 characters per line
- 250 lines per minute
- 6 lines per inch (approximately 12 lines in 5 cm)
- full page width (8 3/4 inches; 22,23 cm)

A B C D E F G H I J K L M N O P
Q R S T U V W X Y Z . 1 2 3 4 5
6 7 8 9 0 ( ) + − * / ↑ / = @ ,
? ' & % $ # = ! ; < > [" :]

Fig. 1 CHARACTER SET FOR MODEL 9866A PRINTER

The characters [,] , " , and ; are not available in Model 20 systems using PCI. PCII, however, permits all 64 characters, as do all Model 10 and 30 systems.

Thermal printing paper for the Model 66 is available in 250 foot (76,2 m) rolls. The Model 66 is just as easy to load as the strip printers; simply place the opened roll in the printer and press the paper advance button.

The Model 66 Printer is designed to sit on top of the calculator, or off to one side.

THE DIFFERENT MODEL 66's

There are four configurations in which the printer can be ordered: Option 10, Option 20, Option 30, or Standard.

The various options work with the respective model calculators. (There are differences in the cables and manuals.) The standard, no-option printer is supplied with an unterminated cable and technical interfacing information. *When you order a Model 66 for your calculator, be sure to specify the appropriate option.*

A Model 66, Option 30, will work directly with the Model 30 Calculator; no additional ROM or other equipment is required. The basic Model 30 has the ability to operate the printer, and even has a special place for connecting it, as if the printer were actually part of the calculator.

In Model 10 and 20 Calculator systems, a PC block is required. For Model 10 systems, use an 11264A; Model 20 systems use an 11220A or an 11224A.

USING THE 66

Each model calculator provides means to print both data and messages, and to control the position of each on the page. In addition, there are means to control the form in which numerical data appears (i.e., fixed or floating point, and the number of digits). These ways are too numerous to cover here, save to make some general remarks and give some brief examples.

In Model 20 and 30 systems there are default modes of operation which are simple and easy to use, and which provide the output in certain standard ways.

For complete and sophisticated control of the form and placement of the printed information, *format statements* are used. These statements are used in conjunction with *write statements*. Format statements are composed of a series of *specifications*. These in turn control the appearance of the actual *information to be printed*, which is contained in a write statement.

In Model 10 systems, the capability remains nearly the same. There is a key sequence (FMT 4 8 FMT) which addresses the printer and instructs it to receive the information that is to follow next. Then another key sequence causes the information (either the contents of the X register or a message) to be passed to the printer. Finally, there is a termination sequence that instructs the printer to print what has been sent to it.

There is also a sequence (FMT 4 . w . d) that provides additional control of the appearance of numerical data, beyond what is available with the FIXED and FLOAT keys on the keyboard.

PROGRAM LISTINGS

The 66 can make listings of programs when it is connected in Model 30 systems. (The Model 30 does not have a built-in strip printer.)

As this is written, Model 10 and 20 systems cannot list programs on the 66. An investigation is underway to determine the feasibility of providing special machine language programs to allow this mode of operation.

SELECT CODES

Each 9800 series peripheral has a *select code* that distinguishes that individual peripheral from others connected to the same calculator. In a sense, the select code is the identification of the peripheral, as far as the calculator is concerned.

The Model 66 Option 30 has a permanently assigned select code of 15. Options 10 and 20 have user-adjustable select codes of 1 through 9. When options 10 and 20 are shipped from the factory the select code is preset to 8. ■

```
***** TABLE OF VALUES *****

 X          1/X          X SQUARE          X CUBE          SQRT X

1.0      1.000000      1.000000E+00      1.000000E+00      1.000000
1.1      0.909091      1.210000E+00      1.331000E+00      1.048809
1.2      0.833333      1.440000E+00      1.728000E+00      1.095445
1.3      0.769231      1.690000E+00      2.197000E+00      1.140175
1.4      0.714286      1.960000E+00      2.744000E+00      1.183216

1.5      0.666667      2.250000E+00      3.375000E+00      1.224745
1.6      0.625000      2.560000E+00      4.096000E+00      1.264911
1.7      0.588235      2.890000E+00      4.913000E+00      1.303840
1.8      0.555556      3.240000E+00      5.832000E+00      1.341641
1.9      0.526316      3.610000E+00      6.859000E+00      1.378405
```

Fig. 2 THIS TABLE OF INFORMATION CAN BE PREPARED BY EITHER A MODEL 10, 20, OR 30

```
1 FORMAT F9.1,F13.6,2E18.6,F15.6
10 PRINT TAB24"***** TABLE OF VALUES *****"
20 PRINT
30 PRINT
40 PRINT TAB7"X     1/X     X SQUARE     X CUBE     SQRT X"
50 PRINT
60 FOR X=1 TO 1.9 STEP 0.1
65 IF X#1.5 THEN 70
66 PRINT
70 WRITE (15,1)X,1/X,X↑2,X↑3,SQRX
80 NEXT X
90 PRINT
100 PRINT
110 END
```

Fig. 3 LISTING OF A MODEL 30 PROGRAM

Investment Analysis on the 9830A

The Investment Analysis Program is part of the Business Demonstration package that shows the power, flexibility, and ease of use of the Model 30 Calculator. At the touch of a key, a user can run Investment Analysis, Depreciation Analysis, Mortgage Analysis, Bonds, or Installment Loans.

The Investment Analysis program is very powerful and easy-to-use. At the touch of a key any of the following can be done:

- Enter initial investment.
- Enter cash flows.
- Update or modify cash flows.
- Print summary of investment.
- Calculate and print payback period.
- Calculate and print internal rate of return.
- Calculate and print net present value of the investment for any given cost of capital.
- Print a plot of net present value as a function of the cost capital.
- Run sensitivity analysis on cash flows by increasing or decreasing them by a given percent.

Let's look at a potential investment. For an initial investment of $3,000 there are three annual cash flows. At the end of year one, $1,500; year two, $1,200; and at the end of year three, $1,000.

Here's how to analyze this with the 9830 Investment Analysis Program. Fig. 1 shows the template for the special function keys on this program. To start the program type RUN on the calculator, then press the START special function key.

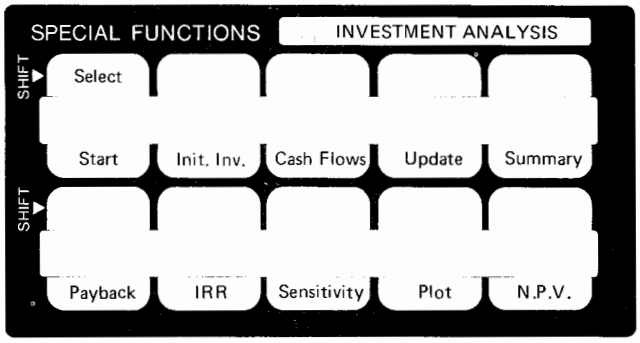


Fig. 1 9830 INVESTMENT ANALYSIS TEMPLATE

Touch the INITIAL INVEST key, the calculator will ask you to type the initial investment. Enter 3000.

Next touch the CASH FLOWS key. The calculator asks, "HOW MANY CASH FLOWS?"; the response is 3. Next the calculator asks how many periods per year. If the cash flows are monthly, the response is 12; if the cash flows are quarterly, the response is 4. In this example, the

```
                I N V E S T M E N T   S U M M A R Y

INITIAL INVESTMENT $ 3000

PERIOD          CASH FLOW
------          ---------
   1          $    1500.00
   2          $    1200.00
   3          $    1000.00
```

Fig. 2 INVESTMENT SUMMARY

cash flows are yearly so the response is 1. Now the calculator asks if the cash flows are to be entered individually or in series. Series input would be the same cash flow for many consecutive periods, for example, $275 for 30 periods. In this example, the cash flows must be entered individually. When the last cash flow is entered, the calculator responds with READY.

It takes just 20 seconds to completely enter this investment. Now the investment can be analyzed. To see a summary of the investment, touch the SUMMARY key. Fig. 2 is the summary table.

To see the payback period, or the amount of time it takes to recover the initial investment given the cash flows, touch the PAYBACK key. Fig. 3 shows the payback result.

The internal rate of return is printed by touching the IRR key. The calculation of internal rate of return is complex, consisting of trial and error approximations. The 9830 calculates this in seconds. Fig. 4 shows the internal rate of return.

Net present value is displayed by touching the NPV key. The calculator asks for the cost of capital then prints the net present value. Fig. 5 illustrates this.

```
      P A Y B A C K    P E R I O D

      2 YEARS      4 MONTHS
```

Fig. 3 PAYBACK PERIOD

```
          I N T E R N A L   R A T E   O F   R E T U R N
INTERNAL RATE OF RETURN  12.16 %
```

Fig. 4 INTERNAL RATE OF RETURN

```
            N E T    P R E S E N T    V A L U E
TYPE IN YOUR COST OF CAPITAL


NET PRESENT VALUE $    211.53 AT   8.00% COST OF CAPITAL
```

Fig. 5 NET PRESENT VALUE

A very valuable tool in investment analysis is a plot of net present value versus cost of capital. This reveals much about the investment in an understandable form. First, the net present value at any cost of capital can easily be seen. Second, the internal rate of return is easy to see since it is the cost of capital where the net present value is zero. Third, different investments can be compared easily by overlaying one plot on another. Touch PLOT to get the plot. Fig. 6 shows a plot of this investment. This plot takes less than ten seconds with the high speed 9866 Printer.

In any investment there is always some uncertainty to the cash flows. It is reassuring to see the effect of variations in the cash flows on the investment, but the task is not easy. The 9830 Investment Analysis Program allows for this. To see the effect of a 10% decrease in the cash flows, touch the SENSITIVITY key. The calculator asks whether there is an increase or decrease and what percent. With these new cash flows, the investment can be reanalyzed. Figs. 7a and 7b are the complete analysis of the investment with a 10% decrease in the cash flows.

Finally, there is an option to correct mistakes or update a particular period's cash flow. To do this touch the UPDATE key. The calculator asks what period is to be changed, displays the current cash flow and asks for the new cash flow.

The remaining key is the SELECT key. It was mentioned earlier that the Investment Analysis program is part of a Business Demonstration Package. Touching the SELECT key puts the calculations in a selection mode where the user can select any of the five programs.

In addition to being a powerful Investment Analysis tool, this program shows the strengths of the Model 30.

Power - High speed printing and calculating.
Flexibility - Easy to modify, easy to develop programs.
Ease of Use - With the special function keys, touch of a key execution.

To find out more about the Model 30, contact your local Hewlett-Packard representative. ●

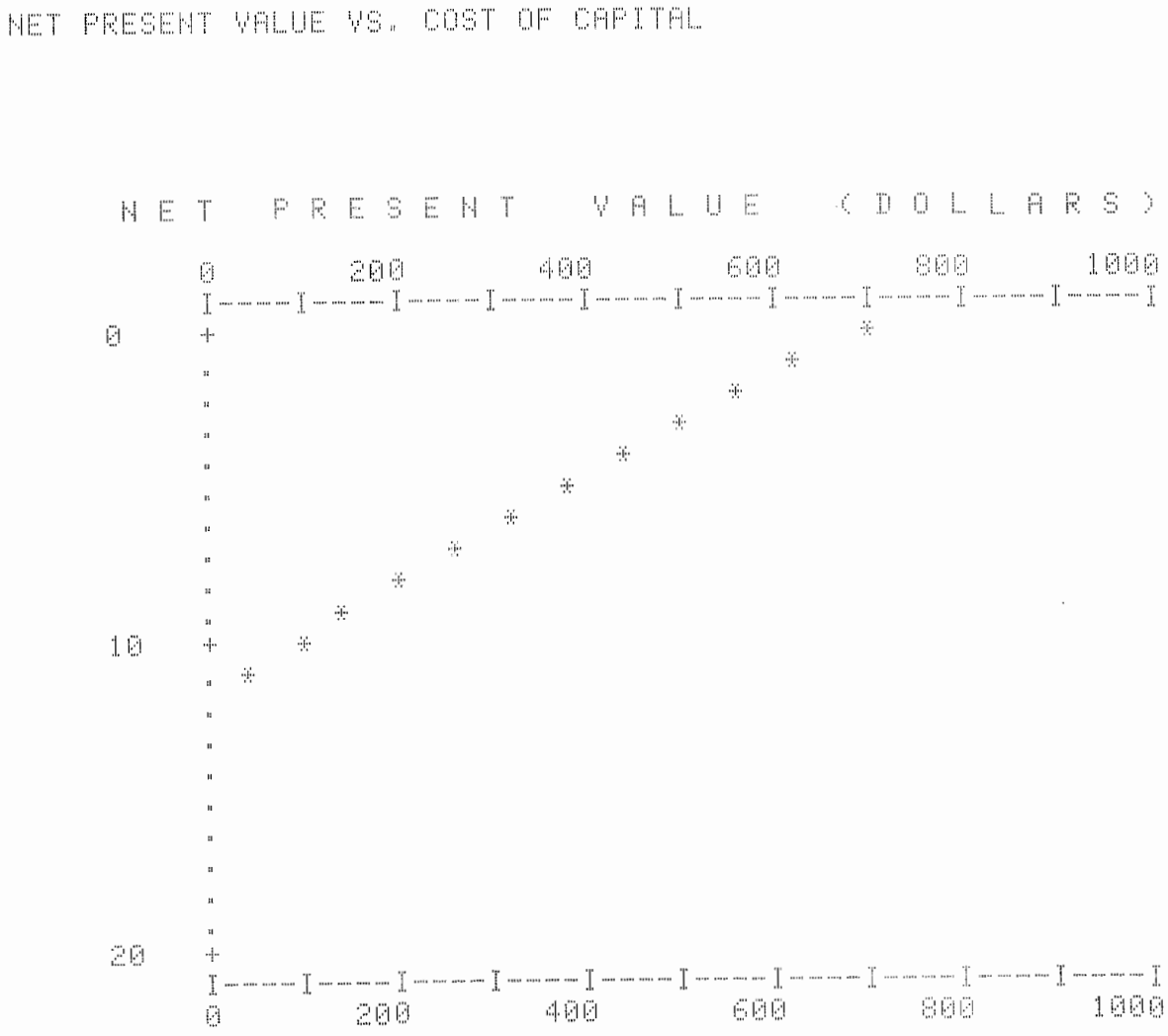


Fig. 6 NET PRESENT VALUE VERSUS COST OF CAPITAL

```
          I N V E S T M E N T    S U M M A R Y

INITIAL INVESTMENT $ 3000

PERIOD          CASH FLOW
------          ---------
   1          $    1350.00
   2          $    1080.00
   3          $     900.00

     P A Y B A C K    P E R I O D

    2 YEARS      8 MONTHS

        I N T E R N A L   R A T E   O F   R E T U R N

INTERNAL RATE OF RETURN   5.81 %

          N E T    P R E S E N T    V A L U E

TYPE IN YOUR COST OF CAPITAL

NET PRESENT VALUE $   -109.63 AT   8.00% COST OF CAPITAL
```

Fig. 7a ANALYSIS OF INVESTMENT AFTER 10% DECREASE IN CASH FLOWS

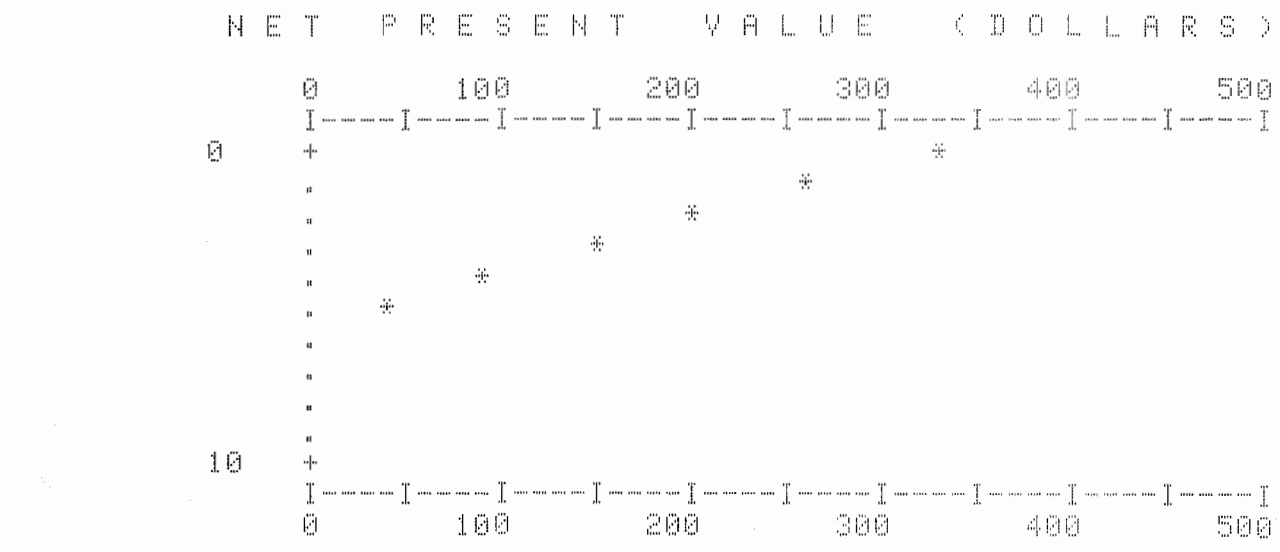


Fig. 7b PLOT OF INVESTMENT AFTER 10% DECREASE IN CASH FLOWS

9800 SYSTEM APPLICATION CONTEST

The contest for the most unusual applications of HP 9800 systems was announced in the last *KEYBOARD*. The rules are repeated here for your convenience.

Two branches of the contest are being held with different time limits to allow participation by users in all countries. A similar prize, a Series 9800 plug-in ROM (Read-Only-Memory) block of the winner's choice will be awarded in each branch. The USA branch of the contest will run until March 15, 1973. The outside-USA branch will run until April 30, 1973. Here are additional rules:

1. Each entry shall be in the form of an article suitable for publication in *KEYBOARD*, and a publication release shall be included.
2. Entries shall be typed double-spaced on paper approximately 8½ by 11 inches (21,6 cm by 27,9 cm).
3. 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 shall be included.
4. Entries shall be submitted to either a field editor or directly to HP *KEYBOARD*, P.O. Box 301, Loveland, Colorado, 80537, postmarked not later than the deadline date.
5. Entries become the property of Hewlett-Packard and cannot be returned.
6. Winners will be notified in advance of publication. Winning articles will be published in *KEYBOARD* following the contest deadline dates.
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.

NEW PROGRAM CATALOGS

Two new program catalogs are now available. The Series 9100 Catalog lists all available programs for the 9100A and 9100B Calculators. The Series 9800 Catalog lists all programs for the 9810A, 9820A, and 9830A Calculators.

A free copy of either catalog may be obtained by indicating your choice on the enclosed reply card.

PART NO.
09820-70006

MODEL 20

HARMONIC ANALYSIS

by Dr. James N. Shapiro* and David Jones

This program will calculate the trigonometric coefficients a_n and b_n of a function f(x) sampled at the n points $x_i = \frac{iT}{n}$, i = 0, 1, ..., n-1, where T is the period. Then f(x) is represented approximately by the trigonometric series

$$f(x) \cong \frac{a_0}{2} + \sum_{k=1}^{n/2-1} a_k \cos\left(\frac{2\pi kx}{T}\right) + \sum_{k=1}^{n/2-1} b_k \sin\left(\frac{2\pi kx}{T}\right) + \frac{1}{2} a_{n/2} \cos\left(\frac{\pi nx}{T}\right) \qquad \text{n even,}$$

Equation 1a

$$f(x) \cong \frac{a_0}{2} + \sum_{k=1}^{(n-1)/2} a_k \cos\left(\frac{2\pi kx}{T}\right) + \sum_{k=1}^{(n-1)/2} b_k \sin\left(\frac{2\pi kx}{T}\right)$$

n odd.

Equation 1b

with a_n and b_n given by

n even

$$a_j = \frac{2}{n} \sum_{i=0}^{n-1} f(x_i) \cos\frac{2\pi ij}{n} \qquad j = 0, 1, 2, ..., n/2$$

$$b_j = \frac{2}{n} \sum_{j=0}^{n-1} f(x_i) \sin\frac{2\pi ij}{n} \qquad j = 1, 2, ..., n/2-1$$

n odd

$$a_j = \frac{2}{n} \sum_{i=0}^{n-1} f(x_i) \cos\frac{2\pi ij}{n} \qquad j = 0,1,2,...,(n-1)/2$$

$$b_j = \frac{2}{n} \sum_{j=0}^{n-1} f(x_i) \sin\frac{2\pi ij}{n} \qquad j = 1,2,...,(n-1)/2$$

with $b_0 = 0$ by definition, in both cases.

An algorithm developed by G. Goertzel is used to perform the summations in Eqn. 1. This algorithm reduces the number of operations substantially by requiring only one trigonometric calculation --- $\cos\frac{2\pi}{n}$.

When used with the basic 9820A up to 122 data points may be handled. The corresponding number for the expanded memory model is 378. It is to be noted that this program incorporates its own routine for calculating $\sin\frac{2\pi}{n}$ and $\cos\frac{2\pi}{n}$, and thus does not require a math block. If a math block is available these lines may be modified or eliminated as necessary increasing the number of available storage registers.

*See *KEYBOARD* Vol. 4, No. 2, page 13 for curriculum vitae.

REFERENCES

1. C. Lanczos, *Applied Analysis*, (New Jersey: Prentice-Hall, Inc., 1964), pp. 130-137.
2. Ralston and Wilf, *Mathematical Methods for Digital Computers*, Volume I (New York: John Wiley and Sons, Inc., 1967), pp. 258-262.

Editor's Note: This complete program is available through the Calculator Program Catalog.

With n = 20 the input waveform is the symmetric triangular function

$$f(x_i) = \frac{i\pi^2}{2n} \qquad 0 \leqslant i \leqslant \frac{n}{2}$$

$$= \frac{\pi^2}{2n} \ (n\text{-}i) \qquad \frac{n}{2} \leqslant i \leqslant n$$

$$f(x_i) = \frac{\pi^2}{40} \ (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1)$$

The Fourier series for this triangular function is

$$f(x) = \frac{\pi^2}{8} - (\cos \frac{2\pi x}{T} + \frac{1}{9} \cos \frac{6\pi x}{T} + \frac{1}{25} \cos \frac{10\pi x}{T} + \ldots)$$

COEFFICIENTS

N	AN	BN
0	0.00000	
	2.46740	
	0.00000	
1	1.00000	
	-1.00827	
	-.00000	
2	2.00000	
	.00000	
	.00000	
3	3.00000	
	-.11971	
	-.00000	
4	4.00000	
	.00000	
	.00000	
5	5.00000	
	-.04935	
	-.00000	
6	6.00000	
	.00000	
	.00000	
7	7.00000	
	-.03108	
	-.00000	
8	8.00000	
	.00000	
	.00000	
9	9.00000	
	-.02529	
	-.00000	
10	10.00000	
	.00000	
	.00000	

EXAMPLE 2

Input here is a shifted δ function

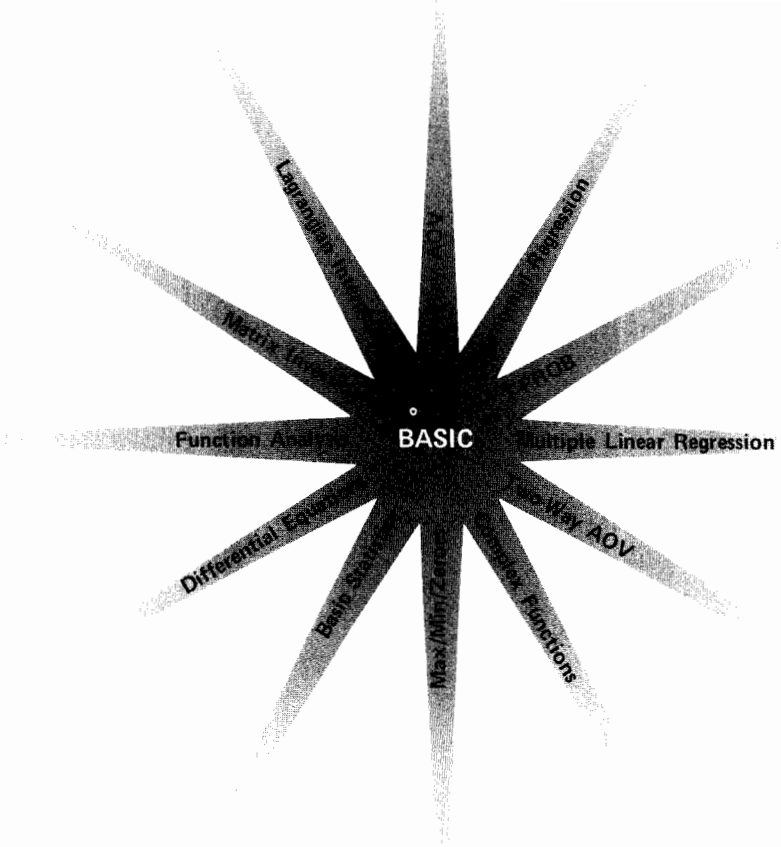
$$f(x_i) = \frac{n}{2}\ \delta(x_i - \frac{T}{n}) \text{ with } n = 10 \text{ or } f(x_i) = (0,5,0,0,0,0,0,0,0,0)$$

```
COEFFICIENTS
     N
     AN
     BN

    0.00000
    1.00000
    0.00000

    1.00000
     .80902
     .58779

    2.00000
     .30902
     .95106

    3.00000
    -.30902
     .95106

    4.00000
    -.80902
     .58779

    5.00000
   -1.00000
    -.00000
```

The output is easily shown to be

$$\begin{matrix} a_j \\ b_j \end{matrix} = \begin{Bmatrix} \cos \\ \sin \end{Bmatrix} \frac{2\pi j}{10}$$

L. David Jones is a senior undergraduate student majoring in geophysics at Texas A&M University. His primary academic interests are in computer processes for improving geophysical data quality, and numerical analysis techniques. He is a student member of the Society of Exploration Geophysicists. Currently, he is employed by the geophysics department as a programmer and plans to do graduate work at Texas A&M. His hobbies include reading and classical music.



Model 30 Program Pacs

"FLEXIBILITY" is the word for the Model 9830 program packages. The Special Function Keys allow each program to define up to 20 immediately executable subprograms, all at the user's fingertips. The programs in these packages are much more complete than most "stand-alone" programs. This means increased flexibility to the user. Their design is a result of experience gained from prior program packages, suggestions from actual users, and consultation from experts in their particular field. These program packages, together with the vast selection of published BASIC programs, make the 9830 an extremely versatile calculating tool.

Program packages for the Model 30 differ from those offered for the previous models. A Model 30 program package bears a five-digit number with a suffix, such as 98300A, and consists of a prerecorded tape cassette, an overlay for the definable keys, and a printed book of complete program descriptions. The book may also be purchased separately. Currently-available program pacs for the Model 30 are described below.

MODEL 30 MATH PAC
PROGRAM LISTING
Overall-Pac Part Number 98300A
Printed-Book-Only Part Number 09830-70000

1. Complex Functions

   This program transforms the special function keys into a complex calculator, allowing the user to add, subtract, multiply, and divide complex numbers. In addition, exponential and trigonometric functions of complex variables may be evaluated.

2. Lagrangian Interpolation

   This program takes the X and Y coordinates of a set of data points, and interpolates the value of Y at any given X coordinate.

3. Function Analysis (4K)

   Given any function which can be defined in closed form, this program finds its maximums, minimums, and zeros over a given range of the argument.

In addition, the function, its derivative, or its integral may be evaluated at a point, tabulated over a range, or plotted (with or without printed coordinate values).

4. Function Analysis (2K)

   Given any function which can be defined in closed form, the function, its derivative, or its integral may be evaluated at a point, tabulated over a range, or plotted (with or without printed coordinate values).

5. MIN/MAX/ZEROS

   Given any function which can be defined in closed form, this program finds its minimums, maximums, and zeros over a given range of the argument.

6. Differential Equations

   This program solves the initial value problem for a first or second order differential equation using the second order Runge-Kutta method.

7. Polynomial Regression

   This program calculates the coefficients of a polynomial (up to 6th degree) using a least-squares fit. Basic statistics on the data, r-square measure of fit, and tables of calculated values may also be obtained.

8. Basic Statistics, Histogram

   This program takes raw data and calculates the mean, standard deviation, skewness, and kurtosis for the input data. A histogram and/or histogram with normal curve overlay may be plotted and cell statistics may be printed.

9. Matrix Inversion

   This program takes an N x N square matrix and computes its inverse and determinant, with printed input and results. The matrix inversion routine is also available for use within a user program. The program employs a modified Gauss-Jordan reduction technique.

10. Additional Functions

    28 defined functions may be used alone or as part of the user's program. They are, for the most part, the more common mathematical functions that are not available in the standard BASIC compiler of the 9830.

MODEL 30 STAT PAC, VOLUME 1
PROGRAM LISTING
Overall-Pac Part Number 98301A
Printed-Book-Only Part Number 09830-70800

1. Polynomial Regression

   This program will fit a least squares polynomial of degree k where $k \leqslant 9$ to data points (x,y). The user has the following options:

   1. Transform either x or y, or both x and y.
   2. Plot input data.
   3. Print means, variances, and correlation coefficient of input data, and of transformed data.
   4. Calculate and print a preliminary analysis of variance table to aid in the selection of regression degree.
   5. Select or change degree of regression for any degree up to, and including, a specified maximum.
   6. Calculate and print an analysis of variance table for the selected degree.
   7. Calculate and print regression coefficients for a selected degree of regression, together with their standard error and t-value.
   8. Calculate and print R-square, the multiple correlation coefficient.
   9. Plot a regression equation.
   10. Correct incorrectly entered data.
   11. A table of residuals may be calculated and printed for a given degree of regression.
   12. Standardized residuals may be plotted.
   13. The Durbin-Watson statistic may be calculated and printed.
   14. The plot range may be changed for doing different regressions over different ranges of x without replotting the axes.

2. One Way AOV

   This program analyzes data from an unbalanced one way classification. The user options include printing all statistics, Bartlett's test for homogeneity of variance, a complete AOV table, F-prob for calculated F values, comparisons between means, and ability to add, delete, or correct data.

3. Two Way AOV

   This program analyzes the source of variation in a two way table of data with one of more replications. The user options include data correction, cell means and variances, overall mean, row means and column means, AOV table including interaction sum of squares and F-test for interaction, AOV table, pooling interaction sum of squares and error sum of squares, Tukey's test for interaction, and row and column contrasts.

4. F-Prob

   Given numerator degrees of freedom, V_1, and denominator degrees of freedom, V_2, and an F-value, this program calculates the probability that an F random variable has a value greater than, or equal to, the input value.

5. T-Prob

   Given a t-value with n degrees of freedom, this program calculates the probability that a T random variable is greater than, or equal to, the input value.

MODEL 30 STAT PAC, VOLUME 2 PROGRAM LISTING

Overall-Pac Part Number 98302A

Printed-Book-Only Part NUmber 09830-70825

1. Multiple Linear Regression

   This program determines a least squares regression of a variable y on a set of k independent variables $x_1, ..., x_k$ where $k \leqslant 12$. The equation is of the form:

$$y = b_0 + b_1 x_1 + ... + b_k x_k .$$

The user has the following options:

1. Output:
   - A table of means and variances of all variables.
   - Correlation matrix.
   - A complete AOV table.
   - Regression coefficients with estimates of their variances and t-values.
   - Residuals.
   - Durbin-Watson statistic.
2. Other options:
   - Various transformations of the input data.
   - Data correction.
   - A stepwise procedure for building a model.

MODEL 30 STRUCTURES PROGRAMS

A series of powerful structural design programs is being prepared. Here is a partial listing.

1. Modified Moment Distribution--up to 20 spans, co-planar, variable section.
2. Multistory Moment Distribution--up to 50 stories; includes sidesway due to gravity, seismic, and wind loads; members may be variable section.
3. Reinforced Concrete--preliminary design and final analysis for columns, beams, slabs, T's, L's (per ACI 318-71).
4. Design and Analysis of Steel Beams and Columns (per AISC-1970).
5. Three-Dimensional Beam Analysis--constant section.
6. Ring, Portal and Gable Frame Analysis--variable section.
7. Pre/Post-Processing of Information for Large Computers.
8. Grade Beam Analysis--variable section.
9. Prestressed Concrete Beam Design--full design capability for beams for various cross-section types.
10. Perspective drawings. ■

CORRECTION

A group of words was omitted from the conclusion of Mark Metcalf's article on orbiting bodies in *KEYBOARD* Vol. 4, No. 3. The third sentence on page 10 should read: The relationship can be expressed by saying that the average velocity of a planet is inversely proportional to the average radius of orbit of the given planet.

PART NO.
09810-70006

MODEL 10

LAGRANGIAN INTERPOLATION
(for n points, n ≤ 21)

by Jean-Pierre Borgogno

This program performs Lagrangian interpolation over a set of n data points for n ⩽ 21. It takes less memory and is faster in operation than program III-8 of the Model 10 Math Pac.

EXAMPLES

1. $y = \frac{x^2}{10}$; n = 11

X	Y
-10	10
-8	6.4
-6	3.6
-4	1.6
-2	0.4
0	0
2	0.4
4	1.6
6	3.6
8	6.4
10	10

Find y at x = 3.5, x = 0.35, x = 0.035.

```
-10.000000000
 10.000000000

 -8.000000000
  6.400000000

 -6.000000000
  3.600000000

 -4.000000000
  1.600000000

 -2.000000000
  0.400000000

  0.000000000
  0.000000000

  2.000000000
  0.400000000

  4.000000000
  1.600000000

  6.000000000
  3.600000000

  8.000000000
  6.400000000

 10.000000000
 10.000000000

 11.000000000


  3.500000000
  1.225000000

  0.350000000
  0.012250000

  0.035000000
  0.000122500
```

Editor's Note: This complete program is available through the Calculator Program Catalog.

2. $y = -x^2$; n = 6

X	Y
1	-1
2	-4
3	-9
4	-16
5	-25
6	-36

```
 4.00000000
-16.00000000

 5.00000000
-25.00000000

 6.00000000
-36.00000000
```

Find y at x = 2.5, x = 2.85, x = 6.2.

```
 6.00000000
```

```
 1.00000000
-1.00000000

 2.00000000
-4.00000000

 3.00000000
-9.00000000
```

```
 2.50000000
-6.25000000

 2.85000000
-8.12250000

 6.20000000
-38.44000000
```

Born: November 24, 1941, Beaulieu-sur-mer (NICE, France)

Studies: Mathematics--ECOLE NORMALE SUPERIEURE de SAINT-CLOUD (University of Paris/Licence + Diplôme d'études supérieures)

Prof.: Professor of Mathematics (I.U.T. dept. "MESURES PHYSIQUES")

PART NO.
09810-70008

MODEL 10

CORRECTION OF ENTRIES-Math Pac IV-6

by M. A. Nouel P.

This program is an enhanced version of the "Gauss-Jordan Elimination for the Solution of Simultaneous Linear Equations, N ⩽ 9" (program IV-6 of the Model 10 Math Pac). It allows changing any incorrect input items prior to the final listing of the solution. Consequently, all the data can be entered, checked, and corrected without reentering all the values. The original program allowed for manual correction by loading the data into particular registers. However, this modified program places the entries in the correct registers automatically, given the row, column, and the data item.

EQUIPMENT NEEDED

- [X] PRINTER
- [ ] 9860A MARKED CARD READER
- [ ] 9861A TYPEWRITER
- [ ] 9862A PLOTTER

TOTAL REGISTERS		TOTAL PROGRAM STEPS	
[X] 51	or	[X] 500	
[X] 111		[ ] 1012	
		[ ] 2036	

ROM'S
1 _____
2 _____
3 _____

STEP	USER INSTRUCTION	DISPLAY x	y	z
	Press: END			
	LOAD Program			
	Press: END			
	Press: CONTINUE	0	1	0
1	Enter: N(N ⩽ 6 or 9)	N		
2	Press: CONTINUE	0	j	i
3	Enter: Aij	Aij	j	i
	Repeat step 3 for j = 1 to N			
	When display contains, 00i enter Ci	0	0	i
	Press: CONTINUE			
	Enter every term Aij & Ci	0	j	i
	After all elements have been entered 0, 0, 0 will appear on display.	0	0	0
4	If any element is to be changed press SET FLAG and enter: i, j, & Aij	Aij	j	i
	or i, 0, & Ci	Ci	0	i
	Press: CONTINUE	0	0	0
	It is necessary to press SET FLAG for every wrong entry you want to			
	correct.			
	If there is no correction or if the corrections are completed, press			
	CONTINUE.	D	2	0
5	If desired, change Fix-Float setting, press CONTINUE: Print D			

Editor's Note: This complete program is available through the Calculator Program Catalog.

6	Press CONTINUE	x1	1			
		x2	2			
		.	.			
		.	.			
		.	.			
		xn	n			
7	To read the results again press GO TO, 4, 3, 0, CONTINUE, CONTINUE,					
	CONTINUE.					

EXAMPLE

7 linear equations in 7 unknowns.

Correct data	Data as keyed in		Correct data	Data as keyed in	
1.00*	1.00*		1.00*	1.00*	
1.00*	1.00*		2.00*	2.00*	
1.00*	1.00*		3.00*	3.00*	
1.00*	1.00*		4.00*	4.00*	
1.00*	1.00*		5.00*	5.00*	
1.00*	1.00*		5.00*	5.00*	
1.00*	7.00*	a	5.00*	5.00*	
1.00*	2.00*	b	5.00*	5.00*	
1.00*	1.00*		1.00*	1.00*	
2.00*	3.00*	c	2.00*	2.00*	
2.00*	2.00*		3.00*	3.00*	
2.00*	2.00*		4.00*	4.00*	
2.00*	2.00*		5.00*	5.00*	
2.00*	2.00*		6.00*	6.00*	
2.00*	2.00*		6.00*	6.00*	
2.00*	2.00*		6.00*	6.00*	
1.00*	1.00*		1.00*	1.00*	
2.00*	2.00*		2.00*	2.00*	
3.00*	3.00*		3.00*	3.00*	
3.00*	3.00*		4.00*	4.00*	
3.00*	3.00*		5.00*	5.00*	
3.00*	3.00*		6.00*	6.00*	
3.00*	3.00*		7.00*	8.00*	d
3.00*	3.00*		7.00*	7.00*	
1.00*	1.00*	D	1.00	1.00	
2.00*	2.00*				
3.00*	3.00*	X_1	0.00	0.00	
4.00*	4.00*	X_2	0.00	0.00	
4.00*	4.00*	.	0.00	0.00	
4.00*	4.00*	.	0.00	0.00	
4.00*	4.00*	.	0.00	0.00	
4.00*	4.00*	.	0.00	0.00	
		X_7	1.00	1.00	

Corrections keyed as:

	X	Y	Z
a	1	7	1
b	1	0	1
c	2	2	2
d	7	7	7

Remember to SET FLAG before entering each correction.

Manuel A. Nouel P. obtained a B.S. in Civil Engineering from Universidad Católica Andrés Bello, Caracas, Venezuela in 1966, and an M.S. in Engineering from the University of California, Berkeley, in 1970. He has worked for a Spanish consulting company EDES, S.A. and is now a consulting engineer with Nouel Ingenieros C.A. in Venezuela. His primary interests are in coastal engineering and maritime studies.

CORNER

MODEL 20

PART NO.
09820-75801

COMPLEX NUMBER ARITHMETIC

by Bill Haselmire*

This program is useful in illustrating complex number manipulations in the classroom. It will perform the following operations:

1. Addition or subtraction of any number of vectors.
2. Vector multiplication.
3. Vector division.
4. Rectangular to polar conversion.
5. Polar to rectangular conversion.

ROM BLOCKS

1	2	3
UDF	MATHEMATICS	

INTERNAL REGISTERS

☐ 173 ☒ 429

PERIPHERALS

☐ 9860A MARKED CARD READER ☐ 9862A PLOTTER ☐ 9864A DIGITIZER ☐ _____

☐ 9861A TYPEWRITER ☐ 9863A PAPER TAPE READER ☐ 9865A CASSETTE ☐ _____

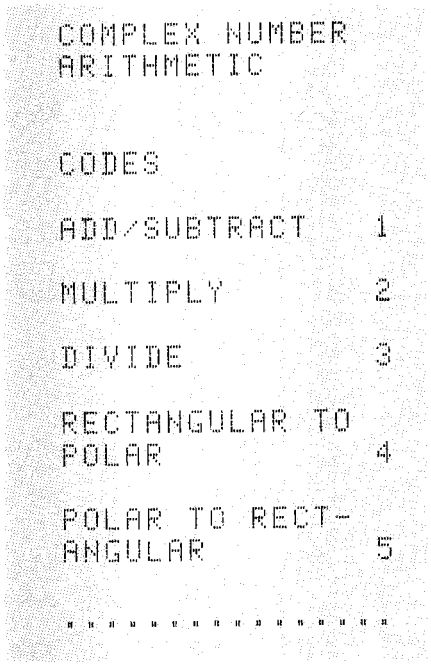
STEP	DISPLAY	INSTRUCTIONS
1		ERASE LOAD EXECUTE
2		Insert magnetic cards until NOTE 14 no longer appears.
3		END RUN PROGRAM
4	CODE =	Decimal setting is at 3. (Optional: FIXED N n EXECUTE or FLOAT N n EXECUTE)
		Codes are: 1 Add/Subtract
		2 Multiply
		3 Divide
		4 Rectangular to Polar
		5 Polar to Rectangular
		RUN PROGRAM
5A		IF CODE 1
	X = ?	X RUN PROGRAM
	Y = ?	Y RUN PROGRAM
	Z = ?	Z RUN PROGRAM
		Prints out X, Y, and Z then returns to line 5A for next Vector entry. After all data is entered, press RUN PROGRAM. For new case, return to step 4.
5B		IF CODE 2
	X =	X RUN PROGRAM
	Y =	Y RUN PROGRAM
		Prints out Ax and Ay
	X =	X RUN PROGRAM
	Y =	Y RUN PROGRAM
		Prints out Bx and By. Then prints product, angle, and X and Y components of resultant vector. For new case, return to step 4.

*Hewlett-Packard, Englewood, Colorado.

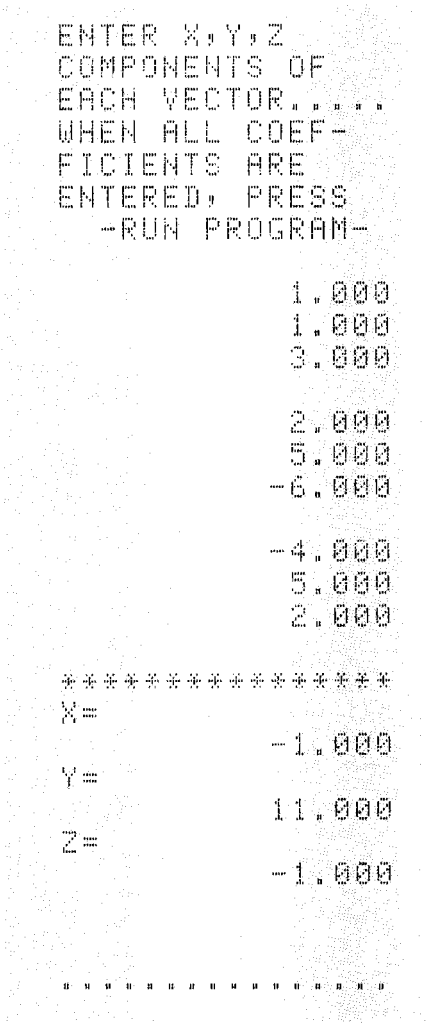
Editor's Note: This complete program is available through the Calculator Program Catalog.

STEP	DISPLAY	INSTRUCTIONS
5C		IF CODE 3
	X =	X RUN PROGRAM
	Y =	Y RUN PROGRAM
		Prints Ax and Ay
	X =	X RUN PROGRAM
	Y =	Y RUN PROGRAM
		Prints out Bx and By. Then prints quotient, angle, X and Y components of resultant vector. For new case, return to step 4.
5D		IF CODE 4
	X =	X RUN PROGRAM
	Y =	Y RUN PROGRAM
		Prints out magnitude and angle of vector. For new case, return to step 4.
5E		IF CODE 5
	MAGNITUDE = ?	Enter n
	ANGLE = ?	Enter angle (degrees)
		Prints out X and Y coordinate values. For new case, return to step 4.

EXAMPLES



Addition/Subtraction



Multiplication

```
ENTER X,Y COM-
PONENTS OF VEC-
TOR A
              3.000
              4.000

ENTER X,Y COM-
PONENTS OF VEC-
TOR B
              6.000
              8.000

****************

MAGNITUDE=
             50.000
ANGLE(DEG.)=
            106.260
.......OR.......
X=
            -14.000
Y=
             48.000
```

Division

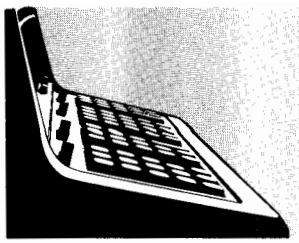
```
.................
ENTER X,Y COM-
PONENTS OF VEC-
TOR A

            -3.000
            -4.000

ENTER X,Y COM-
PONENTS OF VEC-
TOR B
              6.000
             -8.000

****************

MAGNITUDE=
               .500
ANGLE=
           286.260
.......OR.......
X=
               .140
Y=
             -.480
```

Rectangular to Polar

```
.................
ENTER X,Y COM-
PONENTS OF VEC-
TOR

            -3.000
            -4.000
****************
MAGNITUDE=
             5.000
ANGLE(DEG.)=
           233.130
```

Polar to Rectangular

```
.................
MAGNITUDE =
            10.000
ANGLE=
           -53.000
****************
X COORD.=
             6.018
Y COORD.=
            -7.986









.................
```



MULTIPLE 2-POINT GAUSSIAN INTEGRATION

PART NO. 09100-70092

by A. D. Williams

This program is a subroutine to determine $\int_a^b f(x)dx$ by using a two-point Gaussian integration formula over N strips. Gaussian integration, in general, gives higher accuracy with fewer function evaluations than Simpson's rule, and is useful in some cases where an integral cannot be evaluated by Simpson's rule; e.g., $\int_0^1 \ln(x)dx$.

The subroutine must be called by a main program which loads the upper limit, the lower limit, and the allowable error, ϵ, into specified storage registers. On return, the main program takes the result from the y register for display or further calculations.

The subroutine calculates f(x) from a value of x in the y register, and returns f(x) to the y register. It must terminate with a "RETURN" instruction. The accumulator registers are also available for use in the main program, or in a function subroutine. Unused spaces should be filled with "CONTINUE's" to avoid possible difficulties in recording on magnetic cards; do not use the "END" instruction in the main program.

It is advisable to carry out first calculations using low accuracy, say $\epsilon = 0.01$, because calculation time may be excessive when too small a value of ϵ is used.

Two calculations are carried out initially, one with N = 8, then one with N = 16. If these integrals differ by more than 15ϵ, the next integration takes place with N = 32. The process is repeated (the screen displays, momentarily, at the end of each integration) until two successive integrals differ by less than 15ϵ. If I_2 is the final integral calculated, and I_1 the penultimate value, the result returned in the y register is $(I_2 + (I_2 - I_1)/15)$.

Example 1 calculates $\int_a^b e^{2x}dx$

(a)	$b = 2, a = 0, \epsilon = 0.01$	Result 26.79907486
(b)	$b = 2, a = 0, \epsilon = 10^{-9}$	Result 26.79907502 (takes about 2 minutes)

Example 2 calculates $\int_0^1 [\ln(x)]^3 dx$

$b = 1, a = 0, \epsilon = 0.01$ Result -5.83131621

This is slow, and not very accurate with this tolerance setting; the value should be -6. However, this integral cannot be evaluated by program 09100-70409, Simpson's rule, with the lower limit set at zero.

A. D. Williams received his B.Sc. Mathematics from London University. He worked as Assistant Technical Officer in the I.C.I. (Imperial Chemical Industry) Research Laboratories from 1947 to 1952, and as a Geophysical Observer for the Ray Geophysical Company, Houston from 1952 to 1958.

From 1958 to 1970, Mr. Williams lectured in Mathematics at the University College, Nairobi. He is now a Senior Lecturer at Didsbury College of Education, Manchester.

Editor's Note: This complete program is available through the Calculator Program Catalog.

PROGRAMMING TIPS

PEN DROP CONTROL FOR 9810A

This routine by Dr. James Lindauer, MD of San Francisco General Hospital, overrides the pen drop when proceeding to the first point plotted, then allows plotting of a solid or dashed line. This applies to the Model 10 with the plotter ROM.

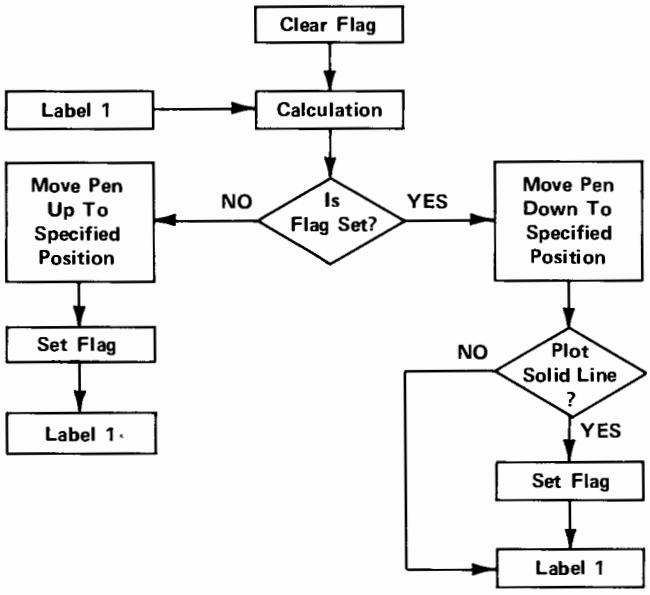


Fig. 1 Flow Chart

Sample Program

The routine has been incorporated into a program to plot the line X = Y, in increments of 100 until Y = 9000.

```
0000-- 9 ---11
0001-- 9 ---11
0002-- 9 ---11
0003-- 9 ---11
0004-- UP---27
0005--CLX---37
0006--FMT---42
0007-- 1 ---01
0008-- 2 ---02
0009--FMT---42
0010-- 1 ---01
0011-- 3 ---03
0012--CLR---20
0013--STP---41
0014--XTO---23
0015-- 0 ---00
0016--LBL---51
0017-- 1 ---01
0018-- 9 ---11
0019-- 0 ---00
0020-- 0 ---00
0021-- 0 ---00
0022-- UP---27
0023-- a ---13
0024--X>Y---53
0025--STP---41
0026--CNT---47
0027--CNT---47
0028--CNT---47
0029-- 1 ---01
0030-- 0 ---00
0031-- 0 ---00
0032--XTO---23
0033-- + ---33
0034-- a ---13
0035--XTO---23
0036-- + ---33
0037-- b ---14
0038-- a ---13
0039-- UP---27
0040-- b ---14
0041--IFG---43
0042--GTO---44
0043--LBL---51
0044-- a ---13
0045--CNT---47
0046--SFL---54
0047--FMT---42
0048-- 1 ---01
0049-- UP---27
0050--CNT---47
0051--GTO---44
0052--LBL---51
0053-- 1 ---01
0054--LBL---51
0055-- a ---13
0056--FMT---42
0057-- 1 ---01
0058-- DN---25
0059--CNT---47
0060--XFR---67
0061-- 0 ---00
0062-- UP---27
0063-- 1 ---01
0064--X=Y---50
0065--GTO---44
0066--LBL---51
0067-- 1 ---01
0068--CNT---47
0069--SFL---54
0070--GTO---44
0071--LBL---51
0072-- 1 ---01
0073--END---46
```

PROGRAMMING TIPS (Continued)

EXTENDING MODEL 10 LAGRANGIAN INTERPOLATION

M. Jean-Pierre Borgogno of Marseilles, France, sent this suggestion for modifying the Lagrangian Interpolation program, III-8 in the Model 10 Math Pac, to compute up to n = 19. It consists of changing four program steps:

Existing Step			Change To	
Step	Key	Code	Key	Code
0015	2	02	3	03
0016	3	03	0	00
0092	2	02	3	03
0093	3	03	0	00

EXAMPLE: $y = \frac{x^2}{4}$, n = 19

Find y at x = 2.50
x = 7.50
x = 18.50
x = 19.50

```
 1.00*
 0.25

 2.00*
 1.00

 3.00*
 2.25

 4.00
 4.00

 5.00*
 6.25

 6.00*
 9.00

 7.00*
12.25

 8.00*
16.00

 9.00*
20.25

10.00*
25.00

11.00*
30.25

12.00*
36.00

13.00*
42.25

14.00*
49.00

15.00*
56.25

16.00*
64.00

17.00*
72.25

18.00*
81.00

19.00*
90.25



 2.50*
 1.56

 7.50*
14.06

18.50*
85.56

19.50*
95.06
```