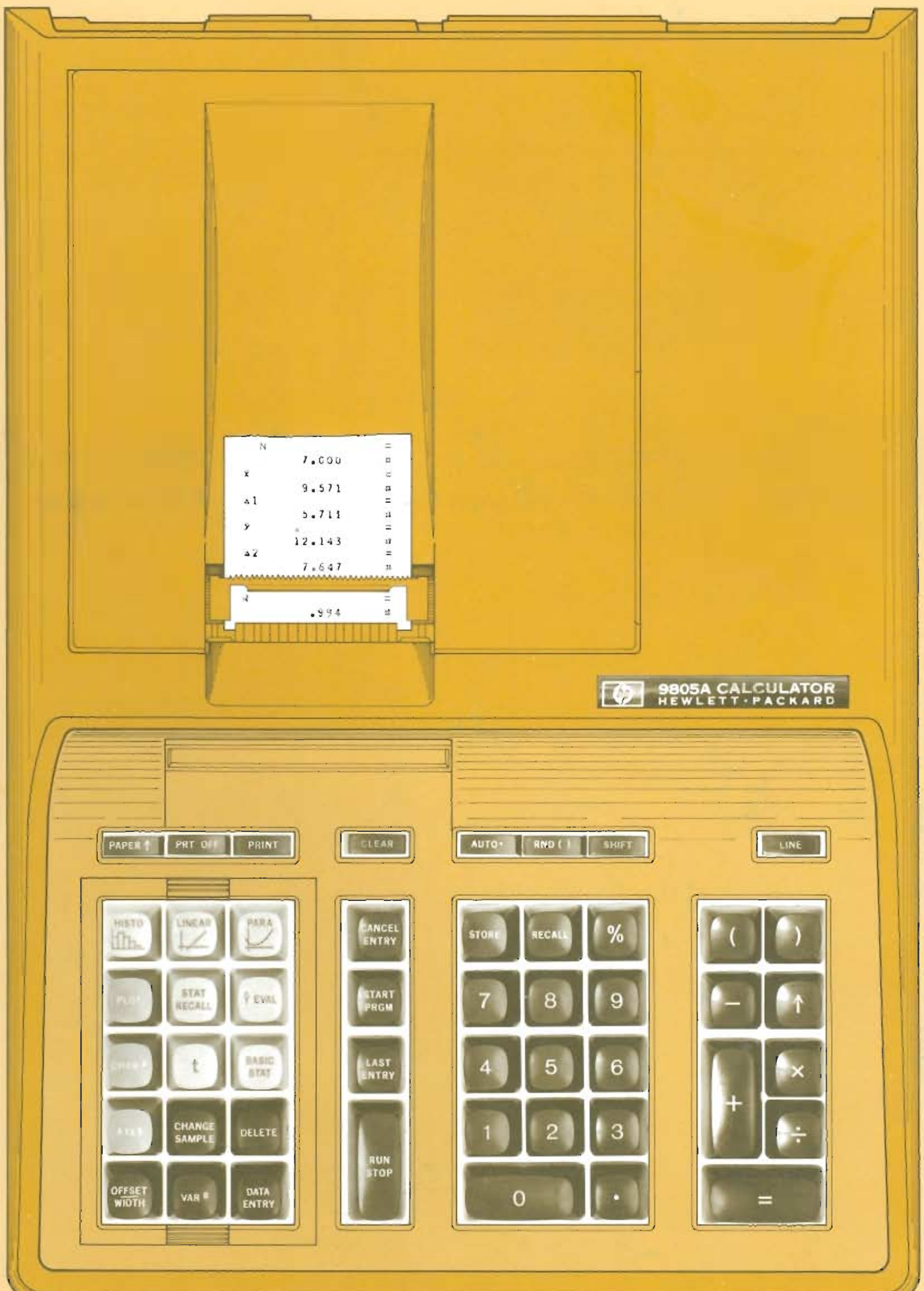
HEWLETT-PACKARD

KEYBOARD

VOL. 5 NO. 2



APPLICATIONS INFORMATION
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MODEL 20 CALCULATOR USERS' CLUB

Every Model 9820A Calculator user has the opportunity of joining the Model 20 Calculator Users' Club (CUC) and thus make use of a large and sophisticated software reservoir. The CUC has been operating in Europe for some time, and it is being extended to include Model 20 users in other countries.

The Model 20 Calculator Users' Club is based on an exchange system, in which one submitted program entitles the contributing user to select a copy each of five programs from the central CUC program file. The programs are unpublished, and are not generally available except through the CUC.

CUC members receive a program catalogue and monthly information on the latest programs sent to the club. A prize is awarded from time to time, the winner being selected by a drawing from the list of users who submitted a program to the CUC program file.

If you would like to join the Model 20 Calculator Users' Club, mail your request and your unpublished Model 20 program directly to:

Model 20 Calculator Users' Club
Hewlett-Packard GmbH
703 Böblingen
Postfach 250
Germany

TO HP *KEYBOARD* READERS

For the third consecutive issue, this *KEYBOARD* features a new Hewlett-Packard calculator. The Model 9805A, called the Number Cruncher, shown on the front cover and described in the article starting on page 2, is a dedicated statistical calculator. It solves everyday statistics problems without external programming. It is a desktop unit that is smaller and more portable than the Model 10, 20, or 30. If you are a statistician or if statistics is an integral part of your vocation, we think you will like its ability to solve general mathematical as well as statistical problems.

The winners of the 9800 System Application Contest will be announced and the winning entries published in *KEYBOARD* Vol. 5, No. 3. We wish to thank the contestants for submitting their excellent entries.

Since the *KEYBOARD* mailing list for the U.S.A. and other non-European countries has become complex and out-of-date, we would appreciate your completing and returning the appropriate *KEYBOARD* verification form in the center of this issue *for readers in those countries*. This will ensure your continuing to receive *KEYBOARD*. If we do not receive your verification, we will assume that you are no longer there or are no longer interested, and will discontinue your subscription.

Although the selection of programs for HP calculators is large, there is a continuing need for new programs in many fields. If you have an interesting program that is not available through the Calculator Program Catalog, send it to us for evaluation and possible publication in *KEYBOARD* or the Program Catalog. Programming tips and articles describing your interesting experiences with an HP calculator system are also welcome at any time.

R.B. Sperry

Statistical Analysis at your desk

HP MODEL 9805A

On April 9, 1973 Hewlett-Packard Company introduced the newest member of the 9800 Series calculators. The official number is 9805A, but this calculator also has a nickname: the NUMBER CRUNCHER. It combines the calculating power of a large system with the simplicity of a small desk calculator.

The Model 5 is a dedicated statistics calculator. It calculates everything from mean and standard deviation to histograms and curve fitting, all at the press of a single key. There are no magnetic cards to load, no programs to write, and no languages or new terminology to learn. The words and symbols used on the keyboard and on the printed listing are standard statistical terms. For entering data there is a DATA ENTRY key; for generating a histogram for a set of data there is a HISTO key; when a mean is output the symbol $\overline{x}$ or $\overline{y}$ is printed; and when a goodness-of-fit coefficient is output, the symbol r^2 is printed. The Model 5 was designed for your convenience.

FIVE POWERFUL SYSTEMS

There are four variations of the basic Model 5, each one a complete system.

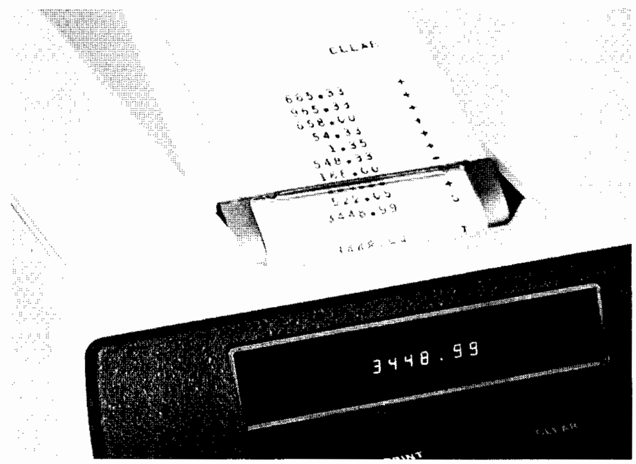
SYSTEM 1

BASIC STAT CALCULATOR

- printer
- built-in stat keys to calculate:
  - -mean, standard deviation of single data array.
  - -means, standard deviation, correlation coefficient of 2-variable array.
  - -best fit straight line of the form $y = A + Bx$
  - -best fit parabolic curve fit $y = A + Bx + Cx^2$.
  - -ten cell histogram including frequency and relative percent frequency.
  - -students t for both grouped and ungrouped data.
- built-in mathematical functions

SYSTEM 2

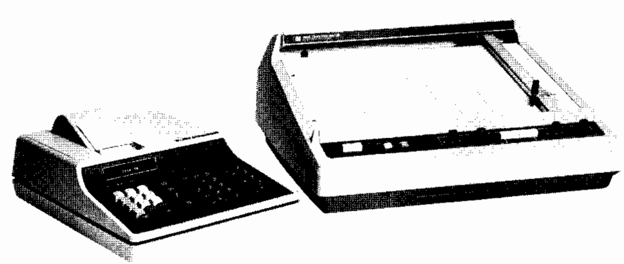
BASIC STAT CALCULATOR
WITH DISPLAY



- printer
- same calculations as System 1
- 10 character light emitting diode display.

SYSTEM 3

PLOTTING STAT CALCULATOR



- compatible with HP 9862A Plotter (ordered separately)
- plots linear and parabolic curve fits and histograms with calibrated axes.
- printer
- same calculations as System 1
- display

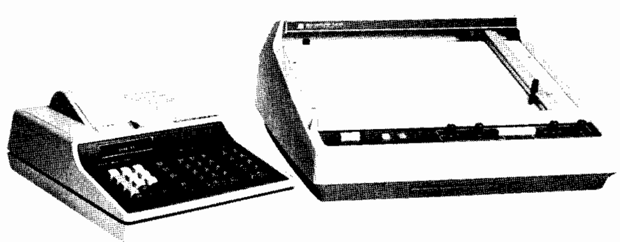
SYSTEM 4

EXPANDED STAT CALCULATOR

- calculation of best fit power curve $y = Ax^B$
- calculation of best fit exponential curve $y = Ae^{Bx}$
- calculation of best fit logarithmic curve $y = A + B\ln x$
- calculation of one-way analysis of variance
- same calculations as System 1
- printer
- display

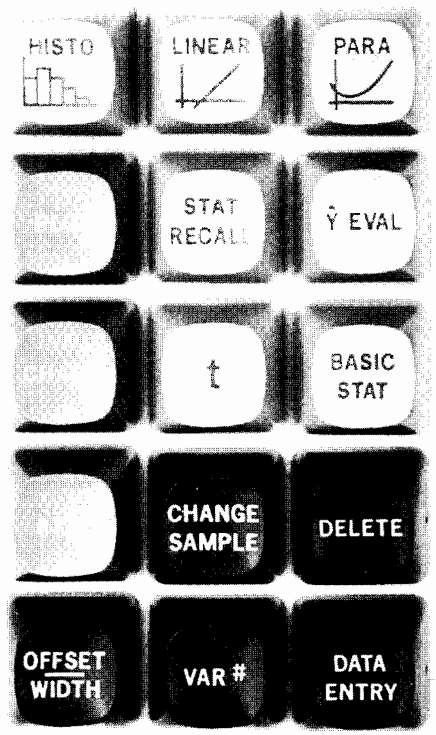
SYSTEM 5

PLOTTING EXPANDED STAT CALCULATOR



- compatible with HP 9862A Plotter (ordered separately)
- plots linear, parabolic, power, exponential, and logarithmic curve fits and histograms with calibrated and labeled axes.
- plots normal curve overlays for histograms
- same calculations as System 1 and System 4
- printer
- display

There are fifteen keys on the Model 5 dedicated to statistics functions. They are all interrelated and therefore can solve many different types of problems using the same keys. For example, the DATA ENTRY key can be used to input data in three different ways: 1) a single array $(x_1, x_2, \ldots, x_n)$; 2) paired array (x_i, y_i); and 3) two sample array $(x_1, x_2, \ldots, x_n; y_1, y_2, \ldots, y_k)$. Similarly, the BASIC STAT key outputs values corresponding to the type of input. A description of each of the keys follows:



STAT CALCULATIONS

Calculates complete histogram on data set. Resulting printout includes cell number, lower bound of cell, number of occurrences in cell, relative percent frequency of cell.

Establishes cell width and offset for histograms.

LINEAR — Completes linear curve fitting calculation using least squares technique. Prints A, B, and coefficient of determination r^2 for straight line $y = A + Bx$.

PARA — Completes parabolic curve fitting calculation using least squares technique. Prints A, B, C, and coefficient of determination r^2 for parabolic $y = A + Bx + Cx^2$.

Ŷ EVAL — Given an x value, projects the corresponding y value based on the last curve fit completed.

BASIC STAT — Calculates and prints number of entries, mean, and standard deviation. May be pressed during any analysis in order to review data.

DATA ENTRY / **DELETE** — Enters data for all calculations. All data are printed as entered. Also combines with the DELETE key to remove erroneous data.

t — Calculates t for both paired and unpaired data including degrees of freedom.

CHANGE SAMPLE — Initiates the transition from one data array to the next.

VAR # — Initializes the calculator and establishes the number of variables used in the analysis.

RECALL — Recalls intermediate statistical quantities stored in 17 storage locations; for example, sum of squares, sum of cross products, cell contents, etc.

PLOT — Plots last curve fit or histogram completed using scale factors established by AXES key.

CHAR # — Selects one of eight available characters for point plotting.

AXES — Establishes plotting scale for x and y axes; also establishes "tic mark" interval for drawing axes.

EXAMPLE

The following is a typical example of the Model 5's statistical analysis power. It shows how you might use the Model 5 in day-to-day problem solving.

Suppose we want to determine a formula relating the time required to cut down a tree (felling time) to the tree's diameter. We could choose a simple linear model, such as:

$$y = A + Bx$$

$$\text{felling time} = A + B\,(\text{tree diameter})$$

Such a formula could permit the prediction of *felling time*, given the *tree's diameter*, by substituting the tree's diameter into the formula.

Here is the 'raw' data:

x Tree Diameter	y Felling Time
10	1.1
15	1.6
20	2.3
25	3.2
30	4.3
35	5.6

Let's plot this data as we enter it. To do so requires that we set up our axes. First we must specify that the input data will be paired.

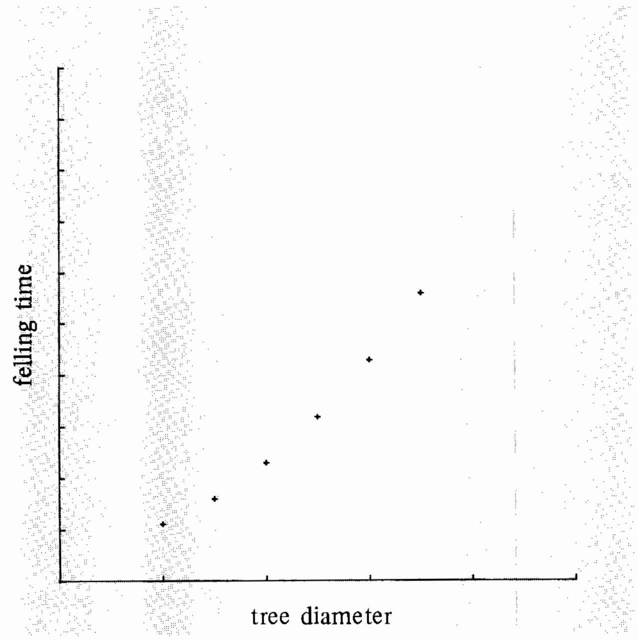
Press	Printout	
Press: VAR # 2	V2 •••••••	
	.00	→
Now set up the axes: X axis; 0,50		
	RG1	=
0 STORE 50 AXES 1	.00	#
	50.00	#
Y axis; 0,10	.00	→
0 STORE 10 AXES 2	RG2	=
	.00	#
	10.00	#
Tic Marks; 10,1	10.00	→
10 STORE 1 AXES 3	T I	=
	10.00	#
	1.00	#
X-Y Intercept; 0,0	.00	→
0 STORE 0 AXES 4	AI	=
	.00	#
	.00	#

Enter the data as follows:

x_i [DATA ENTRY] y_i [DATA ENTRY]

for each data pair

The point plot occurs as each data point is entered. The plot of the data points is shown below:



Having entered the data, basic statistics and the linear fit can be determined.

Press: [BASIC STAT]

```
      N            =
        6.00       #
 x̄                 =
       22.50       #
 ▲1                =
        9.35       #
 ȳ                 =
        3.02       #
 ▲2                =
        1.71       #
 R                 =
         .99       #
```

Press: [LINEAR]

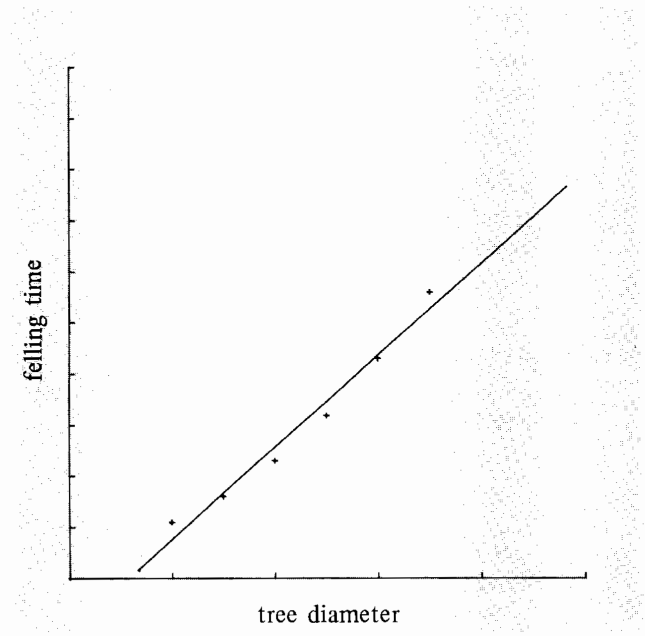
```
             A     =
 -      1.03       #
             B     =
         .18       #
 r2                =
         .97       #
```

Results: $y = -1.03 + 0.18x$

felling time = -1.03 + 0.18 (tree diameter)

Notice r^2 = .97, which indicates a reasonable fit although not the best possible. Let's plot the data using this linear fit.

Press: [PLOT]



The plot shows that the felling time is not linear. This should not come as a surprise because tree area increases as the square of the tree diameter. Thus, a parabolic model would probably yield a better fit.

Press: [PARA]

```
             A     =
         .700      #
             B     =
         .000      #
             C     =
         .004      #
 r2                =
        1.000      #
```

Results: $y = A + Bx + Cx^2$

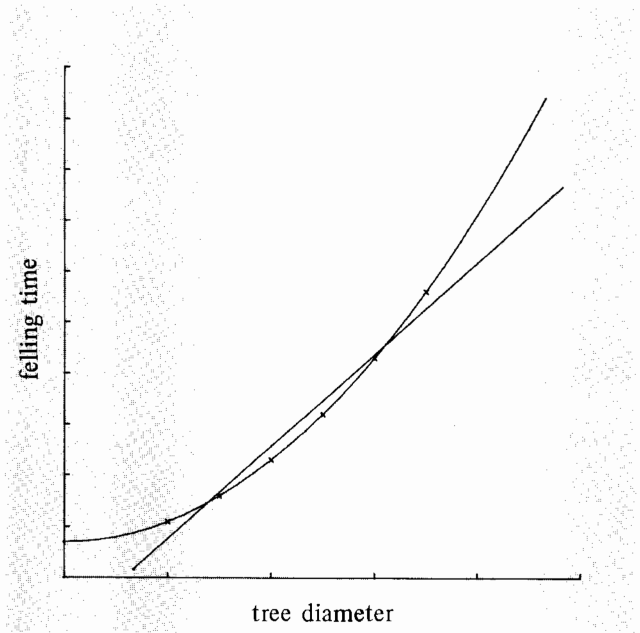
felling time = A + B (tree diameter) + C $(\text{tree diameter})^2$

felling time = 0.700 + 0.000 (tree diameter) + .004 $(\text{tree diameter})^2$

The r^2 value (1.00) indicates a perfect fit. Consequently, we can use the formula to predict the felling time for any size tree.

Now to plot the data using this parabolic fit,

Press: [PLOT]



Notice the parabolic curve goes through all the data points, whereas the linear curve fit does not.

To determine the felling time for a tree with a diameter = 5,

Press: [5] [ŷ EVAL]

```
PE
        5.00    #
         .80    #
```

So for a tree diameter of 5, the felling time = .8.

To determine the felling time for a tree with a diameter = 22.5,

Press: [2] [2] [.] [5] [ŷ EVAL]

```
PE
       22.50    #
        2.73    #
```

So for a tree diameter of 22.5, the felling time = 2.73.

MATHEMATICAL FUNCTIONS

The right side of the Model 5 looks very much like a four function calculator, but it does much more than add, subtract, multiply, and divide. Many of the arithmetic keys perform two functions. For example, by pressing the ↑ key it raises a number to a power. By pressing both the SHIFT and the ↑ key it finds the reciprocal of a number. The secondary functions are printed on the front side of the key. Mathematical calculations include:

- Add, subtract, multiply, divide
- Percentage, reciprocal, division by 12
- Natural logarithm, common logarithm, natural antilogarithm
- Exponentiation
- Grand total accumulation
- Sign change

All of these calculations have a range of -10^{-98} to 10^{98} and are made to 10 significant digits. The equations are entered in algebraic notation. For example, to solve this problem:

$$\frac{35 \times 5}{(-2 \div 9)} = ?$$

Press: [3] [5] [×] [5] [÷] [(] [2] [SHIFT] [(] [÷] [9] [)] [=]

(SHIFT (= CHANGE SIGN)

```
        35.00    ×
         5.00    ÷
                 (
-        2.00    ÷
         9.00    )
-         .22    =
-      787.50    R
```

The result will print in red since the answer is negative.

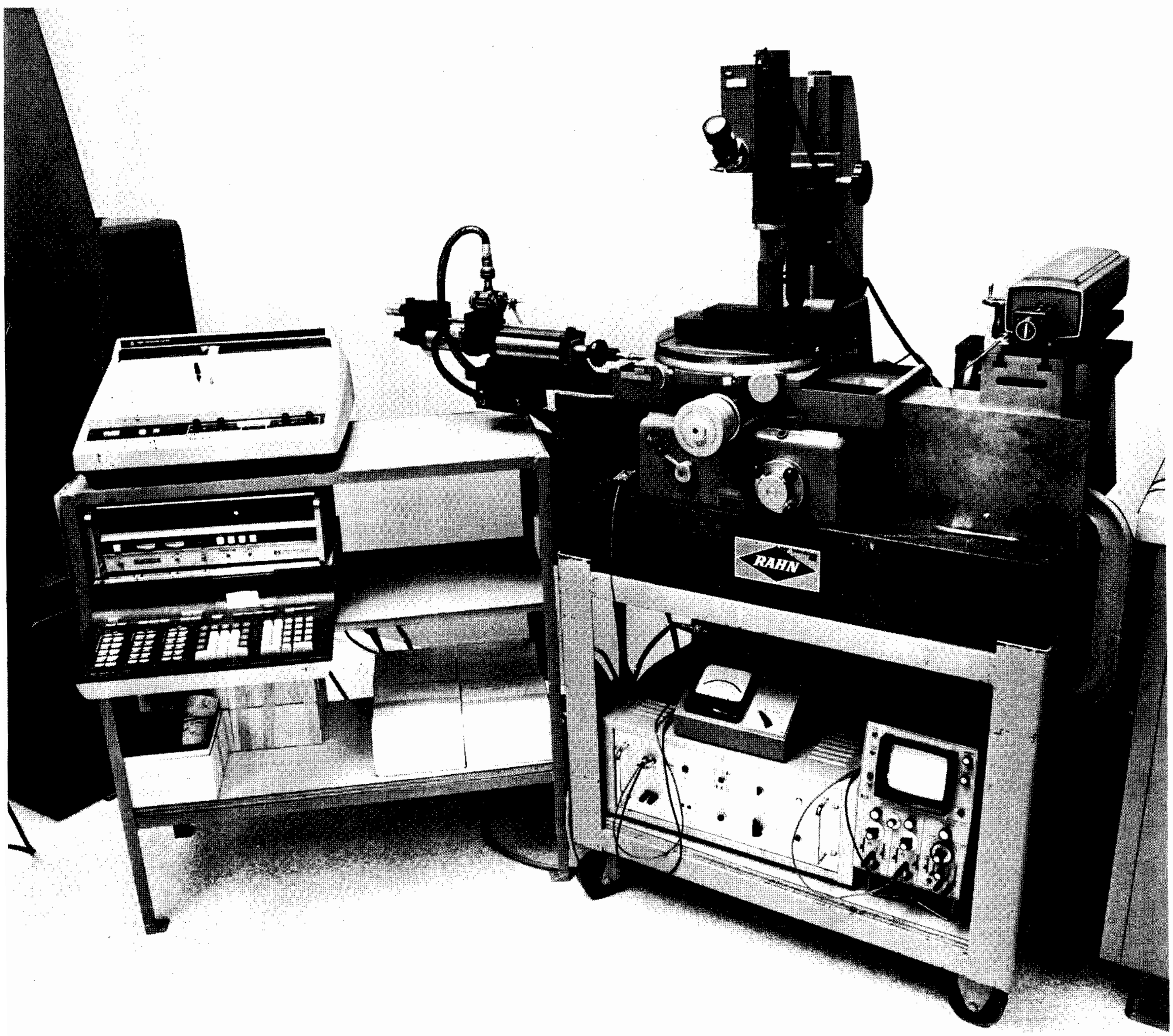
OTHER FEATURES

The Model 5 has several other features which will aid you in day-to-day processing. It has a storage register which can be accessed by the STORE and RECALL keys. The optional LED (light-emitting diode) display and the built-in impact printer will display or print up to 6 places to the right of the decimal point and can be set to scientific notation. This is controlled by the RND ( ) key. The AUTO • key fixes the decimal point at the last RND ( ) statement. The numbers can then be entered from right to left disregarding the decimal point.

ORDERING

If you are tired of being a NUMBER CRUNCHER and would rather buy one than be one, then fill out the enclosed reply card or contact your local Hewlett-Packard sales office. The Model 5 is the answer to your statistics problems. ■

PRECISION
ENCODER PLATE MEASUREMENT



by Glenn Herreman*

*Metrology Department, Manufacturing Division, Hewlett-Packard Company, Palo Alto, California.

Many companies manufacture or use line scales or glass encoder scales as measuring or positioning devices. HP uses a glass encoder scale to rapidly and accurately position a flying head in a computer memory disc system. The measuring system for these encoder plates evolved when we in metrology asked engineering how they checked the encoder plate, and how they knew the line edges were spaced within tolerance. The first test proved the need for inspection.

The evolution of our measuring system started with a microscope and micrometer measurement. Because of the accuracy and reliability problems the laser interferometer soon replaced the micrometer head for positional readout. The laser interferometer told us that an operator could not reliably and accurately set the microscope to a line edge, so we added a photoelectric microscope for line edge detection. We could now set a line edge by nulling a center zero meter from the photoelectric microscope. At this point the operator manually positioned the stage with a large micrometer head until he nulled the meter. The laser display was then manually printed with a remote switch. Now our problem was time. It took about 2½ hours to manually inspect each line edge and more time to check the tapes. We simply had to improve the system.

An air motor was added to replace the micrometer head. This allowed us to move at a constant rate of speed and automatically print each position, but we still had the tedious job of proofing the printed tapes. In addition, the tapes only gave us numbers not easily translated into a picture so we could see what was happening. We wanted to know whether the windows were wide or narrow, and we also wanted to know the shape of the curve. A falling curve indicates a short pattern and, conversely, a rising curve indicates a long pattern. The final stage of this evolution was to interface a model 9820A Calculator and a 9862A Plotter to the laser interferometer.

The system, now completely automated, measures the location of every line edge relative to line edge #1 to an accuracy of ±10 microinches (±.000 010). The air motor pushes the precision stage at a constant speed of .007" per second (checked with the velocity mode of the laser interferometer).

The encoder plate passes under the photoelectric microscope, and as each edge passes the photo detector a pulse is sent to the laser display. The laser displays the position at that point in time and transfers the number to 9820A, which compares this input to the equivalent nominal position. The deviation from nominal is then plotted on the 9862A Plotter. In addition, the 9820A counts each line edge and is instructed to sum the deviation between specific edges and then divide by the number of edges for a centerline average. After the last line is inspected the 9820A instructs the plotter to go to this centerline average and draw a line back to the beginning, then from this reference line draw the upper and lower limit lines. The final instruction from the 9820A is to have the plotter write the maximum point, the minimum point and the average as related to the starting zero. Any point falling beyond the limit lines signals a reject plate.

The operation takes about 6½ minutes per plate, and we can see at a glance the magnitude of window opening deviations as well as the pattern geometry. We can easily communicate with the supplier simply by sending him the plots so he can see the results first hand and make corrections if necessary. This measuring package, including working with the supplier, has improved our yield from approximately 20% acceptance to approximately 90% acceptance. ■

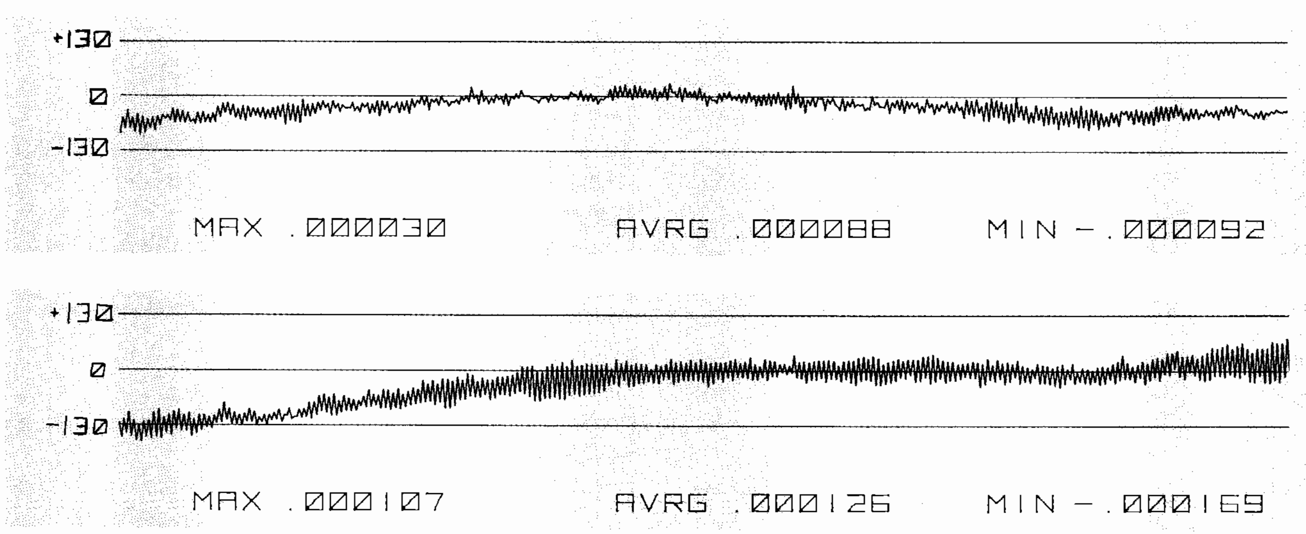


Figure 1. Sample plots showing cumulative deviation in inches from nominal distance between encoder plate lines.

CALCULATOR PROGRAM CATALOG ADDITIONS

Since the new Calculator Program Catalogs were published in January, a number of customer-submitted programs have been added to the selection available. These programs, which can be ordered through your local Hewlett-Packard sales office, are described below.

MODEL 20 PROGRAMS

Part Number: 09820-76005
Title: The Game of Life
Author: Glen Worstell and Homer Russell
Equipment: 9820A, 429 registers, Mathematics and Peripheral Control I ROMs, 9862A
Description: This program calculates and plots successive generations of organism populations using the genetic rules of John Conway's game of Life. The user inputs an initial population pattern.

MODEL 10 PROGRAMS

Part Number: 09810-70006
Title: Lagrangian Interpolation for n Points ($x \leqslant 21$).
Author: J. P. Borgogno
Equipment: 9810A, Printer
Description: This program performs Lagrangian interpolation over a set of n data points for $n \leqslant 21$.

Part Number: 09810-70008
Title: Correction of Entries - Math Pac IV-6
Author: M. A. Nouel P.
Equipment: 9810A, 111 registers, Printer
Description: This program is similar to program IV-6 of the Model 10 Math Pac except that it allows correction of erroneous input items without reentering all the data.

Part Number: 09810-75258
Title: Determination of "Classical" Electrical Axis of the Heart
Author: Dr. E. J. Reininger, Indiana State University, Terre Haute, Indiana
Equipment: 9810A; 1012 steps; 9862A; Math, Plotter, and Printer Alpha ROMs
Description: This program will calculate and plot the magnitude and direction of the "classical" electrical axis of the heart vector.

Part Number: 09810-75259
Title: Computation of Cardiac Output, Central Volume and Other Cardiovascular Parameters from Indicator-Dilution Curves
Author: Dr. E. J. Reininger, Indiana State University, Terre Haute, Indiana
Equipment: 9810A; 111 registers; 2036 steps; 9862A; Math, Plotter, and Printer Alpha ROMs
Description: This program will calculate cardiac output, central volume, total peripheral resistance, minimum transit time, mean transit time, and stroke volume flow given the indicator-dilution curve, heart rate, and mean blood pressure.

Part Number: 09810-75260
Title: Computation of Oxygen Uptake, Respiratory Exchange Ratio, and Heat Production
Author: Dr. E. J. Reininger, Indiana State University, Terre Haute, Indiana
Equipment: 9810A; 111 registers; 1012 steps; Math, Plotter, and Printer Alpha ROMs
Description: This program will calculate O_2 uptake, CO_2 output, respiratory exchange ratio, corrected volume/minute of inspired and expired gas, and heat ratio.

Part Number: 09810-75261
Title: Teaching the Concept of the Central Volume
Author: Dr. E. J. Reininger, Indiana State University, Terre Haute, Indiana
Equipment: 9810A; Math, Plotter, and Printer Alpha ROMs
Description: A physiology teaching program to be used with a programmed text to familiarize students with the concept of the central volume.

Part Number: 09810-76003
Title: Three-Dimensional Transformation Subroutines for the Model 10
Author: Robert W. Conley
Equipment: 9810A, 2036 steps, 111 registers, 9862A, Plotter Alpha ROM
Description: This set of subroutines computes the projection of three-space points into two dimensions for plotting objects in three dimensions.

MODEL 9100 PROGRAMS

Part Number: 09100-70422
Title: Solution of Polynomials (degree up to 32)
Author: Dr. R. Butler and Mr. F. Turner
Equipment: 9100B, 9101A, 9120A
Description: This program extracts the quadratic factors and roots from a polynomial of degree up to 32 using Bairstow's method.

Part Number: 09100-76018
Title: Fire-Danger Index Generation
Author: Bruce P. McCammon and David A. Rainey
Equipment: 9100A, 9101A, 9120A
Description: This program generates three daily fire-danger indexes from meteorological data for a fuel model which is specified by the user.

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9810A

Company or organization type (circle one)

A - INSTITUTIONAL   B - GOVERNMENT   C - INDUSTRIAL   D - COMMERCIAL AND PROFESSIONAL

Appropriate classification (circle one)

A - Aviation/Aerospace
B - Agriculture
C - Banking
D - Business Analysis
E - Bond & Stock Analysis
F - Chemical
G - Civil Engineering
H - Communications
I - Construction
J - Data Processing
K - Electronics
L - Forestry

M - Government, Federal
(1) AEC
(2) Army
(3) Air Force
(4) Navy
(5) Bureau of Mines
(6) Life Science
(7) NASA
(8) Public Health
(9) Other

N - Government, State and Local
(1) Highway Dept.
(2) Finance Dept.
(3) Other

O - Life Science
P - Medical
Q - Manufacturing
R - Mechanical
S - Metals
T - Mining
U - Oceanography
V - Real Estate
W - Schools
(1) Elementary
(2) Secondary
(3) Private
(4) Other

X - Tax Analysis

Y - Universities & Colleges
(1) Agriculture
(2) Business
(3) Chemical Engr.
(4) Chemistry
(5) Civil Engr.
(6) Electrical Engr.
(7) Forestry
(8) Life Science
(9) Mathematics
(10) Mechanical Engr.
(11) Medical
(12) Mining
(13) Oceanography
(14) Physics
(15) Psychology
(16) Public Health
(17) Statistics
(18) Other (Specify) ____________
____

Z - Other (Specify) ____________
____

Applications: (indicate order of importance-1,2,3,4)

____ A - Business
____ B - Chemistry
____ C - Chem. Engr.
____ D - Education
____ E - Electrical Design
____ F - Electronics Design
____ G - Finance
____ H - Fluid Mechanics
____ I - Life Sciences
____ J - Machine Design
____ K - Mathematics
____ L - Medical
____ M - Microwave
____ N - Physics
____ O - Quality Control
____ P - Statistics
____ Q - Structures
____ R - Surveying
____ S - Thermodynamics
____ T - Other (Specify)
____
____
____
____

Check the models and options you own:

☐ 9810A - Serial No. ____________   Date of receipt Mo. ☐☐ Yr. ☐☐

PROG. STEPS
☐ 500
☐ 1012
☐ 2036

REGISTERS
☐ 51
☐ 111

PLUG-IN BLOCKS
☐ Printer Alpha
☐ Mathematics
☐ Defin. Function
☐ Statistics
☐ Plotter
☐ Typewriter
☐ Peripheral Control

Peripherals:

☐ Printer
☐ 9860A Card Reader - Serial No. ____________
☐ 9861A Typewriter - Serial No. ____________
☐ 9862A Plotter - Serial No. ____________
☐ 9863A Papertape Reader - Serial No. ____________
☐ 9864A Digitizer - Serial No.
☐ 9865A Tape Cassette - Serial No. ____________
☐ ____________

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MODEL 30
PLOTTER PAC
Program 1

GENERAL FUNCTION PLOT

DESCRIPTION

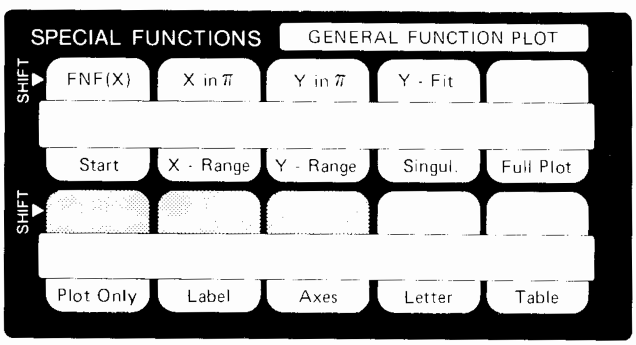
This program allows the user to define any general function of a single variable in Cartesian (X,Y) coordinates, and to obtain a plot of that function over any specified interval. Setting of the scale, labels, and axes can be automatic, or they may be specified by the user.

SPECIAL CONSIDERATIONS

In setting the X range, the user specifies the X MIN, X MAX, and either the plotting increment size or the number of increments into which the range should be divided for plotting. If this increment is too large (or the number of increments too small) the final plot will not be smooth. If the increment size is too small (or the number of increments is too large) considerable time will be required to find the Y MAX and Y MIN, and to plot the curve. Generally, dividing the X range into 30-50 increments will give optimum results.

SYSTEM SPECIFICATIONS

9830A (2K R/W) and Plotter ROM
9862A Plotter
9866A Printer or 9861A Typewriter (optional)



OPERATION

1. Type LOADKEY 1 and press EXECUTE.
2. Press FETCH then press FNF(X) [SF Key 10]. The display will read "KEY."
3. Define the function to be plotted as FNF(X), either as a single- or as a multi-line function. Pressing END OF LINE will store the defined function on this key.

   For example, to define the function f(X) = SIN(X) + X/2, fetch SF Key 10 and type

   10 DEF FNF(X) = SIN(X) + X/2

   and press END OF LINE. The display will again read "KEY."
4. After defining the function to be plotted, press RUN and START [SF Key 0]. The program will then ask for the paper ratio (height, width). Enter these numbers and press EXECUTE. The display will read "PRESS 'X RANGE' KEY."
5. Press the X RANGE key [SF Key 1] and enter the minimum X and the maximum X over which the function should be plotted.
6. Enter the increment (along the X range) which the plotter should use between plotted points (see SPECIAL CONSIDERATIONS). It may be more convenient to enter the number of increments into which the X range should be divided for plotting. If so, enter a zero for the plotting step size and the program will ask for the number of increments instead.
7. Enter the label step size. This increment is for labeling the axis only, and does not affect the plotting increment.
8. If other specifications are to be made, any of the options described under the SPECIAL FUNCTIONS section below may be used.
9. If all other calculations are to be done by the program, pressing FULL PLOT [SF Key 4] will produce a complete, fully-labeled plot.

   Note: If the Y range is not set, but is to be determined by the program, there will be a delay before plotting begins while this range is being calculated.

SPECIAL FUNCTIONS

Y RANGE [SF Key 2]

Pressing this key allows the user to specify the minimum Y, the maximum Y, and the label step size for the Y range.

If the user already knows the range that the function will take in Y, the time required for the program to find these extremes can be eliminated. It also allows the user to obtain a labeling of the Y axis that is more suited to his desires.

Y-FIT [SF Key 13]

The user may wish to specify the Y-axis labeling, but does not know the range which Y will take for the given X range. This range may be determined by pressing the

Y-FIT key. After a delay for determining these extremes, the display will show the minimum Y and the maximum Y of the function over the given X range.

X in PI [SF Key 11]
Y in PI [SF Key 12]

When the program is asking for input, only numbers are accepted as valid input. For example, if the program were asking for XMIN and 4*PI were entered, only the 4 would be accepted. Normally, 12.56637061 (=4*PI) would have to be entered. By using the X in PI key, however, the user simply enters 4 for XMIN, and uses the X in PI key to tell the program that all X values are in terms of PI.

The X in PI and the Y in PI keys are "mode" keys. This means that when the X in PI key is pressed (the display will read "ON") all given X values will be in units of PI. Pressing the key a second time (the display will read "OFF") cancels this mode. When the program is started, the X in PI and the Y in PI options are in the off mode.

SINGULARITIES [SF Key 3]

A singularity is a point (i.e., value of X) at which evaluation of the function would result in an error. For example, attempting to evaluate 2*X + 1/X at X = 0 would result in ERROR 103 (division by zero). To avoid such difficulties, the user may tell the program which values of X (if any) within the X range are singularities, and these points will be skipped during plotting.

Press the SINGULARITIES key and the display will read "SINGULARITY AT X=?". Enter all singularities within the X range pressing EXECUTE after each entry. The program will accept up to 20 singularities in all. Note that each time the SINGULARITIES key is pressed, the old list of singularities (if any) is destroyed and a new list is started.

PLOT ONLY [SF Key 5]

Pressing the PLOT ONLY key causes the user-defined function to be plotted from X MIN to X MAX at the specified increments (see OPERATION, Step 6).

LABEL [SF Key 6]

Pressing this key causes the plot to be labeled using the current specifications.

AXES [SF Key 7]

If the lines X=0 and/or Y=0 fall within the plotted ranges of X and Y, pressing AXES will cause these lines to be drawn on the plot.

Note: Pressing the FULL PLOT key is equivalent to pressing the three keys PLOT ONLY, LABEL, and AXES.

The three keys are provided separately in order to provide the user with more control over the results of his plot. For example, many times it is convenient to "see what the function looks like" without having to wait for the labeling to be done.

LETTER [SF Key 8]

This key puts the calculator/plotter system in a unique "typewriter" mode, in which any key that is pressed on the Model 30 causes that character to be written on the plotter. This LETTER mode is useful for additional labeling of finished plots.

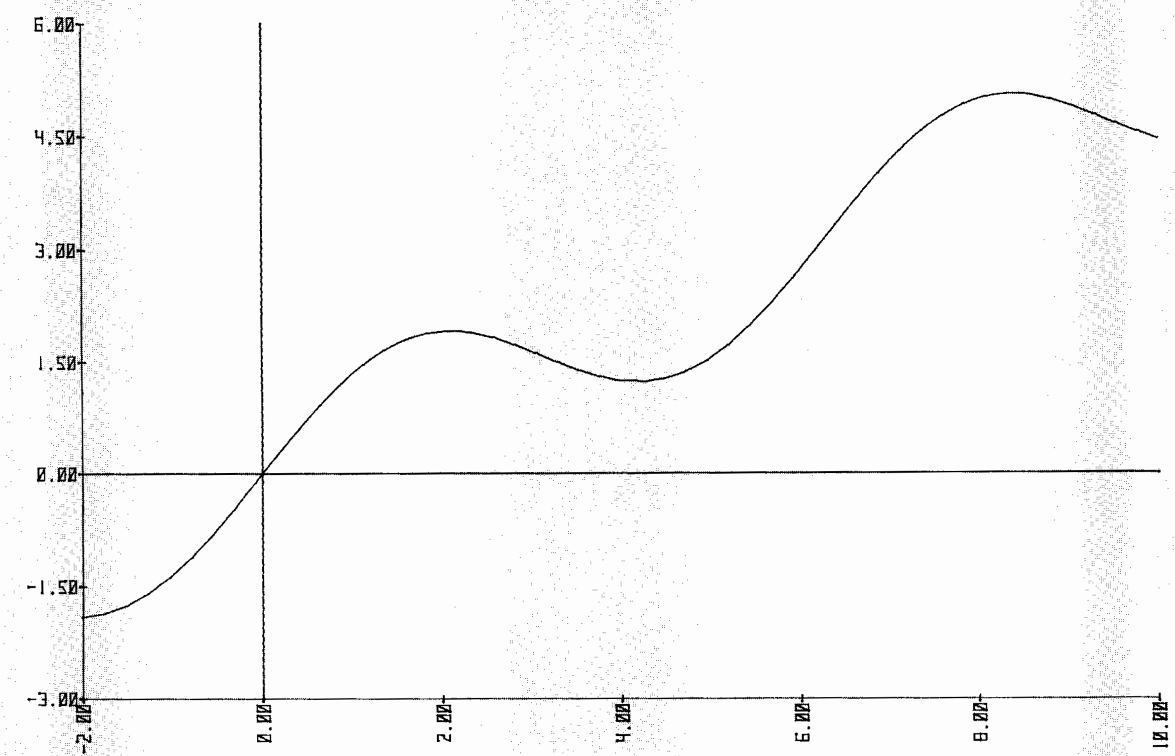
To enter the mode, press LETTER and enter the height of the characters as a percent of total paper height. (For reference, the axes labeling is done at a specification of 1.5%.) In the LETTER mode, the four display control arrows can be used to position the pen over any desired location on the plotting surface. Pressing STOP will exit the LETTER mode.

TABLE [SF Key 9]

The TABLE key allows the user to obtain a printed table of X and Y values from a specified X MIN to X MAX at a specified increment.

EXAMPLE

```
FETCH, FNF(X)
10 DEF FNF(X)=SIN(X)+X/2

RUN, START
PAPER RATIO(HEIGHT, WIDTH)=?10,15
PRESS 'X RANGE' KEY

XMIN, XMAX=?-2,10
PLOTTING INCREMENT SIZE=?0
NO. PLOT INCREMENTS=?50
LABEL STEP SIZE=?2

FULL PLOT

LETTER
CHARACTER HEIGHT(%)=?2

DONE

TABLE
XMIN, XMAX, INCRM.=?-2,10,2

        X                    Y

   -2.00000000          -1.90929743
    0.00000000           0.00000000
    2.00000000           1.90929743
    4.00000000           1.24319750
    6.00000000           2.72058450
    8.00000000           4.98935825
   10.00000000           4.45597889
```



MODEL 30 PLOTTER PAC

Part Number 09830-76000

The Model 30 Plotter Pac is a book containing six practical programs which illustrate the application of plotter output to several types of problems solved by the new Basic calculator. This packet is supplied with each 11271 Plotter Control Block, or it can be ordered separately through your local Hewlett-Packard sales office. Following is a description of the programs.

1. General Function Plot

   This program allows the user to define any general function of a single variable in Cartesian (X,Y) coordinates, and to obtain a plot of that function over any specified interval. Setting of the scale, labels, and axes can be automatic, or they may be specified by the user.

2. Histogram Plot

   This program allows the user to obtain a histogram plot of a given set of data using a specified offset and cell width. Complete labeling is provided with an option for plotting the normal curve overlay. In addition, the basic statistics for the data and the cell counts and frequencies may be printed.

3. Polynomial Regression

   This program takes a set of data points (X,Y) and calculates the coefficients of a polynomial (up to 9th degree) using a least-squares fit. Basic statistics on the data, coefficients, and r^2-measure of fit may be printed. The data points and the resultant polynomial(s) may be graphically displayed on the plotter.

4. Loan Amortization Plot

   This program uses the 9862A Plotter to graphically display the declining balance, amount of interest, and amount to principal for an installment loan. A complete amortization schedule may optionally be printed.

5. Compounded Interest Plot

   Given the amount invested and compounding rate, this program plots the amount of principal at all times over a given period, and shows the exact amount of principal at the end of this period.

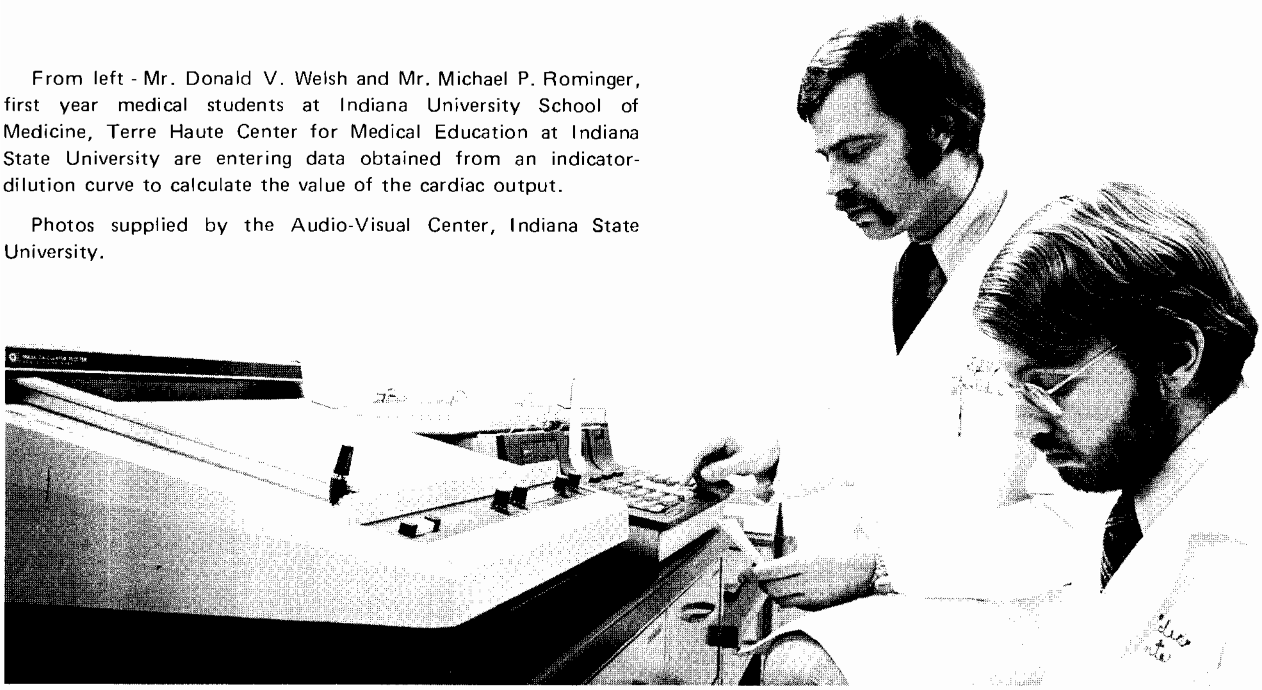
6. Calendar Plotting Program

   This program will plot a calendar for any month and year. The user may, if he wishes, specify the size of the numerals.

The Model 10 In Physiology

From left - Mr. Donald V. Welsh and Mr. Michael P. Rominger, first year medical students at Indiana University School of Medicine, Terre Haute Center for Medical Education at Indiana State University are entering data obtained from an indicator-dilution curve to calculate the value of the cardiac output.

Photos supplied by the Audio-Visual Center, Indiana State University.



USE OF THE HP 9810A CALCULATOR TO PACKAGE PHYSIOLOGICAL CONCEPTS AND PROCESS DATA

by Edward J. Reininger, Ph.D.

Traditionally, physiology is taught as a laboratory course in which a series of didactic lectures is supplemented by a varying number of laboratory experiments to illustrate important physiological principles. The laboratory period provides an opportunity for active participation by students getting involved with physiology and making their own "discoveries." Laboratories tend to be time consuming and one must carefully balance the potential value that can be gained in the laboratory against all the other demands on the available time in organizing a medical physiology course. Medical students are expected to assimilate more and more information in less and less time so that the question of the amount of time and effort it takes to learn a particular principle in the laboratory becomes a matter of practical concern. For example, it is easy to justify the time spent by students performing the classical blood pressure experiment in the dog to learn about the circulatory system's negative feedback system in regulating the blood pressure. On the other hand, it would be more difficult to justify using the same amount of time to learn the principles of vector electrocardiography; nevertheless, every medical physiology student requires a minimal exposure to this subject. There are major concepts that may require a full laboratory period of three hours, but some concepts would be valuable if they could be "packaged" in a 10 or 15 minute time slot--just long enough to get the idea across.

This communication is concerned with the author's experience with packaging physiological concepts and data processing using a Hewlett-Packard 9810A Calculator and a 9862A Calculator Plotter; provided with read-only memories (ROMs), a printer, extra data storage registers and extra program steps. Using these, medical students have the opportunity to work with "physiological" systems, yet conserve more of their time by eliminating much of the tedium of performing calculations and plotting graphs that were formerly done by hand. The author has had an opportunity to test these programs with the cooperation of a group of ten first year medical students and one graduate student currently enrolled in the course, Physiology for Medical Students, at Indiana University School of Medicine, Terre Haute Center for Medical Education at Indiana State University.

The programs have been written in a conversational manner so that a student who wishes to use any of the programs is able to do so with 5 to 10 minutes instruction. The students quickly become familiar with the function and location of a minimum number of keys, including the numerical keys 0-9, SET FLAG to signal that all the data have been entered, CLEAR, CLEAR X, LOAD, CONTINUE, END, FORMAT, and the on-off switches on the calculator and the plotter.

COMPUTATION OF CARDIAC OUTPUT, CENTRAL VOLUME AND OTHER CARDIOVASCULAR PARAMETERS FROM INDICATOR-DILUTION CURVES

The determination of cardiac output in the dog using the indicator-dilution technique is done as a demonstration in the author's laboratory. The cardiac output determination is performed automatically (1,2) and the indicator-dilution curves are recorded before and after the infusion of epinephrine, which changes the value of the cardiac output. Using the Graph Digital Reader (3) the students digitize the curves that have been produced. Employing this program (published as HP part number 09810-75259), the data are entered into the HP 9810A Calculator and are subsequently replotted on semi-log paper using the HP 9862A Plotter; the indicator-dilution curve is extrapolated. See Figure 1. The paper-tape output prints out the values of cardiac output, central volume and other cardiovascular parameters. This program is used to perform calculations required in the author's laboratory where determinations of cardiac output in trained, unanesthetized dogs are routinely made.

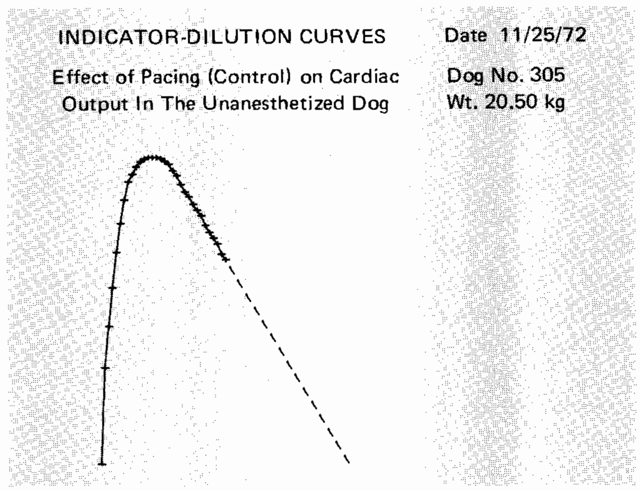


FIGURE 1

TEACHING THE CONCEPT OF CENTRAL VOLUME USING THE HP 9810A CALCULATOR

It is possible to measure cardiac output and central volume after the single injection of an indicator into the venous side of the circulation by determining serially the changing concentration of the indicator in the arterial blood with respect to time. The program discussed earlier, Computation of Cardiac Output, Central Volume and other Cardiovascular Parameters From Indicator-Dilution Curves, may be used by the students to calculate their experimental data. Although central volume can be defined as the volume of blood contained in the vessels from the point of injection to the point of sampling, including congruent vessels (4); nevertheless, generally students have had difficulties in understanding what was really being measured. To calculate the value of central volume, the mean transit time of the injected indicator is multiplied by the cardiac output. No doubt, the mathematics required to obtain the value of the mean transit time may have contributed to students' difficulties in grasping the significance of what is meant by central volume.

Laboratory sheets with a programmed text entitled, "Teaching the Concept of Central Volume Using the HP 9810A Calculator" (published as HP part number 09810-75261) are provided. These instructions illustrate a model in which various parameters are modified: (1) the effect of changing the site of sampling, (2) the effect of branching, (3) the effect of distensible tubes on central volume and (4) the central volume in a physiological system are considered. The HP 9810A Calculator is used with this programmed text to facilitate performing the necessary calculations.

DETERMINATION OF THE "CLASSICAL" ELECTRICAL AXIS OF THE HEART

This program (published as HP part number 09810-75258) is designed to determine the "classical" electrical axis of the heart, providing the magnitude of this vector as well as the direction. Vectors are used to represent the electrical potential derived from an electrocardiogram of the heart. Problems are solved trigonometrically using a Hewlett-Packard 9810A Calculator; but a graphic solution is also displayed using the HP 9862A Calculator Plotter with a piece of graph paper measuring 10" x 15" as it might be preferred to visualize an answer obtained in a traditional manner (5). The potentials are picked up using the three standard bipolar limb leads. Lead I, II and III are defined as the difference in potential between (1) the left arm (+) and the right arm (-); (2) the left leg (+) and the right arm (-); (3) the left leg (+) and the left arm (-), respectively. By convention, a vector oriented horizontally and directed to the subject's left side is designated as having an angle of 0 degrees; downward deviations are positive and upward deviations are negative. See Figure 2.

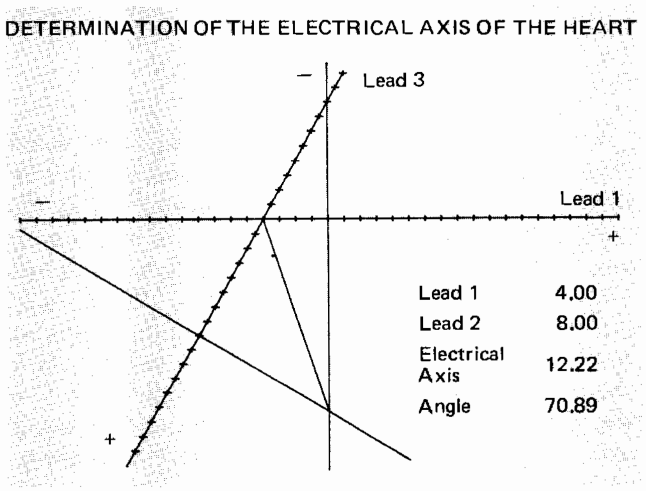


FIGURE 2

In this calculation it is assumed that the heart is located in the center of Einthoven's equilateral triangle, whose apices are the left groin, and right and left shoulders (the arms and the left leg serve as extensions of these sites); secondly, that the body behaves as a homogeneous volume conductor. These assumptions are not strictly valid since the heart has an eccentric location in the chest and the body is not a homogeneous volume conductor between the heart and the surface electrodes. Nevertheless, the classical lead system of three bipolar limb leads, devised by Einthoven, "remains the bedrock of present clinical electrocardiography (6)."

This program could be of value to a clinical cardiologist, i.e., deviation of the "classical" mean electrical axis beyond the normal limits of +90 to -30 degrees had diagnostic significance; however, this program was especially designed as a teaching tool. In medical physiology classes students are frequently requested to determine the mean electrical axis, or determine changes in the electrical axis throughout the period of ventricular depolarization (the QRS complex) and during the period of ventricular repolarization (the T wave). The latter serves to introduce students to the theory of vectorcardiography. Unfortunately, it is difficult to justify all the time that must be spent by a student plotting by hand the magnitude and direction of the heart's electrical axis, instant by instant, to obtain these concepts. On the other hand, by inserting data into the calculator the answers are available within seconds; in addition, one can see how an answer could be obtained if it were necessary to obtain a solution graphically.

COMPUTATION OF OXYGEN UPTAKE, RESPIRATORY EXCHANGE RATIO AND HEAT PRODUCTION

Measurements of oxygen uptake and carbon dioxide output are made to study metabolism and the effects of exercise. This program (published as HP part number 09810-75260) is designed to calculate in a "classical" manner the oxygen uptake and respiratory exchange ratio of an animal when: (1) the concentration of oxygen (O_2) and carbon dioxide (CO_2) in the inspired and expired gases are determined; (2) the ambient barometric pressure is corrected by subtracting the appropriate water vapor pressure which is calculated from values stored in the calculator for temperatures between 18 and 25°C; (3) the volume of gas expired per minute is known and corrected to standard temperature and pressure, and is dry (STPD); (4) a correction is made for the difference in the corrected volume of gas which is inspired and expired (7,8). The heat production is calculated by multiplying the oxygen uptake by the thermal equivalent of a liter of oxygen. The value of the thermal equivalent is computed for any respiratory exchange ratio by an equation which is part of the program. The oxygen uptake, the respiratory exchange ratio, the heat production, the corrected volumes of gases inspired and expired, the water vapor pressure and the carbon dioxide output produced, in addition to the data which are entered, are printed out on the paper tape. These calculations are particularly tedious to perform manually, since there are so many "corrections" that must be made. This is the case where there is little value in having the students spend time to work out the answers, when the HP 9810A Calculator can be used to perform these calculations automatically and error free.

Certain features are incorporated into the program. Up to 25 sets of the values of the oxygen uptake, respiratory exchange ratio and heat production can be stored in the numeric registers along with date, dog number and dog weight. The information in these registers can be removed and stored on a program card so that it can be subsequently retrieved to graph the relationship between either oxygen uptake or heat production versus time using another program.

PRESSURE-VOLUME CURVES OF ISOLATED ATELECTATIC RAT LUNGS

The experiment devised by Karl von Neergard is performed, which illustrates the contribution of surface tension to the elasticity of the lungs. Isolated collapsed rat lungs are "inflated" with either a known volume of air or with saline and the resulting pressures are recorded; the lungs are then deflated. The student can observe that the pressure required to enlarge the lungs with fluid is less than half of that required to inflate the degassed lungs with air (9). A program has been written so that the paired pressure-volume values are entered into the HP 9810A Calculator for the air-filled and fluid-filled lungs and a graph is constructed on the HP 9862A Plotter of the Pressure-Volume Curves of the isolated atelectatic rat lungs. The pressure in cm H_2O is shown on the abscissa and the volume is indicated on the ordinate. See Figure 3.

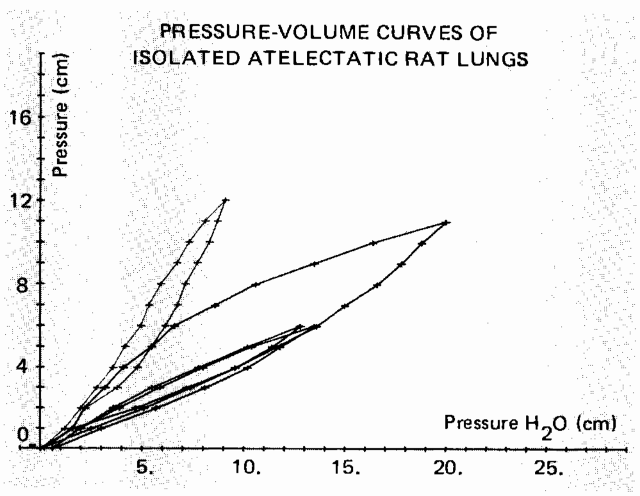


FIGURE 3

TWO STATISTICAL PROGRAMS USED IN THE BLOOD PRESSURE IN MAN EXPERIMENT

The systolic (maximum) and diastolic (minimum) blood pressures in human subjects are determined using the auscultatory technique along with the heart rate. These parameters are determined under a variety of conditions, e.g., changes in position and exercise. The set of values obtained from the entire class is tabulated. In this laboratory period the students are also exposed to some very basic statistics. Handouts indicate how the statistical parameters are calculated by hand, using machine formulas, and by using the programs that have been prepared for the HP 9810A Calculator equipped with the statistics ROM (11214A). One program is used to compute and print out the mean value, the standard deviation and the standard error of the mean. The second statistical program permits two sets of paired values to be compared so that the value of t is computed in order to determine if, for example, changes in position and exercise have caused a significant variation in the measured experimental parameter.

There appear to be many advantages when the desk top programmable calculator is employed in the physiology laboratory. It is always accessible and there is the further convenience of not having to punch cards or type data into a terminal connected to a large computer. The capacity of the HP 9810A Calculator and the 9862A Calculator Plotter is adequate for problems that would be encountered in a student laboratory. The specific programs can be easily written and programmed by the laboratory instructor who studies and works through the instruction manual.

Certain of the complex calculations which accompany many experiments are simplified, the answers are free of computational errors and are printed out on a paper tape. Data derived from polygraph tracings can be analyzed and graphs can be quickly plotted so that some relationship becomes apparent, enabling the student to reach conclusions of what the experiment was meant to illustrate. The students have an opportunity to obtain "instant" answers during the lab period when they are actively concerned with a specific question rather than working out the problem several days later.

It is possible to shift the emphasis from just getting the information to "seeing" what it means during the same laboratory period. No doubt, the commercial success of the Polaroid Camera can be accounted for because the image develops before your eyes and you do not have to wait several days before you make your "discovery." Several programs have been especially developed so that the student can read through the text and solve any required problems in order to comprehend a concept.

The students' reactions to using the programs written to date have been very favorable and they have indicated their approval; they specifically appreciate how much of their time is saved since the mechanics of performing the calculations and plotting the graphs can be very laborious.

Today, the physician's principle role is involved with the interpretation of data that he perceives by questioning and examining his patient as well as from laboratory test results. The information made available to the physician from the clinical laboratory may be extremely valuable; however, it is usually not necessary for the doctor to know the detailed laboratory procedures employed in running specific tests. The physician only requires accurate and reliable data concerning his patient. It is on the basis of all the available information that a diagnosis can be made and a course of treatment planned. The same pedagogical principle can be adapted in training medical students; namely, one might be less concerned with the methodology of how certain information is obtained and processed so that greater emphasis can be placed on the significance and interpretation of information determined in the physiology experiments performed in the laboratory. The use of the Hewlett-Packard 9810A Calculator has assisted in achieving this goal. ●

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MODEL 20 ELECTRICAL ENGINEERING PAC
Vol. 1
Part Number 09820-71000

The new Electrical Engineering Pac Vol. 1 for the 9820A Calculator is now available. This is a compilation of programs directed toward network analysis and design using accepted techniques to help the design engineer in his day-to-day job functions. Here are the titles and abstracts of the programs included in this pac.

Section I. NETWORK ANALYSIS

1. Calculator Network Analysis Program

   This program analyzes networks of up to nine nodes and 40 components, including R, L, C, and voltage-controlled current sources. The user can specify log or linear frequency sweep, and can change the frequency increment at any time. The value of a component can be changed without reentering other data. The output is a print and/or plot of both magnitude and phase of the output voltage.

2. Ladder Network Analysis Program

   This is a general purpose frequency domain analysis program for analyzing passive ladder networks. Each branch consists of a single R, L, or C element. The maximum number of branches that may be calculated is 93 with a plot of the output, or 104 without the plot.

Section II. FILTER AND ATTENUATOR DESIGN

1. Active Filter Design With Plotting

   This program designs low pass, high pass, or band pass RC active filters with Butterworth response. The program calculates component values, draws a labeled schematic diagram, and plots both the amplitude and phase response. It also allows the calculated values to be varied and the resultant responses noted.

2. Active Filter Design Using Second Order High Pass and Low Pass Sections

   This program will design either a high pass or a low pass filter with a Butterworth response, using a second order filter section. Two or more sections can be cascaded to obtain desired characteristics. In addition, a low pass filter can be cascaded with a high pass filter to form a bandpass filter.

3. Bandpass Filter Design

   Given the center frequency, terminal impedance, 3-dB bandwidth, passband ripple in dB, and lowpass prototype order (number of poles), this program calculates the element values for a passive bandpass filter with Butterworth, Tchebycheff, or user-defined response and prints a picture of the circuit.

4. Attenuator Network Design

   This program can be used to design an unbalanced T, an unbalanced Pi, or a minimum-loss pad matching section. The user selects the type of section desired and inputs the source and termination impedance, and desired attenuation in dB.

Section III. TRANSFER FUNCTIONS

1. Transfer Function Analysis and Design

   For the designer who deals with active filters, linear control systems, operational amplifiers, or analog computer circuits, short circuit transfer functions can be very useful. This series of programs allows the designer to either 1) determine circuit component values from a short circuit transfer impedance function or 2) determine the values for the transfer function from an actual circuit.

Section IV. COMPONENT DESIGN

1. Wire Table Data

   This program will compute wire table data given the wire size and the type of insulation. The accuracy of this program has been verified for American Wire Gauges (AWG) 10-45. The output includes:

   Turns/inch (random wound coil)
   Turns/square inch (random wound coil)
   Ohms/1000 feet
   Ohms/pound

2. Reed Relay Design

   This program will design a reed relay, given the reed switch sensitivity expressed in ampere-turns for the maximum and minimum pull-in ratings and the geometry of the coil winding space. Output includes wire size, number of turns, coil resistance, coil power, pull-in and drop-out voltage at 25°C.

3. Random-Wound Coil Design

   This program will design a random-wound coil, given input of the geometric winding shape (cylindrical, rectangular, or toroidal); the American Wire Gauge; and the insulation type. The program calculates the number of turns of wire that will fit on the coil and the coil resistance.

4. Linear Low Level Inductor Design on Molypermalloy Powder Cores

   This program will optimize the inductor design by selecting the smallest core size and all μ's that fit that core size and the user-specified inductance, frequency, voltage, and minimum Q. The program selects, from 18 core sizes and various permeabilities, the smallest practical core size. It prints the core size, permeability, number of terms, and wire size.

Section V. LOGIC CIRCUITS

1. Quine-McCluskey Minimization

   The Quine-McCluskey method first finds the prime implicants of a Boolean function by a matching process, and then chooses some of the prime implicants to form the minimized function. This program will handle minimization problems with up to seven variables. The P terms and all don't-care conditions are entered. The program prints the prime implicants, then selects and prints a set of essential prime implicants to form the minimized function.

Programming Tips

The two following programming tips for the Model 20 were submitted by Richard Trommer, Kew Gardens, New York.

FOOLPROOF DATA ENTRY LINE

When the Model 20 comes to an 'ENTER' statement it stops and waits for data. If the user does not enter any data the program continues using the number that was stored in the variable previously. But if you ignore an 'ENTER' statement like this flag 13 automatically is set. You can use this to your advantage. At the end of an 'ENTER' statement simply press the following: IF FLG 13; CFG 13; JMP 0. If this is done the calculator will not be satisfied until data is entered. This avoids the possibility of accidentally running a program with incorrect data.

DIVISIBILITY TEST

Many times while programming the programmer discovers that he would like to test a number of divisibility by another number. This can be accomplished very easily on the Model 20. Suppose you want to see if A is divisible by B. The following expression is equivalent to saying 'if A is divisible by B':

IF (INT(A/B)*B) = A;

The Math ROM or equivalent is needed for this test.

9800 PROGRAM VERIFICATION

Don Sullivan of Raytheon, Burlington, Massachusetts, suggested the following tip for verifying program listings printed out by any 9800 printer.

To check a program that was printed out correctly at a previous date but operates incorrectly when reentered in the calculator, list the program again. Place the two printouts over each other and hold them up to the light. Any differences show up readily, allowing corrections to be made.

Remember that occasional cleaning of the magnetic heads in your cassette reader or card reader is needed to maintain high reading accuracy.

SUMMING A SERIES OF NUMBERS AND DETERMINING THE PROPORTION EACH NUMBER IS OF THE TOTAL

This programming tip is based on an idea submitted by Dr. Harry V. Wiant, Jr., Professor of Forestry at West Virginia University, Morgantown, West Virginia.

The program seems a series of numbers ($n \leqslant 48$) and calculates the proportion each is of the total. The printed output consists of the sum Σn, followed by each number and its proportion of the total, listed in the reverse order of entry.

USER INSTRUCTIONS

1. END, LOAD
2. END, CONTINUE
3. Enter n, CONTINUE
4. Repeat Step 3 through the last n
5. SET FLAG, CONTINUE
6. For new set of data, return to Step 2.

EXAMPLE

```
100.000

  1.060
  0.011

 11.340
  0.113

  7.190
  0.072

  6.580
  0.066

 32.500
  0.325

 41.330
  0.413
```

```
0000--CLR---20
0001--STP---41
0002--XTO---23
0003-- + ---33
0004-- a ---13
0005--XTO---23
0006--IND---31
0007-- b ---14
0008--CLX---37
0009--STP---41
0010--IFG---43
0011-- 0 ---00
0012-- 0 ---00
0013-- 2 ---02
0014-- 3 ---03
0015-- UP---27
0016-- 1 ---01
0017--XTO---23
0018-- + ---33
0019-- b ---14
0020-- DN---25
0021--GTO---44
0022-- 2 ---02
0023-- a ---13
0024--PNT---45
0025--PNT---45
0026--XFR---67
0027--IND---31
0028-- b ---14
0029--PNT---45
0030-- UP---27
0031-- a ---13
0032--DIV---35
0033-- DN---25
0034--PNT---45
0035--PNT---45
0036--CLX---37
0037-- UP---27
0038-- b ---14
0039--X=Y---50
0040-- 0 ---00
0041-- 0 ---00
0042-- 5 ---05
0043-- 1 ---01
0044-- 1 ---01
0045--XTO---23
0046-- - ---34
0047-- b ---14
0048--GTO---44
0049-- 2 ---02
0050-- 6 ---06
0051--END---46
```

MODEL 10 NON-ZERO DATA PRINTOUT

A. S. Hausrath, manager of mechanical design for the Minuteman, Systems Group of TRW, Inc., San Bernardino, California submitted this programming tip for the 9810A.

For debugging purposes, it is frequently desirable to be able to "dump" the contents of only the data registers containing other than zeros. It is convenient to keep a program handy that will be compatible with almost any program in the 9810A and be able to provide this dump. This requirement more or less precludes the use of symbolic addresses.

By entering the following program to end at the highest-numbered step in the memory, and using fixed addresses, the chances of interfering with the main program are minimized. Note that no end statement is needed. The program lists the contents of the a and b registers, and lists all other non-zero data entries and their locations.

SAMPLE DATA PRINT-OUT

```
A;B
 1.200000000 01
 2.700000000 01

 0.000000000 00
 7.563648732 04

 5.000000000 00
 2.245678000 01

 4.300000000 01
 4.336385700 02

 5.800000000 01
 1.000453700 00

 7.200000000 01
 8.549370000 01

 1.000000000 02
 9.200000000-03
```

PROGRAM LISTING

```
2000--FMT---42
2001--FMT---42
2002-- A ---62
2003--CLX---37
2004-- B ---66
2005--FMT---42
2006-- a ---13
2007--PNT---45
2008-- b ---14
2009--PNT---45
2010--PNT---45
2011--CLR---20
2012--XFR---67
2013--IND---31
2014-- a ---13
2015-- UP---27
2016-- 0 ---00
2017--X=Y---50
2018-- 2 ---02
2019-- 0 ---00
2020-- 2 ---02
2021-- 7 ---07
2022-- a ---13
2023--PNT---45
2024-- DN---25
2025--PNT---45
2026--PNT---45
2027-- 1 ---01
2028--XTO---23
2029-- + ---33
2030-- a ---13
2031--GTO---44
2032-- 2 ---02
2033-- 0 ---00
2034-- 1 ---01
2035-- 2 ---02
```

More For Your Money

IT'S THE LITTLE THINGS THAT COUNT

The Model 20 Calculator can save you time in solving day-to-day problems. Besides calculating equations in algebraic form and having a very powerful but simple programming language, the Model 20 has many time-saving features that can be used in several different ways. Which of the following functions do you use each day?

* EDIT *
* TRACE *
* SET FLAG *

All three of these have obvious capabilities corresponding to their name. But they will do much more.

For example, the edit functions DELETE, INSERT, RECALL, BACK, and FORWARD can be used to alter calculations performed from the keyboard as well as to edit program lines. Once an expression has been executed, it can be recalled by pressing DELETE, BACK, or FORWARD. With the equation back in the display editing can proceed as usual.

The TRACE function is a very important tool in debugging programs but it can also be used to print data. Press TRACE prior to entering the data and a record of both input and output will automatically be printed.

SET FLAG is often used in a program to alter the logic flow, but it can also do the same thing from the keyboard. Flag zero is set to 1 by pressing SET FLAG while a program is running. This allows the user to interact with the program, for instance to initiate a print or plot routine whenever he wishes.

If you know of other unusual or different ways of using these functions or other ones not mentioned here, please write and tell us about them. We learn something new about the Model 20 every day. How about you?