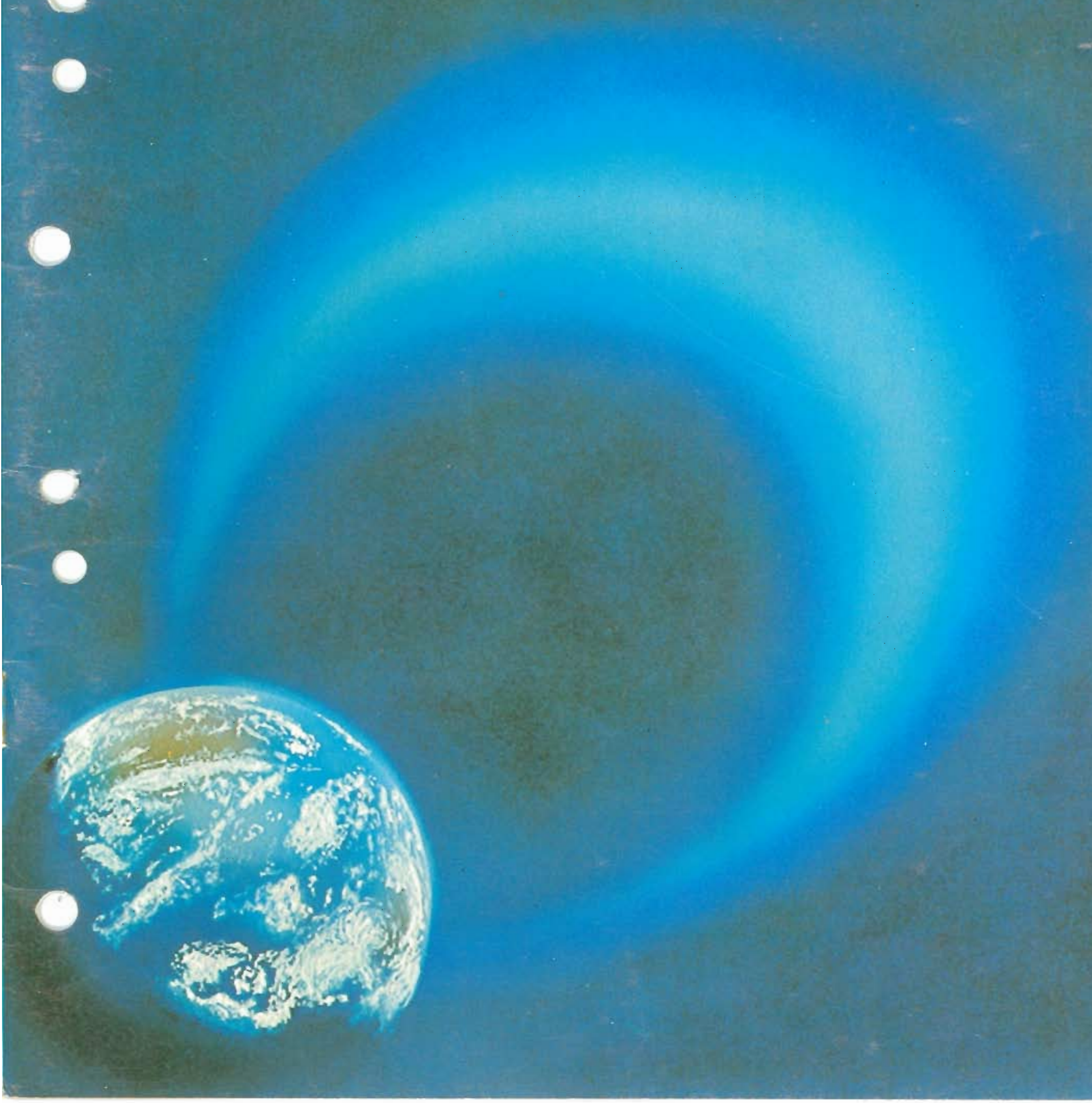
HEWLETT-PACKARD

KEYBOARD

VOL. 4 NO. 2



COVER

This *KEYBOARD* is somewhat space-oriented, considering the articles on lunar module landing, ballistic trajectories, and whistler ducts. The cover shows our artist's concept of a whistler duct (page 2).

NEW KEYBOARD FIELD EDITORS

We are pleased to announce the addition of two new field editors to the *KEYBOARD* staff. Bob McCoy at the Hewlett-Packard sales office in Atlanta, Georgia has accepted this responsibility for the Southern Sales Region. Stan Kowalewski is the new field editor for the Eastern Sales Region.

With these assignments, *KEYBOARD* readers in all parts of the U.S.A. can now send their *KEYBOARD* inputs to a more local place. Any of the field editors will gladly accept programs, programming tips and other material for evaluation and publication.

TO HP KEYBOARD READERS

The Series 9800 HP Calculators are versatile enough to accept many types of peripherals simultaneously. These calculators form the control units of systems to perform tasks which are too complex or time-consuming to be done by less sophisticated methods.

Currently available for delivery are the Model 9860A Marked Card Reader, the Model 9861A Output Typewriter, the Model 9862A Plotter, and the Model 9863A Paper Tape Reader. Also available is the Model 9868A Input/Output Expander which allows connecting all peripherals at one time.

In addition to these devices, Hewlett-Packard is now delivering the Model 9864A Digitizer, which allows quantizing and analyzing your graphic data. Also available is the Model 9865A Cassette Memory, which adds to any Series 9800 Calculator a bulk memory capacity of about 6,000 registers or 48,000 program steps. Both of these devices are described on the following pages.

We hope you will find this information useful. A telephone call to an HP sales office or mailing the postcard in this issue will bring you more information promptly.

A B Sperry

TABLE OF CONTENTS

Page

Features

Whistler Duct Research and the HP Calculator 2
Digitizer Unplots Data 5
Southern California Surveying 8
Cassette Memory Ups Series 9800 Capability 14

Programs

One-Line N! (Model 20) 4
Least Squares Solution of m Equations in n Unknowns (Model 20) 11
Frame With Several Floors and Spans (Model 10) 17
Lunar Module Landing Simulator (Model 9100B) 21

Teachers Corner

Ballistic Trajectory Program (Model 10) 31

Programming Tips

Data Entry Termination on Model 9100A/B and Model 10 35
Cascading 9100B Programs With Protected Stored Data 35
Special Label Sequence for 9810A 35
Sequential 'IF' Conditions 36
Demonstration Stops - 9100A/B 36
Integer X Without INT X Key 36
'No-Operation' Editing Aid - 9820A 36
Model 10 Data Printout 37
Errata 37

Announcements

Model 10 Stat ROM Random Key 10
Calculator Art Contest 10
Program Sharing Plan 16
Calculator Program Catalog Additions 26
New Program Libraries 30
Cassette Memory Pac Listing 30
Model 10 Digitizer Pac Listing 34
Model 10 Quantitative Business Analysis Pac Listing 34
9800 Calculator and Peripheral List . . . . Back Cover

APPLICATIONS INFORMATION FOR HEWLETT–PACKARD CALCULATORS
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KEYBOARD
VOLUME 4 NUMBER 2

Research in the field of long-distance low-frequency signal conduction by the earth's magnetosphere during the past two decades has added greatly to man's knowledge of the nature of this invisible medium. Scientists have discovered ducts of enhanced ionization in the magnetosphere, called ion ducts or whistler ducts, which correspond to the location of the earth's magnetic lines. Very-low-frequency (VLF) electromagnetic waves generated by lightning or other electromagnetic disturbances are trapped by a duct and transmitted to its other end, at a location designated as the conjugate on the duct's related magnetic field line. Signals of sufficient magnitude reflect and may be retransmitted back to the originating location. Fig. 1 shows the approximate horseshoe shape of one of these ducts.

Whistler Duct Research and the H-P Calculator

By A. B. Sperry

Several countries have maintained this research, which started in 1953. In the U.S.A., Stanford University's Radioscience Laboratory is one of the organizations which has maintained monitoring stations at appropriate points, including Byrd Station, Antarctica, and Eights Station, Antarctica. The respective conjugate locations are Great Whale River, Quebec, and Quebec City, Canada.

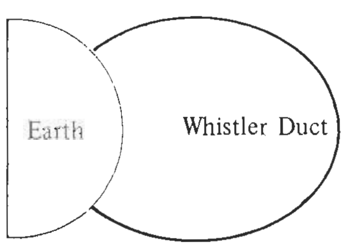


FIG. 1 WHISTLER DUCT

The research by Stanford University is headed by Dr. R. A. Helliwell of the Radioscience Laboratory. Two scientists working with him are Dr. Donald L. Carpenter and Jan C. Siren, both of whom have spent some time at the Antarctic monitoring stations. Dr. Carpenter has been responsible for processing data in Stanford's whistler research program, and has published extensive works related to this field.

Whistlers are whistling tones resulting from the excitation of an ion duct by a lightning flash. They are detected by a high-gain audio amplifier connected to a long-wire or loop antenna. Since the ion ducts have a unique transmission characteristic, not all frequencies are conducted with the same velocity. The result is a signal such as that shown in Fig. 2.

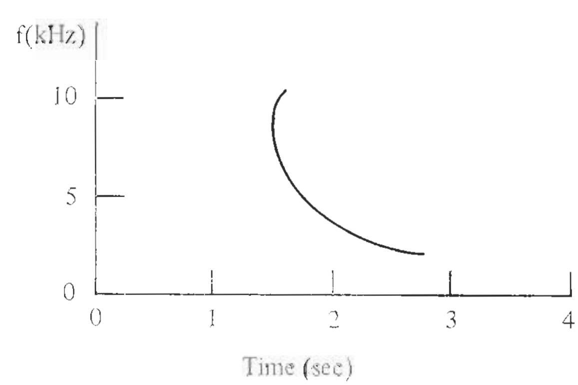


Fig. 2 NOSE WHISTLER

Whistlers like these are often called nose whistlers due to their shape. The frequency of minimum time delay, called the nose frequency, can vary under different conditions but is commonly observed to be around 5kHz at Antarctic stations.

The length of a whistler duct and the signal transmission time are related, so that duct length can be calculated. During a magnetic substorm, changes in transmission time through a duct and nose frequency have been observed. These changes indicate, for whistler ducts located approximately four earth radii from their geocenter, outward or inward motion of the ducts at the equatorial plane as much as one earth radius per hour.

Jan C. Siren, who has been associated with the Stanford whistler research project since 1966, was informed by Donald Carpenter that copious data of high quality were obtained during a 9-hour period during such a substorm. Mr. Siren used the data to model the original motions of the whistler ducts. He programmed the HP 9100B Calculator to do the modeling, with an associated 9125A Plotter for graphic output. The program input consisted of 5-minute averages of location and intensity parameters of selected whistler ducts. The output was 2-dimensional plots of the whistler duct positions relative to the earth (Fig. 3).

Plots for the entire 9-hour period were photographed in sequence on 16mm film. The result was a moving picture film vividly depicting in an accelerated fashion the motion of the whistler ducts during the magnetic substorm. This film was shown at meetings of the International Radio Science Union and the American Geophysical Union.

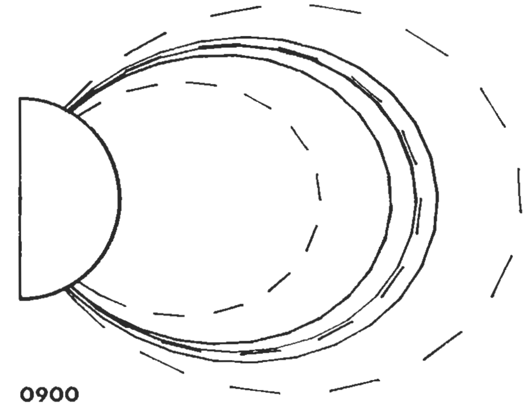
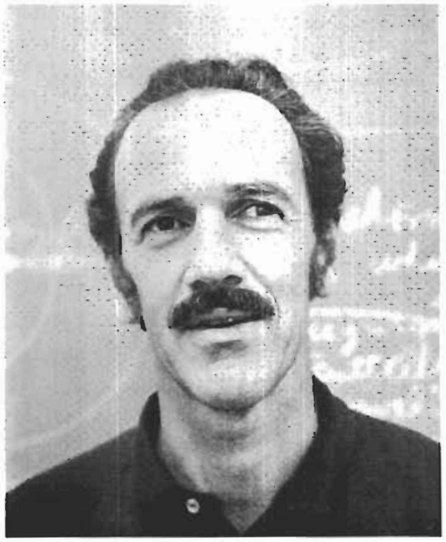


Fig. 3 WHISTLER DUCT PLOT

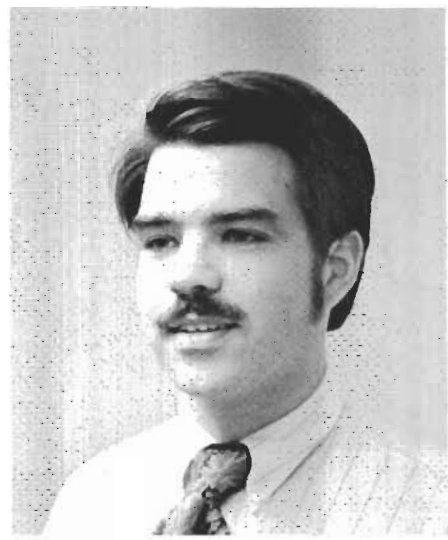
Ion ducts carry many other types of signals in addition to whistlers. Some of these have a less distinct set of discrete whistler-like components over about the same frequency range, and give a hissing sound; these are appropriately named hisslers. The Stanford group is doing further research on these.

An ion duct excitation source is found in low-frequency, high-power continuous wave radio transmissions. These man-made transmissions trigger ducts to emit wave energy at a different frequency than that of the triggering wave. The artificially-stimulated emissions sometimes do not occupy the same frequency spectrum as whistlers. Excitation is believed to occur at or near the center of the duct's length, rather than at the entry point of the duct.

The Stanford group plans to conduct research in the latter type of signals for three years at Siple, Antarctica, beginning in 1973. Experiments can be controlled using continuous wave or frequency-modulated CW signals. Conjugate stations will be located with a transmitter at Siple, Antarctica, and a receiver at Roberval, Quebec, reversing the whistler situation in which natural signals are stimulated in the northern ends of the ducts and received at the southern ends. ■



Donald L. Carpenter received his B.A. degree from Willamette University in 1951, and his M.A. degree from Columbia University. He obtained his M.S. and Ph.D. degrees in Electrical Engineering from Stanford University during 1959 and 1962, respectively. He is a co-discoverer of the plasmapause, the sharp boundary in space between the regions of broken and unbroken magnetic lines of force. Dr. Carpenter has served under Prof. R. A. Helliwell in various capacities since 1961. He is currently working under an NSF grant on studies of the thermal plasma and the geoelectric field in the magnetosphere using VLF techniques. He is a member of Sigma Xi and of the American Geophysical Union.



Jan C. Siren obtained his B.S. degree in 1964 from Carnegie Institute of Technology, and his M.S. degree in 1966 from Stanford University. He joined Prof. R. A. Helliwell's VLF research group in 1966, and is presently working at Stanford University on his Ph.D. degree in Physics.

ONE-LINE N!

Engineers and salesmen are people who love to solve problems. When a salesman is also an engineer, he is hard to beat. When Carl Smolka of the Hewlett-Packard office in Rochester, New York, was initially learning the Model 9820A, he was challenged to design a one-line program for N factorial. Here is the result, which calculates 69! in a few seconds.

Smaller factorials are calculated faster, and the program gives the correct defined result of 1 for 0!.

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

DIGITIZER UNPLOTS DATA

A digitizer allows a Calculator System to perform a wide variety of tasks that are otherwise difficult or impossible. Yet many people know little about this useful device. For many years a digitizer has been a 'computer peripheral.' Now, the HP Calculator-Digitizer combination offers a low cost solution to many problems involving the gathering and analysis of data.

WHAT IS A DIGITIZER?

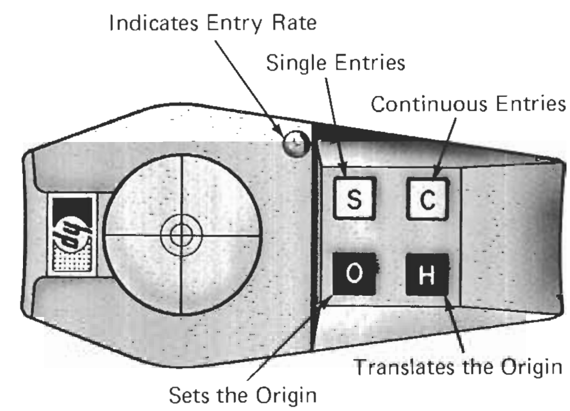
A digitizer determines cartesian coordinates of points on a document, such as a photograph, or a strip chart. The coordinates are in inches, and are with respect to an origin determined by the user. The digitizer transfers the coordinates to the Calculator. The Calculator analyzes the series of incoming coordinates that are generated as the data is digitized.

The HP 9864A Digitizer consists of a *platen*, or digitizing surface, upon which the document to be digitized is placed; a *cursor*, whose cross hairs are used to trace the data; and a *mainframe*, which contains the necessary electronics.

The 9864A will work with both the Model 10 and Model 20 Calculators. A peripheral control block is required for each calculator, however.

Some features of the 9864A are:

- Resolution to .01 inches (0,254 mm)
- Absolute accuracy of .015 inches (0,38 mm)
- 4 Quadrant operation
- Single and continuous sample modes
- Origin translation up to maximum coordinates of ±99.99 inches (2,54 m) in each axis
- Optional large platens - standard is 17 x 17 inches (431,8 x 431,8 mm) - sizes available up to 42 x 60 inches (1,07 x 1,5 m)
- Audible 'beep'



The cursor for the 9864A Digitizer.

CONTROLLING THE DIGITIZER

The Digitizer responds to commands from both the Calculator and the user. To enter the coordinates of a point, the Calculator must first 'ask' for data. In Model 10 Calculator Systems this is accomplished with FORMAT 3 9 DECIMAL POINT*. In Model 20 Systems the data request is READ 9, X, Y (any registers could be used). The *x* coordinate would be placed in the X register, and the *y* coordinate in the Y register, *provided that the operator enables the digitizer to sample.* He can do this by single sampling or by specifying a continuous mode.

When single sampling, the operator determines when each point is to be digitized. This is to allow him to position the cursor properly between samples. This situation often occurs when digitizing the vertices of a figure composed of straight lines.

---

*The 9 represents the 'select code' of the Digitizer. Each 9800 Series peripheral has a select code which distinguishes that individual peripheral from others connected to the same Calculator. The Digitizer's select code is user-adjustable, by setting a switch inside the instrument. We will assume that the select code is set at 9.

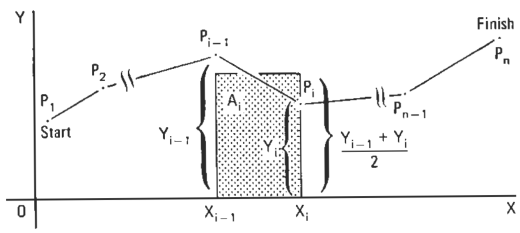
When sampling continuously, the digitizer supplies coordinates to the Calculator immediately upon the data request. This allows the operator to trace along a curved line. The data reaching the Calculator actually represents a series of short line segments that is an excellent approximation of the original data.

The HP Digitizer is equipped with a 'beep.' This is an audible tone that lasts approximately 1/10 second. With the Model 10 the command to beep is FORMAT 4 9 PRINT. The Model 20 beep command is WRITE 9.

The beep can be used to indicate that a closed figure has been completely digitized (see AUTOMATIC CLOSURE). Another use is to alert the operator that the cursor is being moved too quickly to maintain a minimum number of points digitized per inch.

INTEGRATION WITH THE DIGITIZER

One of the most important uses of the Digitizer is to perform integration. A popular algorithm for doing this is to sum the areas of rectangles described by the incoming data (Fig. 1).



$$\text{AREA} = \left| \sum_{i=2}^{n} A_i \right| \quad \text{where } A_i = \frac{\Delta X\,(Y_{i-1}+Y_i)}{2}, \text{ and } \Delta X = X_i - X_{i-1}$$

Fig. 1

The sign of each A_i depends upon the direction of cursor movement. The signs of the individual A_i are useful, and allow the program to compute the area of closed figures.

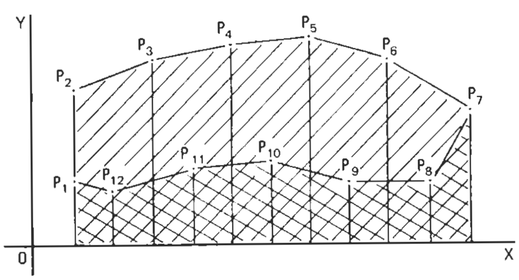


Fig. 2

In Fig. 2, the area of the cross-hatched region is automatically removed from the result, leaving only the area of the single-lined region as the answer. This is a direct consequence of the changes in sign of each individual A_i, as the direction of cursor movement alters while the figure is being digitized.

AUTOMATIC CLOSURE

It is not necessary to remember or mark the starting point when digitizing a closed figure if the program performs *automatic closure*. Automatic closure of the area program is accomplished by saving the coordinates of the first point digitized (P_1). Consider a circle of radius epsilon drawn around P_1. Closure occurs when some P_n (lying inside the circle) is digitized, after at least one point outside the circle has been digitized. Then, after the computations for P_n are completed, the program takes the next point (P_{n+1}) as P_1. This actually closes the figure. Then a beep is given and the answer is displayed or printed.

```
0:
ENT "CLOSURE DIS
TANCE",B⊢
1:
SFG 1;0→A;RED 9,
R0,R1⊢
2:
R0→R2;R1→R3⊢
3:
RED 9,X,Y⊢
4:
A+(X-R2)(Y+R3)/2
→A⊢
5:
IF FLG 1;IF (X-R
0)↑2+(Y-R1)↑2>BB
;CFG 1⊢
6:
X→R2;Y→R3⊢
7:
IF FLG 1=0;IF (X
-R0)↑2+(Y-R1)↑2≤
BB;GTO 9⊢
8:
GTO 3⊢
9:
A+(R0-R2)(R1+R3)
/2→A;WRT 9⊢
10:
FXD 2;PRT "AREA
=",r(AA);SPC 8;
DSP r(AA)⊢
11:
END ⊢
```

An integration program for the Model 20 Calculator.

DIGITIZING LARGE DOCUMENTS

The ability to translate the origin allows documents such as strip charts to be digitized even though they are larger than the platen. The document is digitized in segments of arbitrary size (but less than 17 x 17 inches).

As the document is shifted to bring another segment over the platen, the origin is translated by the same amount (Fig. 3). Thus all points digitized have coordinates correct with respect to the original origin. To translate the origin, the Digitizer is placed in the HOLD mode, and cursor moved by the amount the origin is to shift.

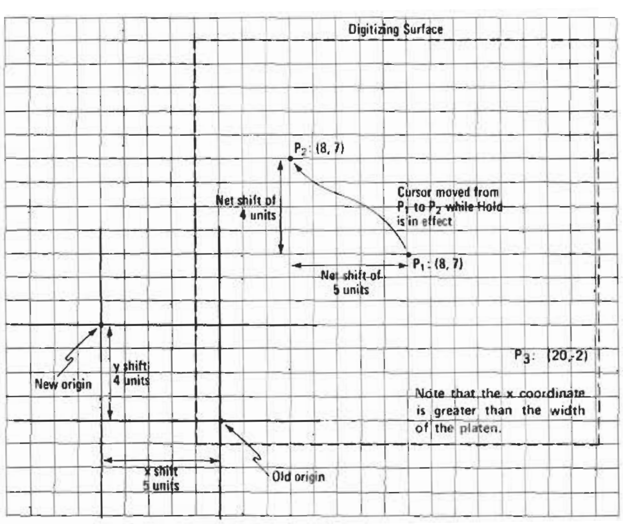


Fig. 3 TRANSLATION OF THE ORIGIN USING HOLD

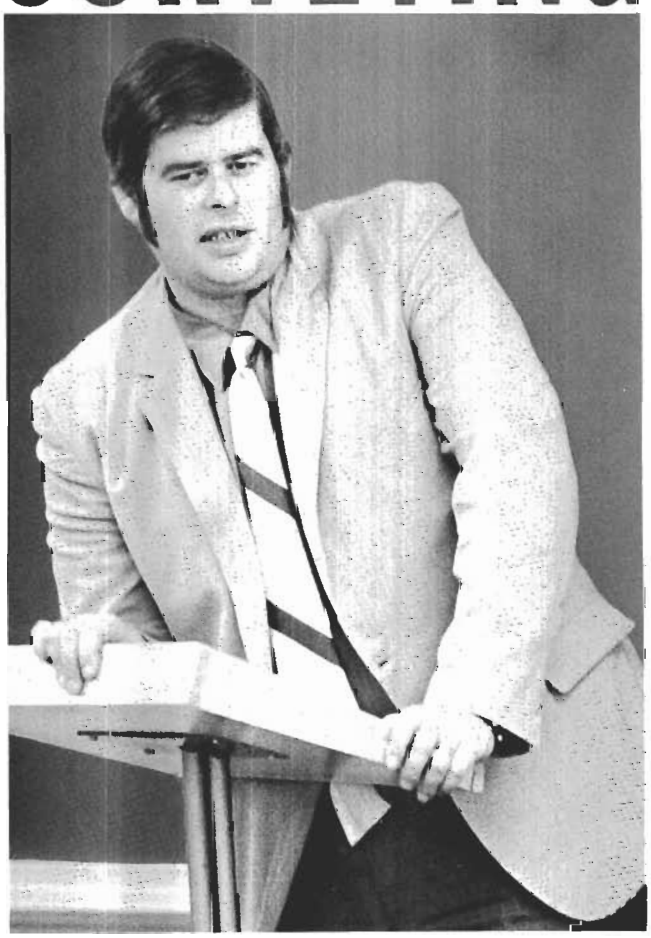
OTHER APPLICATIONS

Typical applications for the Digitizer include the following:

- Statistical Analysis of Data
  Curve fitting - regression analysis
  Analysis of strip-chart recordings
  Histogram analysis - probability density functions
  Mathematical models of families of curves
- Analysis of Irregular Shapes
  Calculate areas with or under irregular shapes
  Calculate centroid
  Calculate moments of inertia
  Determine distance between points over irregular path and lengths of curved and irregular lines
- Analysis of Irregular Waveforms
  Harmonic analysis - determine Fourier coefficients
  Find area under curves
  Transient analysis from oscilloscope photos or plots
- Teaching Mathematical and Statistical Concepts
  Illustrate integration and differentiation by plotting on calculator plotter as curve is traced
- Contour Maps
  Determine volumes of earth that must be moved for road building or site planning
- Cardiology
  Ventricular volume
  Dye dilution curve
- Scaling with Plot
  Trace curve and plot to different scale
  Change from logarithmic plot to linear or vice versa
- Coordinate Transformation
  Scaling
  Rotation
  Translation

For more information about the HP Digitizer (including data sheet and application notes) use the reply card in this issue.

SOUTHERN CALIFORNIA SURVEYING



Orange County, California, is the scene of considerable surveying activity. Much of this activity is directed from the Orange County Engineering Building, which houses the Orange County Flood Control District and the Orange County Road Department. Hewlett-Packard calculators play an important part in the reduction of surveying data and the many other computations related to this surveying work. The use of calculators in this type of computations is considered important enough so that in addition to night classes for professional surveyors, a course is being offered to engineering students at the Santa Ana Community College.

PROGRAMMING COURSE FOR SURVEYORS

A new night course in programming the HP Model 9810A Calculator for surveying computations is being offered to professional surveyors in Orange County. The first course started in February of this year. The classes are given for four hours each week, the only prerequisite being an elementary surveying course at the college level. The course lasts eighteen weeks.

In the first night course, twenty-four professional surveyors learned to program the Model 9810A Calculator to solve their everyday problems. Programming was taught starting with fundamentals. With some basic programming instructions, the students used handout material such as keyboard charts and octal code charts as a basis for assembling their own programming manuals. In a very short time, the students were designing and using their own programs. They coded these programs on marked cards, which were then entered rapidly into the calculator using the HP Model 9860A Marked Card Reader. This allowed maximum accessibility to the calculator.

It is planned to continue the night courses as long as demand keeps up. There are about 2,000 professional surveyors in Orange County, and it is estimated that the majority of them will want to participate in the programming course.

Richard W. Libby, who instructs this course, says it is very encouraging to see how rapidly the students progress, learning the easy calculator language, then designing and using programs to solve their specific problems. Dick studied at Fullerton Junior College, and is currently employed as an engineering technician in the County Surveyor's Office of the Orange County Road Department. He enjoys teaching, and also acts as a part-time instructor at the Santa Ana Community College.

Concerning the equipment used in the night programming course, Mr. Libby said the HP Model 9810A Calculator with a mathematics block for trig functions was chosen because it was the best one available for this course. The Model 9860A Marked Card Reader is used for efficient sharing of the available time. Each student can code his own program on marked cards, so that no calculator time is tied up by keying in programs. The Marked Card Reader is also used during the day in the County Surveyor's Office, mainly for reduction of field surveying data and for checking maps.

COLLEGE COURSE OFFERED

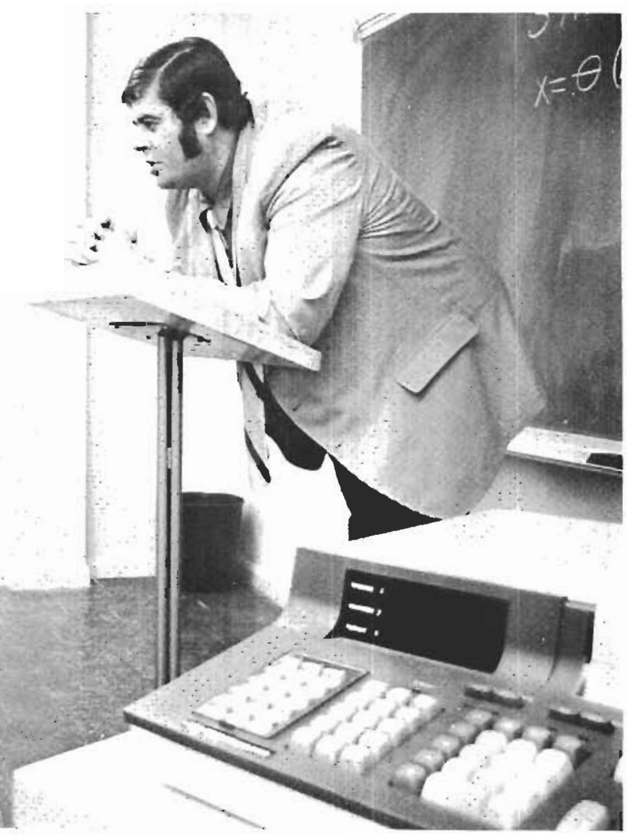
Santa Ana Community College started offering a course this spring entitled 'Desk-Top Computers Applied to Surveying Technology.' It is a course in the use of programmable electronic desk calculators to solve surveying problems, with emphasis placed on using a logical method of solution and translating the method into calculator language. Mr. Libby taught the course this spring.

Recommendations of Prof. Wayne Gibson of the Computer Science Department and Robert R. Cowan, Engineering Department instructor, resulted in the college acquiring a Hewlett-Packard Model 9810A for this course. The Model 10 is used for a variety of additional applications, such as in teaching mathematics so that students can concentrate on solution methods without spending large amounts of time laboring with slide rules and tables.

Another valuable application is in teaching the composition of the calculator memory and the way indirect addressing and other programming functions operate. This is possible with the accessible calculator as a step toward learning the operation of larger computers, which are relatively inaccessible for teaching purposes. ●

Dick Libby (left) and Robert Cowan (right) discuss surveying use of the Model 10 with visitor.

Mr. Libby answers a student question at Santa Ana Community College.



MODEL 10 STAT ROM RANDOM KEY

The RANDOM key on the Model 10 Statistics Block generates a sequence of pseudorandom numbers. This sequence is generated by a method which causes adjacent numbers to be correlated. This is called 'serial correlation.' The effect in some applications is shown in Fig. 1.

Fig. 1

This plot was created by plotting P(x,y) where x and y were adjacent random numbers; $x = r_i$, $y = r_{i+1}$. Note the linear dependence of y on x.

Fig. 2 was generated by plotting P(x,y) where $x = r_i$, $y = r_{i+2}$. The dependence of y upon x is destroyed using this method. If your usage of the Model 10 Statistics Block involves two or more variable Monte Carlo simulations, you can ensure independence of variables by using the technique applied in Fig. 2.

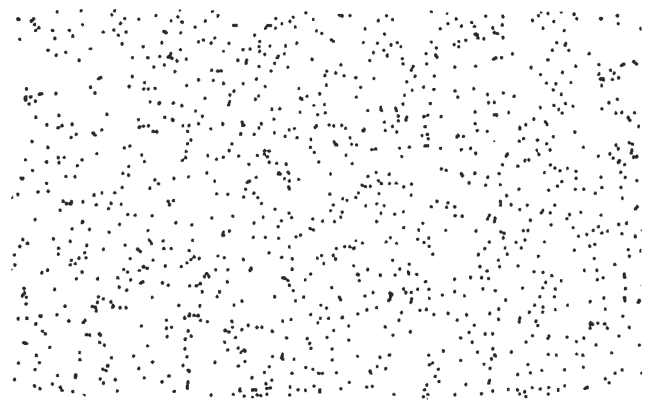
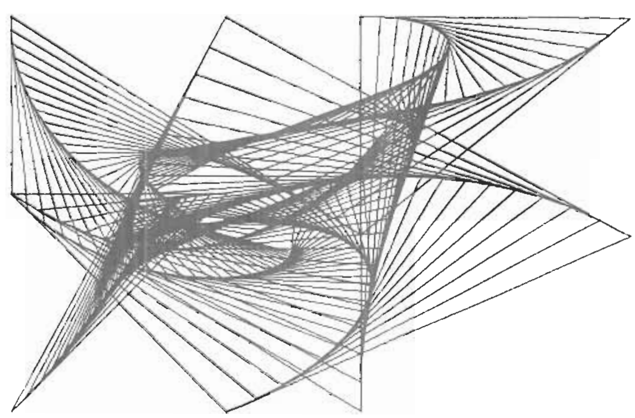


Fig. 2

Our thanks go to Prof. L. Glasser, Department of Chemistry, Rhodes University, Grahamstown, South Africa, for sending us an example showing the serial correlation.

CALCULATOR ART CONTEST

The 1972 Calculator Art Contest entry deadline was revised to September 29, as announced in *KEYBOARD*, Vol. 4, No. 2, to allow time for entries from all countries to arrive. The winners and prizes for both the general branch and the student branch of the contest will be published in the next *KEYBOARD* issue, along with as many runners-up as possible.



PART NO.
09820-70004

MODEL 20

LEAST SQUARES SOLUTION OF M EQUATIONS IN N UNKNOWNS

by Dr. James N. Shapiro

This program gives the least squares solution to a set of overdetermined, incompatible linear equations.[1]

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = b_2$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_n\ ,$$

$$m \geqslant n$$

In addition to the least squares solution the deviation of each equation

$$DEV_i = \sum_{j=1}^{n} a_{ij}x_j - b_i\ ,$$

is calculated as well as the standard deviation

$$S.D. = \left[\frac{1}{m} \sum_{i=1}^{m} (DEV_i)^2\right]^{1/2}$$

In the case that the equations are evendetermined and compatible (m = n, and all equations compatible) or only artificially overdetermined and compatible (m > n but m-n redundant equations and n compatible equations) this is indicated by $D_i = 0$ for all i, and S.D. = 0, so that the situation reduces to n linear equations in n unknowns.

The restrictions on m and n are

$$m \geqslant n$$

$$(m + n)(n + 1) < \begin{cases} 72 & \text{standard 9820} \\ 328 & \text{expanded memory model} \end{cases}$$

These numbers may be increased slightly to 91 and 347 respectively by deleting the calculation of the D_i's and the S.D. This may be done by replacing line 35 by END.

ROM BLOCKS

1 3

INTERNAL REGISTERS

X

PERIPHERALS

- [ ] 9860A MARKED CARD
- [ ] 9861A TYPEWRITER
- 9862A PLOTTER
- 9863A PAPER TAPE READER
- [ ] 9864A DIGITIZER
- [ ] 9865A CASSETTE

STEP	DISPLAY	INSTRUCTIONS
1		ERASE LOAD EXECUTE
2		Alternately insert magnetic cards and EXECUTE until NOTE 14 no longer appears, indicating completion of loading.
3		(Optional) FIXED N n EXECUTE, or FLOAT N n EXECUTE as desired.
4		END RUN PROGRAM
5	M?	m RUN PROGRAM, m = # of equations.
6	N?	n RUN PROGRAM, n = # of unknowns.
7	A(I,J)?	a_{ij} RUN PROGRAM by *columns*.
8	B(I)?	After b_n has been entered, the display blanks and calculations proceed. The x_i's are printed sequentially, followed by the deviations, also printed sequentially, and finally the standard deviation is printed.
9		To rerun the program END RUN PROGRAM.

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

$m = 3 \qquad n = 2$

$$x_1 + x_2 = 1$$
$$x_1 + x_2 = 2$$
$$x_1 - x_2 = 0$$

MEMORY ALLOCATION

REGISTER	CONTENTS
A	M
B	N
C	summation index
X	I
Y	J
Z	working
R_o	working

$A_{ij} \rightarrow R((j-1)m + i)$

$b_i \rightarrow R(mn + i)$

$B_{ij} = (A^TA)_{ij} \rightarrow R(m + (m + j - 1)n + i)$

$(A^Tb)_i \rightarrow R(m + (m + n)n + i) = x_i$ after calculations.

Total registers used:

$R_o - R((m + n)(n + 1))$

```
 LEAST SQUARES
  SOLUTION TO

 1.000000000E 00
 1.000000000E 00
 1.000000000E 00

 1.000000000E 00
 1.000000000E 00
-1.000000000E 00


 1.000000000E 00
 2.000000000E 00
 0.000000000E 00


       IS

X
 1.000000000E 00
=
 7.500000000E-01
X
 2.000000000E 00
=
 7.500000000E-01
DEV
 1.000000000E 00
=
 5.000000000E-01
DEV
 2.000000000E 00
=
-5.000000000E-01
DEV
 3.000000000E 00
=
 1.000000000E-12
S.D.=
 4.082482905E-01
```

EXAMPLE 2

```
LEAST SQUARES
 SOLUTION TO


 1.000000000E 00
 2.000000000E 00
 3.000000000E 00
 1.000000000E 00
 3.000000000E 00

 1.000000000E 00
 3.000000000E 00
 2.000000000E 00
-1.000000000E 00
 5.000000000E 00

 0.000000000E 00
-1.000000000E 00
 1.000000000E 00
 2.000000000E 00
-2.000000000E 00

       IS

X
 1.000000000E 00
=
 1.000000000E 00
X
 2.000000000E 00
=
-1.000000000E 00
DEV
 1.000000000E 00
=
 0.000000000E 00
DEV
 2.000000000E 00
=
 0.000000000E 00
DEV
 3.000000000E 00
=
 0.000000000E 00
DEV
 4.000000000E 00
=
 0.000000000E 00
DEV
 5.000000000E 00
=
 0.000000000E 00
S.D.=
 0.000000000E 00
```

$m = 5 \qquad n = 2$

$$x_1 + x_2 = 0$$
$$2x_1 + 3x_2 = -1$$
$$3x_1 + 2x_2 = 1$$
$$x_1 - x_2 = 2$$
$$3x_1 + 5x_2 = -2$$

Note that although this system at first glance appears overdetermined, $m > n$, it is in fact evendetermined and compatible. For example, the third equation is easily seen to be the sum of the second and fourth equations, etc. Whenever the system is compatible the deviations will be identically zero, within roundoff.

James N. Shapiro is an Assistant Professor of Geophysics at Texas A&M University. He received a B.S. degree in Physics from the Massachusetts Institute of Technology in 1962, an M.S. in Physics from the University of California, Los Angeles, in 1965, and a Ph.D. in Physics from U.C.L.A. in 1970. He has published numerous papers in technical journals. Dr. Shapiro is a member of the American Association for the Advancement of Science. He enjoys playing handball and racketball, as well as camping and family activities.

REFERENCE [1]C. Lanczos, Applied Analysis, (New Jersey: Prentice-Hall, Inc., 1964), pp. 156-161.

CASSETTE MEMORY UPS SERIES 9800 CAPABILITY

BULK MEMORY

The recently introduced Hewlett-Packard Model 9865A Cassette Memory significantly increases the effective memory of the HP Series 9800 Calculators. Used with the Model 9810A, for example, each standard 300-foot (91,44 m) tape cassette expands the calculator's memory by approximately 6,000 data registers or 48,000 program steps. Both programs and data may be stored and recalled from the same tape, uniquely identified by numbered file locations on the tape. The capability of cascading the stored programs greatly increases the versatility of the calculator system.

UNIQUELY IDENTIFIED FILES

The 'file' is the basic unit of storage used with the Cassette Memory: each file can contain either data or program information. The user specifies the quantity and storage capacity of all files to be established on each tape. Once files are established, the user can store information into any file or recall information from it. Each file has a unique file number which allows it to be called either from a program or by keyboard operation. This also relieves the operator of any need to remember where a particular file is on the tape. All he needs is a record of the file number to address any stored program or data file.

The storage capacity or size of each file is expressed in 'registers'; each register can hold eight program steps or the contents of one calculator data register.

LOADING ERROR DETECTION

The Cassette Memory routinely checks to insure that information being loaded into the calculator corresponds exactly to the information originally recorded. Any error detected during a 'load data' or a 'load program' operation causes the file to be automatically reloaded into the calculator. If the file cannot be successfully loaded after four attempts, the tape stops in front of the file containing the error, the program stops, and the status light comes on. This feature insures that calculator operation can be continued only when correct data or program steps are loaded into the calculator.

FILE MODIFICATION

It is possible to recall data from a file on the tape, modify it, and store the modified data in the same file in place of the original data. For permanent data, the cassette may be protected as explained below. This gives extremely versatile capability for either modifying or protecting your stored data.

CASSETTES

The cassette recommended for use with the Model 9865A Cassette Memory is the HP Part Number 9162-0050. This is a 300-foot digital-quality tape designed for long life and compatibility with the Cassette Memory. Although tapes of other manufacture may be used, they are not recommended since some of them may damage the Cassette Memory.

Protection of program and data files against accidental rerecording or modification is easily accomplished by removing two plastic tabs on the tape cassette. This provides permanent protection unless the user chooses to unprotect a cassette temporarily to change the contents of a file. To do this, he merely fastens a piece of cellophane tape over the place originally occupied by each tab, modifies the file data as required, and reprotects the cassette by removing the cellophane tape. In this way, the user is not required to duplicate a protected tape to change some of the stored information.

CASSETTE CONTROL

The connector cable for the Cassette Memory plugs directly into the back of the Series 9800 Calculator. The calculator must be equipped with an appropriate plug-in block for cassette control. The blocks available are:

Model 11223A Cassette Memory ROM (9820A)
Model 11265A Cassette Memory ROM (9810A)

Since a number of the HP Calculator peripheral devices may be connected simultaneously in a parallel arrangement, each device must have a unique 'address' so that the calculator can specify which device should respond to which operation. The Cassette Memory's address (or select code) is a one-digit number determined by the circuitry on an interface card. Each instruction from the calculator to the cassette must contain the appropriate select code so that the Cassette Memory will respond to the instruction and other peripherals will ignore it. Select Code 5 is set at the factory for each Model 9865A, but the user may modify the select code to any other single-digit number. Consequently, several cassette memories with different select codes may be used simultaneously in the same system.

COMMAND SET

The following commands for the 9865A Cassette Memory may be given by either the Model 10 or Model 20 Calculator:

MARK TAPE--the cassette tape may be marked in files of different length for program and/or data storage, optimizing tape utilization.

FIND FILE--search for a specified file at high speed from any point on the tape without rewinding. This significantly decreases program execution time, since the specified file number is found directly without rewind. The file search is performed at a speed of 130 feet/minute.

RECORD DATA--this command causes data to be recorded onto the cassette from registers in the calculator memory. It allows the user to specify the number of registers for data transfer.

LOAD DATA--this command loads data into the calculator memory from a file starting at a specified register.

RECORD PROGRAM--this records a program onto the cassette, beginning at a specified program location in the calculator memory. It allows selective program or subroutine storage.

LOAD PROGRAM--this command loads a program from the cassette into the calculator memory beginning at a specified program location in the calculator.

IDENTIFY FILE--this command displays the file number of the current position on the cassette tape. It leaves the tape in the initialized position to read from or write into that particular file.

Additional information and demonstrations of the Model 9865A Cassette Memory may be arranged by contacting your local Hewlett-Packard Sales Office or filling out and mailing the reply postcard in this *KEYBOARD*. ●

PROGRAM SHARING PLAN

The program sharing plan announced in *KEYBOARD*, Vol. 3, Nos. 1 and 3, makes available, on a user-to-user trading basis, individual programs which the author does not wish to have widely distributed by including them in *KEYBOARD* or in a published program library, but which the program author is willing to share with other calculator users in related fields.

These programs are kept by the person offering them in return for copies of a like number of programs from another program-sharing user. If you have programs you would like to trade with other calculator owners on a one-for-one basis, send any *KEYBOARD* editor the title of your program, the equipment it requires, and a short summary of the problem and equations it solves. DO NOT SEND THE PROGRAM ITSELF. You will be contacted directly by other individuals who wish to exchange a copy of their unpublished programs in return for yours. You may withdraw a program at any time by notifying one of the *KEYBOARD* editors.

Listings of shared programs are mailed to members of the program sharing plan as programs are added. Programs included in this plan to date are:

A. D. Williams, Davenport Park, Stockport, U.K.
British Income Tax Calculation; 9100B, 9120A

Dr. H. F. Kay, Bristol, U.K.

1. Calculation of Crystal to Diffractometer Orientation Matrix; 9100B, 9120A
2. Search of Reciprocal Space for Off-Line Diffractometers; 9100B, 9120A

John P. Walsh, Burlington, Massachusetts
Linear Interpolation Subroutine (INTERP); 9100A/B, 9101A

Dr. Eric Lane, Chattanooga, Tennessee
The Freely Falling Body Experiment: Plot and Least Squares Fit to a Parabola; 9100A/B, 9120A, 9125A/B

Stephen A. Nichols, Washington, D.C.
Parabolic Antenna Parameters; 9100B

C. Cardot, Marcoussis, France

1. Ephemeris of Stars; 9100B
2. Yearly Coordinate Correction; 9100B

Herbert E. Ingarfield, Freeport, GBI, Bahamas

1. Payroll, Federal Income Tax, and Deductions; 9810A, 2036 steps, 111 registers, Printer, Math ROM
2. Hardy Cross Water Analysis; 9810A, 2036 steps, 111 registers, Printer, Math ROM
3. Comprehensive Survey & Coordinate Storage; 9810A, 2036 steps, 111 registers, Printer, Math ROM

J. P. MacKean, Schefferville, Quebec, Canada

1. Coordinates of Drill Holes From Stadia Traverse; 9100B
2. Conversion of Drill Hole Coordinates to Offset Distances Relative to a Baseline and Cross Section; 9100B

F. R. Solis, Philadelphia, Pennsylvania

1. Present Worth Factor; 9100B
2. Double or Twin Cable Lines--Load Sharing; 9100B
3. Parallel Complex Impedances; 9100B
4. Customer Duty Calculation Program; 9100B
5. Ruling Span Calculation; 9100B

Ian H. S. Douglas, Glasgow, Scotland
Blood Oxygen Saturation; 9100A/B

Dr. C. E. Styron, Laurinberg, North Carolina

1. Calculation of N, Mean, Standard Deviation, Standard Error, and 95% Confidence Limit (Data Input by Tape Reader); 9100A, 9863A
2. Linear Regression by Least Squares; 9100A, 9863A
3. Frequency Distribution Analysis; 9100A, 9863A
4. Analysis of Variance, Two-way Classification With Replicates and F-test; 9100A
5. Multistat; 9100A
6. SICHAP Single Channel Analysis Program for Conversion of Gross Sample Counts to Sample DPM; 9100A, 9863A
7. DUCHAP Dual Channel Analysis Program for Conversion of Dual Tagged Sample Counts to Sample DPM for Isotopes A and B; 9100A, 9863A
8. Self-scaling Plot of Axes for Plotting Y on X and Z; 9100A, 9863A
9. Plot of Y on X and Z, Constants and Form of Ten Term Polynomial Supplied by User; 9100A, 9863A
10. Plot of Y on Z and X, Constants and Form of Ten Term Polynomial Supplied by User; 9100A, 9863A
11. Self-scaling Plot of Axes for Plotting Y on X, Linear; 9100A, 9863A
12. Plot of Y on X, Constants and Form of Polynomial Supplied by User; 9100A
13. Plot of Y on X, Constants and Form of Polynomial Supplied by User; 9100A, 9863A
14. MULCH Multichannel Analysis Program for Conversion of Dual Channel Sample Counts from MCA to Sample DPM for Isotopes A and B; 9100A, 9863A

PART NO.
09810-77909

FRAME WITH SEVERAL FLOORS AND SPANS

by Dr. Ing. Andrea Sacco

This program calculates the moments at joints in a horizontally movable plane frame under uniformly distributed loads and horizontal point loads with constant dimensions for every beam and column.

The numbers of floors and spans is limited by

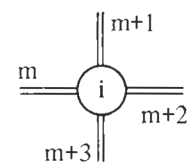
$$2f + s + 1 + 8f(s+1) \leqslant 106$$

wherein s is the number of spans and f the number of floors. With this, there can be 12 joints for a general frame and 11 joints for a 'simplified' frame, which is a frame of one floor with columns fixed above and below.

The method of Hardy Cross is used in this program since this method has the advantage of using the lowest number of elastomechanic constants. Input data for the frame are:

beam lengths L_i, from left to right;
column heights h_i, counting from top to bottom;
dimensions b and h of the horizontal beams;
dimensions b' and h' of the vertical columns;
uniformly distributed vertical loads for every beam;
horizontal point loads caused by wind.

The results are the moments around each joint, in a form as follows:



The moments about a joint are positive in a clockwise direction. For external joints the moments of nonexisting beams and columns are naturally zero. The program compares the moment of the second-to-last joint between two cycles and gives the result when the difference of the moments is less than 10^{-4}. It is possible to accelerate the output of the results if the convergence seems sufficient, as the moments of the second-to-last joint are visible by PAUSE. Pressing PAUSE manually at this point until the display appears stops the program; CLEAR X, ROLL UP, CONTINUE causes the immediate output of the results.

At the end of the output, it is possible to enter new loads by pressing CONTINUE without reentering the geometrical values.

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

TOTAL REGISTERS
[ ] 51
[X] 111

TOTAL PROGRAM STEPS
[ ] 500
[ ] 1012
[X] 2036

ROM S
1 MATHEMATICS
2
3 PRINTER ALPHA

STEP	USER INSTRUCTION	DISPLAY X	DISPLAY Z
1	FMT, GO TO		
2	Enter magnetic card		
3	Enter Data i (see table below), CONTINUE		

i Value Selection Table

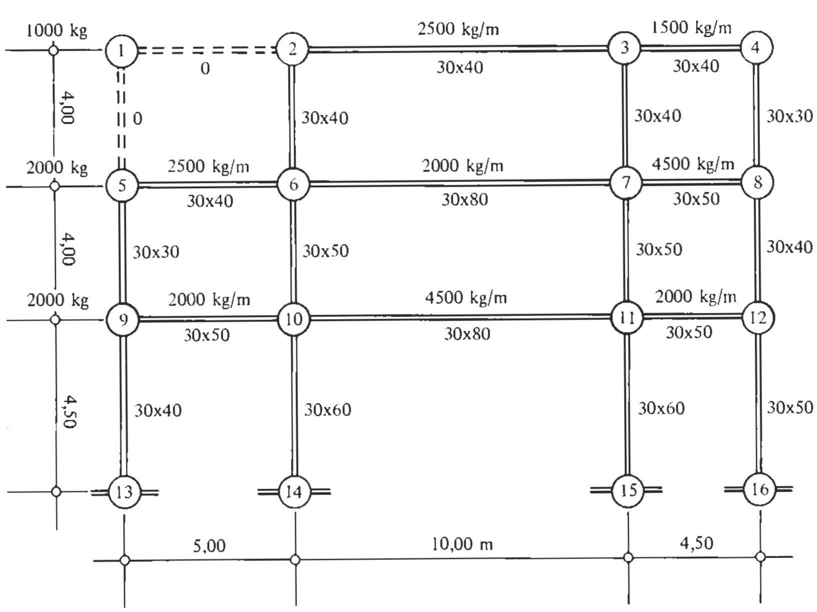
i Value		Dimensions for each floor	
General Frame	One-floor Frame	Beam (b and h)	Column
1	5	Variable	Variable
2	6	Variable	Constant
3	7	Constant	Variable
4	8	Constant	Constant

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

STEP	USER INSTRUCTION	DISPLAY	
4	Further instructions are printed out. All data are entered into the X-register. Loads, lengths, and dimensions (b before h) of beams and also of columns are entered from left to right. Heights and point loads caused by wind (positive from left to right) are entered from top to bottom.		
5	To accelerate the printout of the moments around the points (positive in clockwise direction, Cross !), stop the program by pressing PAUSE and get the result by using CLEAR X, ROLL UP, CONTINUE.		
6	After the last printout it is possible to enter new loads by pressing CONTINUE.		
7	For new problem, press END, CONTINUE		
	Dimensions (optional), used with example:		

	Metric	Equivalent English Units
lengths L_i and heights H_i	(m)	(ft)
sizes b and h of beams and columns	(cm)	(ft x 10^{-2})
uniformly distributed loads	(kg/m)	(kips/ft)
point loads P_{WIND}	(kg)	(kips)
moments	(kgm)	(ft-kips)

EXAMPLE 1: FRAME (i=1)



$g_{2\text{-}4}$ = 1500 kg/m
$g_{5\text{-}6}$ = 1500 kg/m
$g_{6\text{-}8}$ = 2000 kg/m
$g_{9\text{-}12}$ = 2000 kg/m
$P_{2\text{-}4}$ = 1000 kg

$p_{2\text{-}4}$ = 1000 kg/m
$p_{5\text{-}6}$ = 1000 kg/m
$p_{6\text{-}8}$ = 2500 kg/m
$p_{9\text{-}12}$ = 2500 kg/m
$P_{5\text{-}8}$ = 2000 kg

$g+p_{2\text{-}4}$ = 2500 kg/m
$g+p_{5\text{-}6}$ = 2500 kg/m
$g+p_{6\text{-}8}$ = 4500 kg/m
$g+p_{9\text{-}12}$ = 4500 kg/m
$P_{9\text{-}12}$ = 2000 kg

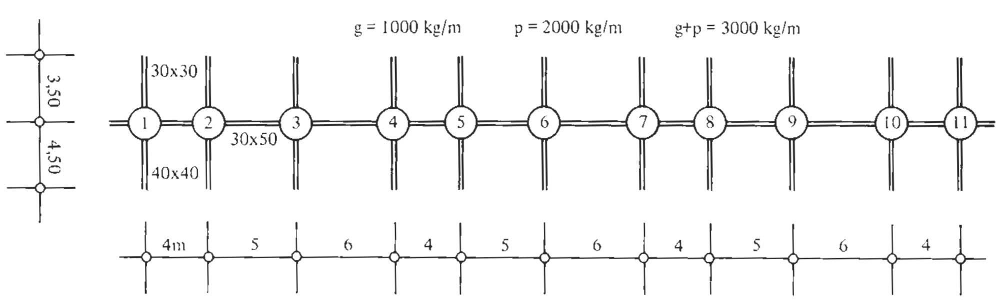
```
FRAME
=====

I=
            1.00*
BEAMS
VARIABLE
COLS.
VARIABLE

# SPANS
            3.00*
# FLOORS
            3.00*

L I
            5.00*
           10.00*
            4.50*
H I
            4.00*
            4.00*
            4.50*

DIM.BEAMS
            0.00*
            0.00*

           30.00*
           40.00*

           30.00*
           40.00*

           30.00*
           40.00*

           30.00*
           80.00*

           30.00*
           50.00*

           30.00*
           50.00*

           30.00*
           80.00*

           30.00*
           50.00*

DIM.COLUMNS
            0.00*
            0.00*

           30.00*
           40.00*
```

```
           30.00*
           40.00*

           30.00*
           30.00*

           30.00*
           30.00*

           30.00*
           50.00*

           30.00*
           50.00*

           30.00*
           40.00*

           30.00*
           40.00*

           30.00*
           60.00*

           30.00*
           60.00*

           30.00*
           50.00*

LOADS
            0.00*
         2500.00*
         1500.00*

         2500.00*
         2000.00*
         4500.00*

         2000.00*
         4500.00*
         2000.00*
P WIND
         1000.00*
         2000.00*
         2000.00*

MOMENTS

   POINT #
             1.00

             0.00
             0.00
             0.00
            -0.00
```

```
   POINT #
             2.00

             0.00
             0.00
        -14748.71
         14748.71

   POINT #
             3.00

         21368.79
             0.00
         -8743.64
        -12625.15

   POINT #
             4.00

          1248.08
             0.00
             0.00
         -1248.08

   POINT #
             5.00

             0.00
            -0.00
         -1236.65
          1236.65

   POINT #
             6.00

          7399.50
          5224.98
        -13833.60
          1209.12

   POINT #
             7.00

         20690.18
         -7903.93
         -7237.24
         -5549.00

   POINT #
             8.00

          5478.01
         -2196.53
             0.00
         -3281.49
```

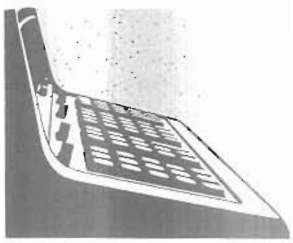
```
   POINT #
             9.00

             0.00
           368.67
           766.10
         -1134.78

   POINT #
            10.00

         12441.66
          5715.43
        -27161.33
          9004.25

   POINT #
            11.00

         34385.28
         -9980.57
         -8183.86
        -16220.85

   POINT #
            12.00

          2746.05
         -1718.81
             0.00
         -1027.24

   POINT #
            13.00

         -1436.39

   POINT #
            14.00

          1569.23

   POINT #
            15.00

        -11043.32

   POINT #
            16.00

         -2210.90
```

EXAMPLE 2: SIMPLIFIED FRAME (i = 8)



```
FRAME
=====

I=
          8.00*
ONE FLOOR:

BEAMS
CONSTANT
COLS.
CONSTANT

# SPANS
         10.00*
L I
          4.00*
          5.00*
          6.00*
          4.00*
          5.00*
          6.00*
          4.00*
          5.00*
          6.00*
          4.00*
H I
          3.50*
          4.50*

DIM.BEAMS
         30.00*
         50.00*

DIM.COLUMNS
         30.00*
         30.00*

         30.00*
         40.00*
LOADS
       3000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*

MOMENTS

  POINT #
           1.00

           0.00
         524.95
       -1492.74
         967.81

POINT #
           2.00

        5824.72
         187.97
       -6359.24
         346.54

POINT #
           3.00

        5117.78
        -443.36
       -3857.03
        -817.38

POINT #
           4.00

        3081.95
         252.02
       -3798.63
         464.64

POINT #
           5.00

        2871.36
        -404.63
       -1720.75
        -745.98

POINT #
           6.00

        4775.44
        1033.02
       -7712.95
        1904.49

POINT #
           7.00

        7389.41
       -1112.89
       -4224.79
       -2051.74

POINT #
           8.00

        2312.76
         798.22
       -4582.59
        1471.62

POINT #
           9.00

        5704.58
        -567.41
       -4091.07
       -1046.09

POINT #
          10.00

        3116.40
         326.81
       -4045.71
         602.51

POINT #
          11.00

        1922.79
        -676.18
           0.00
       -1246.61

LOADS
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*
       3000.00*
       1000.00*

MOMENTS

  POINT #
           1.00

           0.00
         727.84
       -2069.71
        1341.86

  POINT #
           2.00

        3437.96
        -502.66
       -2008.56
        -926.72

  POINT #
           3.00

        4676.37
        1051.47
       -7666.35
        1938.51

  POINT #
           4.00

        7407.88
       -1115.27
       -4236.47
       -2056.14

POINT #
           5.00

        2303.89
         797.22
       -4570.89
        1469.78

POINT #
           6.00

        5732.82
        -558.20
       -4145.51
       -1029.11

POINT #
           7.00

        2970.20
         268.07
       -3732.48
         494.21

POINT #
           8.00

        2906.17
        -404.05
       -1757.20
        -744.92

POINT #
           9.00

        4699.75
        1009.38
       -7570.03
        1860.91

POINT #
          10.00

        7771.03
        -959.76
       -5041.85
       -1769.43

POINT #
          11.00

        -251.85
          88.57
           0.00
         163.28
```

Dr. Ing. Andrea Sacco received the Laureate degree in Civil Engineering at the University of Naples, Italy in 1948. He is presently teaching civil engineering at the University of Naples, as well as running a consulting firm of his own. Dr. Sacco has been engaged in professional activities for more than 23 years in the field of public works, including highways and hydraulics, and civil engineering.



LUNAR MODULE LANDING SIMULATOR

by E. T. Ford and E. L. Heacock

PART NO.
09100-76504
9100B

Program Description and Operation

This program, written by Ted Ford in 1970 and recently modified and improved by Larry Heacock, simulates a spacecraft in the influence of lunar gravity. Very few approximations have been made with the exception of 'flattening' the moon's surface for convenience. The program does, however:

1. take account of lunar gravity and its variation with height
2. include the effect of centrifugal force on a body moving with a tangential velocity component
3. compensate for the burning of fuel by a corresponding reduction in spacecraft overall mass.

The equations used are very simple and are merely the laws of Newton with the appropriate lunar constants inserted. For those interested in re-checking these figures, the constants used were:

$$\text{lunar gravity} = g_m = 5.297 \text{ ft/sec}^2$$

$$\text{lunar radius} = R_m = 5.728 \times 10^6 \text{ ft.}$$

The constants for the illustration given are based on the Apollo II mission, but could be adjusted for Apollo 17 or any other. The values are generally widely available prior to an Apollo mission. The values used here were obtained from a scientific journal.

specific impulse = I_s = 300 sec.
fuel consumption at max Thrust = 40 lb/sec.
initial fuel = 16,080 lb = 500 slugs
lunar module "dry weight" = 16,434 lb. = 511 slugs
initial orbit = 14 statute miles elevation, circular.

The following assumptions and constraints have been applied:

a. The engine may be throttled linearly from 100% down to 20% power, but settings of between 0 and 20% are not possible. This approximates the actual descent engine performance.
b. During any one second increment (equal to one calculation/iteration) the thrust vector may not be rotated through more than 10° of angle.
c. A "safe" landing must meet the following conditions:
   - resultant impact velocity $\leqslant$ 12 ft/sec.
   - landing attitude must be vertical ± 10°.
d. The abbreviations and symbols used in the program are as follows:
   - X = horizontal displacement (positive to the right)
   - Y = vertical displacement (positive up)
   - V_x = horizontal velocity (positive right)
   - V_y = vertical velocity (positive up)
   - a_x = horizontal acceleration (positive right)
   - a_y = vertical acceleration (positive up)
   - M_{of} = initial fuel mass (Slugs)
   - M_{jf} = instantaneous fuel mass (Slugs)
   - M_{jr} = instantaneous total mass (Slugs)
   - S_c = scale constant (plotter units/foot in the horizontal
   - T_j = total instantaneous thrust (0 to 1.0)
   - T_x = thrust component to the right (producing acceleration to the left)
   - T_y = thrust component down (producing acceleration upward)
   - θ = angle of action of thrust vector (in degrees clockwise from the positive X-axis)
   - f(%) = percent fuel remaining
   - X_{ref} = automatic milestone reference
e. The aiming point is the plotter origin. (X = Y = 0)

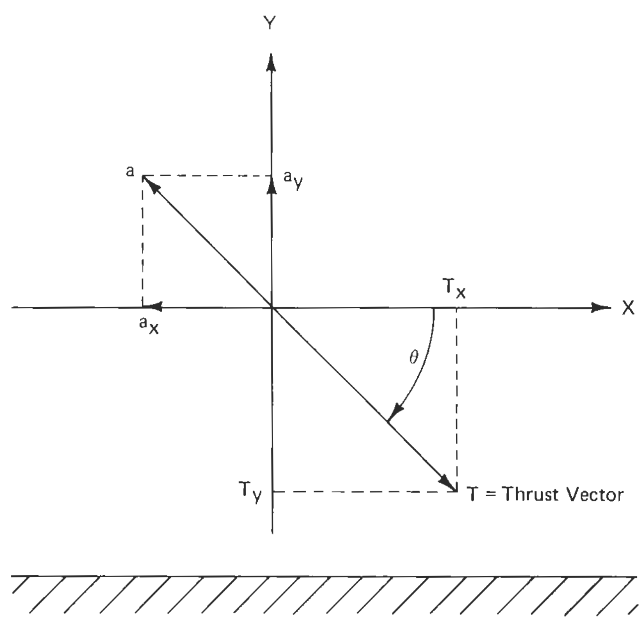


Fig. 1 Thrust Vector Diagram

The program also has several other useful features which are indicated after User Instructions.

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

EQUIPMENT NEEDED ☐ 9100A ☒ 9100B ☐ 9120 ☒ 9125 ☐ 9160 ☐ 9101 ☐ 9104 ☐ 9106

☒ DEGREES ☐ RADIANS ☐ FLOATING ☒ FIXED DECIMAL WHEEL AT 3 PRESS ☐☐☐ ON 9120

STEP	USER INSTRUCTIONS	DISPLAY x	y	z
1	ENTER Program, side A, starting at +00			
2	ENTER Program, side B, starting at -00			
3	ENTER Data:	-5800	0	
4	PRESS: FMT, UP			
5	Set pen at lower left corner of paper using origin controls.			
6	PRESS: STOP			
7	PRESS: END, CONTINUE	1	0	0
8	ENTER Data: $M_{of} \rightarrow Z(500)$			
	$Y_o \rightarrow Y(7.392 \times 10^4 \text{ ft})$			
	$X_o \rightarrow X(-1.16 \times 10^6 \text{ ft})$	-1160000	73920	500
9	PRESS: CONTINUE	2	0	0
10	ENTER Data: $S_c \rightarrow Z(.005)$			
	$V_{yo} \rightarrow Y(0)$			
	$V_{xo} \rightarrow X(5473 \text{ ft/sec})$	5473	0	.005
11	PRESS: CONTINUE	V_{yo}	S_c	S_c
12	PRESS: RCL	T_j	θ_j	
13	ENTER Data: $\theta_j' \rightarrow Y$			
	$T_j' \rightarrow X$	T_j'	θ_j'	
14	PRESS: CONTINUE [NOTE: CONTINUE must be pressed twice after initial			
	program entry and after an error in entering θ_j' or T_j'.]			
15	The j'st position of the LM will now be plotted.			
16	Display (temporary)	V_x	V_y	f(%)
17	Display	0	f(%)	f(%)
18m	Return to Step 12 (except see below)			
	In this mode (the "manual" mode), the program will continue to stop after each			
	iteration. This mode is used initially, whenever it is desired to make a change in			
	thrust level or direction, and (by most operators) during final descent and landing.			
	During mid-course operation, the " automatic" mode is useful. To enter the			
	automatic mode, use the following steps:			
	After Step 17 of the "manual" mode:			
18a	PRESS: GO TO, +, 2, 2			
19	SET: PROGRAM			
20	PRESS: RCL			
21	SET: RUN			
22	PRESS: RCL			

STEP	USER INSTRUCTIONS	DISPLAY		
		x	y	z
23	PRESS: CONTINUE			
	The program now runs continuously in near real time plotting the			
	trajectory of the LM and displaying fuel remaining, vertical and			
	horizontal velocity as in Step 16 above. To return to the "manual"			
	mode, the following steps are executed:			
24	PRESS and hold: PAUSE, until program stops.			
25	PRESS: GO TO, +, 2, 2			
26	SET: PROGRAM			
27	PRESS: STOP			
28	SET: RUN			
29	PRESS: RCL			
	The "manual" mode may now be resumed at Step 13.			
	The program is made as realistic as possible. In the event of fuel			
	exhaustion, no further opportunity is given for control of the spacecraft.			
	Thrust is set to zero, the "error" light is lit, and the simulation			
	switches to "automatic" mode until impact. When impact occurs,			
	whether before or after fuel exhaustion, the following display is			
	presented:	$\bar{V}$	θ_f	X_f
	where: X_f = distance from aiming point (origin)			
	θ_f = attitude at impact (90° = vertical)			
	$\bar{V}$ = resultant impact velocity			

If the criteria for a "safe" landing are met, the above display is steady. If these criteria are not met, the display is flashing and an error is indicated on the 9100B.

Similarly, when a new thrust and thrust angle are entered in the "manual" mode, they must be within preset limits as follows:

$$T = 0$$
$$\text{or } 0.2 \leq T \leq 1.0$$
$$[\theta_j - \theta_j'] \leq 10^\circ$$

If the criteria are met, the program continues. If they are not met, an error is indicated and the program returns to Step 12. To proceed, execute the steps beginning with Step 12 again entering a new T and θ meeting the above criteria. If a thrust of greater than 1 is entered, the program assumes that full thrust is required, i.e.:

$$\text{if } T > 1,\ T_j = 1.0$$

Two other useful features are incorporated into the program. These are the following:

AUTOMATIC MILESTONE

If it is desired to stop the program during "automatic" mode, (e.g., to follow a pre-planned flight plan) a specific value of X_{ref} (in feet) may be entered in computer data register (-)(c). When the LM passes this point (i.e., moves farther right than this point), the program automatically stops. The "pilot" can then follow the appropriate steps (starting at Step 25) to enter the "manual" mode.

He must now, however, enter a new value of X_{ref} in (-)(c) which is further down range (right) than the LM. The program as recorded contains a value of $+10^6$ for X_{ref} so that this feature does not affect the program unless desired.

SCALE CHANGE

The value of S_c is selected to provide a scale of .005 plotter units per foot in the horizontal direction and .05 plotter units per foot in the vertical direction. Some "pilots" prefer the same scale in both directions. This can be easily arranged by changing the contents of Steps -22 and -23 to 0 and 1, respectively.

In connection with the scaling, a change of scale by a factor of 10 is often useful during final maneuvers. To facilitate this, the following steps may be performed *after* setting the origin, but *before* executing the program (i.e., after Step 6).

(A1) PRESS: GO TO (-) (8) (0)
(A2) PRESS: CONTINUE

The plotter will now plot a "final approach" box at the aiming point and proceed to Step 8. The program may now be continued normally. When the "final approach" box is entered by the LM, the scale may be changed by the following steps in "manual" mode:

(B1) ENTER DATA: 0.05 → X
(B2) PRESS: ↑, FMT, ↑
(B3) PRESS: X → ( ), (-), (f)
(B4) PRESS: GO TO (+) (2) (2)
Go to Step 12.

Future plots will be at X10 expanded scale.

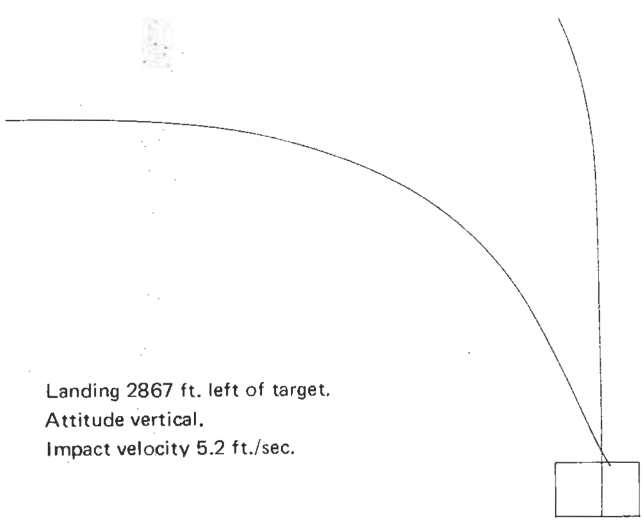


Fig. 2 Plot of a Successful Landing

The flow chart shows all of the functions of the program and indicates the location of key steps to aid in analysis and modification.

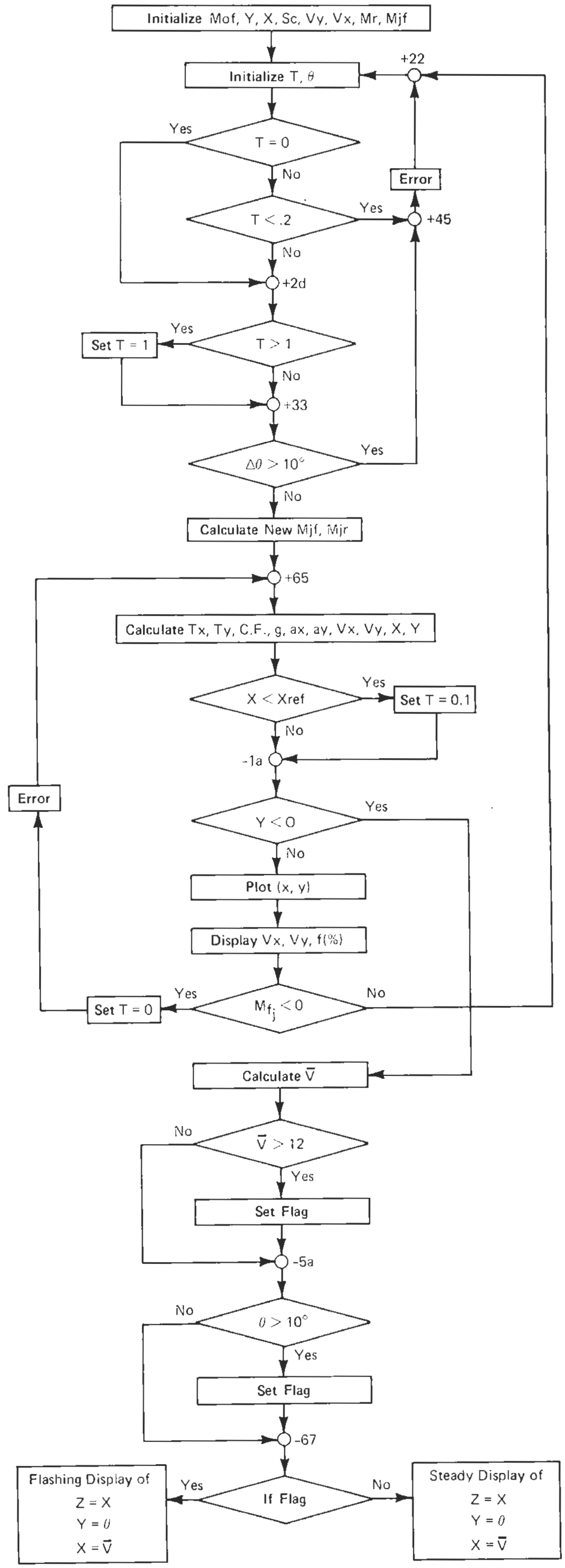
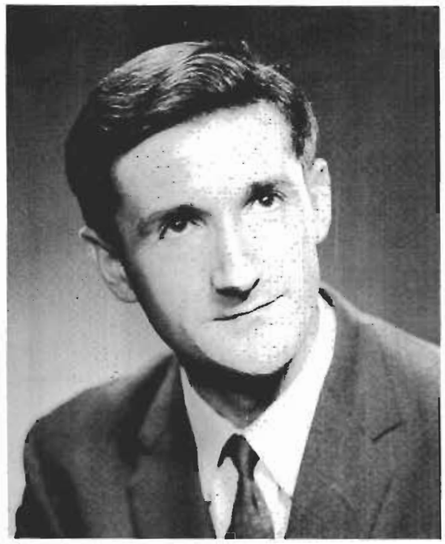


Fig. 3 Flow Chart



Ted Ford was, until recently, with the European Space Research Organization in the Netherlands where he was engaged in antenna projects for satellites. He received a B.S. degree in Electrical Engineering from the University of London in 1963 and worked for four years on radar antenna development in Britain before going to ESRO. His work on the 9100B and Plotter includes the analysis of ground reflections on antenna test ranges, computation of polar diagrams of planar arrays and parabolic reflectors, and geographic coverage of satellite antennas directed at the Earth.

Larry Heacock is an electrical engineer and meteorologist. He is a U.S. citizen working for the European Space Research Organization in Holland. Much of his initial interest in the HP 9100 system stems from his personal friendship with Tom Osborne, another EE-meteorologist who was one of the developers of the 9100A Calculator. (See *KEYBOARD*, Spring, 1969, or HP Journal, September 1968.)

CALCULATOR PROGRAM CATALOG ADDITIONS

Some customer-submitted programs added to the Calculator Program Catalog recently are described below. These programs are not yet listed in the Program Catalog, but will be included in a revision. They can be ordered through your local Hewlett-Packard sales office.

MODEL 20 PROGRAMS

Part Number: 09820-70003
Title: Matrix Inversion For a Positive Definite Symmetric Matrix
Author: Dr. James N. Shapiro, Texas A&M University, College Station, Texas
Equipment: 9820A
Description: This program will invert up to a 12 x 12 positive definite (real) symmetric matrix on the basic 9820A, or up to 25 x 25 with the expanded internal memory.

Part Number: 09820-70004
Title: Least Squares Solution of m Equations in n Unknowns
Author: Dr. James N. Shapiro, Texas A&M University, College Station, Texas
Equipment: 9820A
Description: This program gives the least squares solution to a set of overdetermined, incompatible linear equations.

Part Number: 09820-70005
Title: Weighted Moments
Author: Dr. James N. Shapiro, Texas A&M University, College Station, Texas
Equipment: 9820A
Description: This program solves the problem of 'weighted moments' described in C. Lanczos' text, *Applied Analysis*.

MODEL 10 PROGRAMS

Part Number: 09810-70005
Title: Bessel Functions
Author: D. Gerard, Marsaille, France
Equipment: 9810A, Printer, Math ROM
Description: This program calculates $J_p(x)$, $J_p(ix)$, $J_{p+1}(x)$, $J_{p+1}(ix)$, . . ., $J_{p+d}(x)$, $J_{p+d}(ix)$ and other Bessel Functions.

Part Number: 09810-70805
Title: Blackhat Sorter
Author: Capt. Robert J. Meyer, Eglin AFB, Florida
Equipment: 9810A, 111 Registers, Printer
Description: This program sorts in ascending order a set of data (N up to 105) and calculates the mean, standard deviation, median, minimum, maximum, and root mean square.

Part Number: 09810-70806
Title: Nth Order Polynomial Regression, $N \leq 9$ With Plot
Author: David L. Eichblatt, Houston, Texas
Equipment: 9810A, 111 Registers, 2036 Steps, Printer, 9862A, Math and Alpha ROM's
Description: This program determines the coefficients for a polynomial equation up to 9th order giving a least squares curve fit and plots a regression curve.

Part Number: 09810-75001
Title: Pipe Network Balancing
Author: Dr. Johannes Gessler, Fort Collins, Colorado
Equipment: 9810A, 111 Registers, 2036 Steps, Printer, Math and Printer Alpha ROM's
Description: This program balances the flow in a pipe network having a sum of up to 49 pipes plus nodes.

Part Number: 09810-76002
Title: Model 10 Plotter Routine
Author: Prof. L. Glasser, Rhodes University, Grahamstown, South Africa
Equipment: 9810A, 2036 Steps, Printer, 9862A, Plotter and Printer Alpha ROM's
Description: This program organizes and automates the set-up of axes and labels on the plotter. Individual data points may also be plotted.

MODEL 9100A/9100B PROGRAMS

Part Number: 09100-70080
Title: Associated Legendre Polynomials and Functions Calculator and Plotter
Author: Dr. Eric Lane, University of Tennessee, Chattanooga, Tennessee
Equipment: 9100B, 9125A/B
Description: This program will plot the Associated Legendre Functions or their squares in either polar or rectangular coordinates in either of two normalizations.

Part Number: 09100-70081
Title: Roots of a Quartic Equation
Author: L. Zboray and F. Magyar, Technical Univ. at Kosice, Czechoslovakia
Equipment: 9100B
Description: This program solves any 4th degree equation of the form:
$x^4 + a_3x^3 + a_2x^2 + a_1x + a_0 = 0$
with real coefficients.

Part Number: 09100-70082
Title: Error Function Complement
Author: Dr. Tony Crossley, RCA Laboratories, Princeton, New Jersey
Equipment: 9100B
Description: This program is intended for use as a subroutine in diffusion calculations. It calculates erfc to the entire machine accuracy.

Part Number: 09100-70084
Title: Natural Modes and Frequencies of N Degree of Freedom Systems - the Holzer Method
Author: Dr. J. C. Dutertre, Ecole Polytechnique, Montreal, P.Q., Canada
Equipment: 9100B
Description: This program enables the user to obtain the n natural frequencies of an n degree of freedom system. The n systems elements need not be identical.

Part Number: 09100-70085
Title: Generalized Characteristic Value Problem
Author: Dr. J. C. Dutertre, Ecole Polytechnique, Montreal, P.Q., Canada
Equipment: 9100B
Description: Program 1 computes eigenvalues and eigenvectors of a real square nonsymmetric 3 x 3 matrix of special form B^{-1} x A where B is diagonal and A symmetric. Program 2 verifies consistency of and normalizes the eigenvectors produced by Program 1.

Part Number: 09100-70087
Title: Solution of Five Equations in Five Unknowns
Author: P. Petricevic, Rome, Italy
Equipment: 9100B, 9120A
Description: This program solves a system of five equations in five unknowns.

Part Number: 09100-70088
Title: Simultaneous Solution of Six Equations in Six Unknowns
Author: P. Petricevic, Rome, Italy
Equipment: 9100B, 9120A
Description: This program solves a system of six linear simultaneous equations in six unknowns.

Part Number: 09100-70089
Title: Solution of n Linear Equations in n Unknowns, $n \leqslant 25$
Author: P. Petricevic, Rome, Italy
Equipment: 9100A/B, 9101A, 9120A
Description: This program will solve a system of up to 25 linear equations in 25 unknowns with real coefficients.

Part Number: 09100-70090
Title: Interpolation Using a Sixth Power Polynomial
Author: M. J. T. Robinson, University of Oxford, Oxford, England
Equipment: 9100A/B
Description: This program interpolates for data points near x_0,y_0 using tabulated data for uniformly spaced abscissas with spacing δ_x.

Part Number: 09100-70091
Title: Dashed & Dotted Curve Plot With Equal Arc Length Segments for Arbitrarily Spaced Data
Author: Richard Muck, Cornell University, Ithaca, New York
Equipment: 9100A/B, 9125A/B
Description: This program connects successively entered data point coordinates with straight line segments.

Part Number: 09100-70420
Title: Symbol Plotter With Self-Scaling Linear Plot
Author: Dr. D. F. Davey, McGill University, Montreal, P.Q., Canada
Equipment: 9100A/B, 9125A/B
Description: This program is designed to plot points of the type (x_i,y_i) on the 9125 Plotter as an aid in preparing graphs for display or publication. A self-scaling linear plot is included.

Part Number: 09100-70421
Title: Complex Package (Cartesian Coordinates)
Author: Dr. J. C. Dutertre, Ecole Polytechnique, Montreal, P.Q., Canada
Equipment: 9100B
Description: This program allows one to compute complex functions of complex numbers.

Part Number: 09100-70862
Title: Slope and Intercept Errors of a Straight Line
Author: Dr. D. M. McEachern, Instituto Politecnico Nacional, Mexico, D.F.
Equipment: 9100A/B
Description: This program calculates the probable error, within a fixed level of confidence, in the slope and intercept of a straight line whose constants have been previously determined by least squares using program 09100-70800 IV-1.

Part Number: 09100-70863
Title: Hyperbolic Regression
Author: Dr. A. E. Russell, Grahamstown, South Africa
Equipment: 9100B, 9101A
Description: This program permits the coefficients to be determined for the two-term hyperbolic equation:

$$y = \frac{n_1 k_1 x}{1 + k_1 x} + \frac{n_2 k_2 x}{1 + k_2 x} \quad (k_1 \neq k_2)$$

giving the best least-squares fit to a set of data points (x_i,y_i) specified by the user.

Part Number: 09100-70864
Title: Sort Up to 84 Numbers in Descending Order
Author: Eng. A. G. Nascimento, Companhia Metropolitana de Agua, Sao Paulo, Brazil
Equipment: 9100B, 9120A
Description: This program sorts positive integers less than 10^6 in descending order. 84 two-digit numbers, 56 three-digit numbers, etc. may be sorted.

Part Number: 09100-70865
Title: Point Plot
Author: Dr. John D. Roberts, California Institute of Technology, Pasadena, California
Equipment: 9100A/B, 9125A/B
Description: These programs will make point plots with open circles, filled circles, triangles, or squares at the desired positions.

Part Number: 09100-70866
Title: Chi-Squared 3 x 3 Contingency Table
Author: Prof. C. D. Stamopoulos, Univ. of London, England
Equipment: 9100B
Description: This program calculates the chi-squared value for a 3 x 3 contingency table.

Part Number: 09100-70867
Title: Percentile Finder
Author: D. B. Blazie and G. R. Gunther, Aberdeen Proving Ground, Maryland
Equipment: 9100B, 9101A, 9120A
Description: With inputs of up to 248 scores, this program calculates and prints, for desired percentile values, the percentile rank, percentile point and number of scores. It also sorts inputs in numerical order.

Part Number: 09100-71201
Title: Parameters of Coupled Symmetric and Single Conductor Striplines
Author: Prof. Dr. Ir. J. Van Bladel, Ghent, Belgium
Equipment: 9100A, 9101A, 9120A
Description: This program computes the characteristic impedances of two coupled symmetric strips and of a single strip in a double shielded stripline.

Part Number: 09100-73209
Title: Clebsch-Gordan Coefficients and Wigner 3J-Symbols
Author: Dr. Stanislav Sykora, Univ. of Illinois at Urbana-Champaign, Urbana, Illinois
Equipment: 9100B, 9120A
Description: This program calculates Clebsch-Gordan coefficients and Wigner 3J symbols for any integer or half-integer values of J1, J2, etc.

Part Number: 09100-74055
Title: Universal Triangle Solution
Author: Robert L. Neal, Jr., Pacific Southwest Forest and Range Experiment Station, Challenge, California
Equipment: 9100B, 9120A
Description: This program solves any plane triangle when any three parts (except three angles) are known.

Part Number: 09100-74056
Title: Field Layout of a Curve
Author: Keith Houseman, Dekalb, Illinois
Equipment: 9100B, 9120A
Description: This program calculates all interval stations, subarcs, subchords, and deflection angles to said stations, given radius, point of curvature, and point of tangency for field layout of a curve.

Part Number: 09100-74057
Title: Survey Traverse Calculations, With Reduced Levels and Drill Hole Calculation Option
Author: J. F. Ashcroft, Cobar Mines Pty Ltd., Cobar, New South Wales, Australia
Equipment: 9100B
Description: This program produces a printed result sheet incorporating the input data, as well as the results calculated from this data, to allow subsequent checking.

Part Number: 09100-75508
Title: Dipole Moments
Author: Dr. D. M. McEachern, Instituto Politecnico Nacional, Mexico, D.F.
Equipment: 9100A/B
Description: This program, used in conjunction with programs 09100-70803 and -70862, calculates the dipole moment and its statistical error of a series of solutions of an organic compound in a nonpolar solvent, such as benzene.

Part Number: 09100-75883
Title: Student Records Program for 9100A
Author: Robert L. Neal, Jr., Pacific Southwest Forest and Range Experiment Station, Challenge, California
Equipment: 9100A, 9120A, 9160A
Description: This program uses standard quiz cards to calculate students' semester averages, standard deviation, and average grade for class.

NEW PROGRAM LIBRARIES

You can order the following new program libraries through your local Hewlett-Packard sales office:

Part Number	Description
09810-70825	Model 10 Non-Parametric Stat Pac
09810-70850	Model 10 Stat Pac Vol. II
09810-70875	Model 10 Quality Assurance Pac
09810-74150	Model 10 Surveying Pac Vol. II
09810-76050	Model 10 Digitizer Pac
09810-77000	Baustatik I (German Structures Vol. I)
09810-77001	Baustatik II (German Structures Vol. II)
09810-77002	Baustatik III (German Structures Vol. III)
09810-70003	Baustatik IV (German Structures Vol. IV)
09810-77600	Model 10 Structures Pac (British)
09810-77950	Quantitative Business Analysis Pac (British)
09820-76000	Model 20 Digitizer Pac
09865-70000	Model 10 Cassette Memory Pac

CASSETTE MEMORY PAC LISTING

The Model 10 Cassette Memory Pac, supplied at no charge with shipment of the new Model 9865A Cassette Memory contains nine programs, which are listed below.

MODEL 10 CASSETTE MEMORY PAC PROGRAM LISTING

Part Number 09865-70000

I-1 Tape Initialization

I-2 Tape Identification

I-3 Subprogram Link

I-4 Data File Update and Editor

I-5 Cassette Tape Duplication

I-6 Matrix Inversion, Determinant and Simultaneous Equations

I-7 Linear Programming with Artificial Variables

I-8 Traverse with Compass Rule Adjustment and Plot (9865A Cassette Version)

I-9 Point-to-Point Inverse with Area and Plot Options (9865A Cassette Version)

PART NO.
09810-75802

MODEL 10

BALLISTIC TRAJECTORY PROGRAM

by Joseph T. Dobmeier

This program plots the trajectories of projectiles under the action of gravity. The plots are normalized to maximum range and maximum altitude constraints, given a fixed launch speed. The student can experiment with different launch angles to determine the various conditions required for maximum range, maximum altitude, and hitting the same point with a high and a low launch angle. The program also computes and prints out the maximum altitude attained, the maximum range (impact range) and time of flight.

Using inputs V (projectile speed at launch in ft/sec) and θ(launch angle in degrees 0 to 90), the following equations are solved:

(1) X maximum for plot scaling. The maximum range for a given speed is obtained with a 45° launch.

$$Xmax = \frac{V^2}{g} \text{ where } g = 32.17 \text{ ft/sec}^2$$

(2) Y maximum for plot scaling. The maximum altitude for a given speed is obtained with a 90° launch.

$$Ymax = \frac{V^2}{2g}$$

Since Ymax = ½ Xmax, the plot should be set up so that the Y range is ½ the X range so that coordinates are the same for altitude (Y) and range (X).

(3) Projectile Coordinates:

$X(T) = V\cos\theta T$

T = Time in sec.

$Y(T) = V\sin\theta T - \frac{1}{2}gT^2$

The time increment used is 1/100 of time of flight (see 4). The program terminates at impact and requests a new launch angle.

(4) Trajectory Data (Printer Outputs)

$$\text{Maximum Height} = \frac{V^2 \sin^2 \theta}{2g}$$

$$\text{Maximum Range} = \frac{2V^2 \sin\theta \cos\theta}{g}$$

$$\text{Time of Flight} = \frac{2V \sin\theta}{g}$$

TEACHING POINTS:

(1) 45 Deg. Launch = Maximum Range
(2) 90 Deg. Launch = Maximum Altitude and Maximum Time of Flight
(3) Complementary Angles at Launch yield same impact point: e.g., 60° and 30°
(4) 75 Deg. Launch = ½ Maximum Range

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

EQUIPMENT NEEDED

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

TOTAL REGISTERS: [X] 51 [ ] 111

TOTAL PROGRAM STEPS: [X] 500 [ ] 1012 [ ] 2036

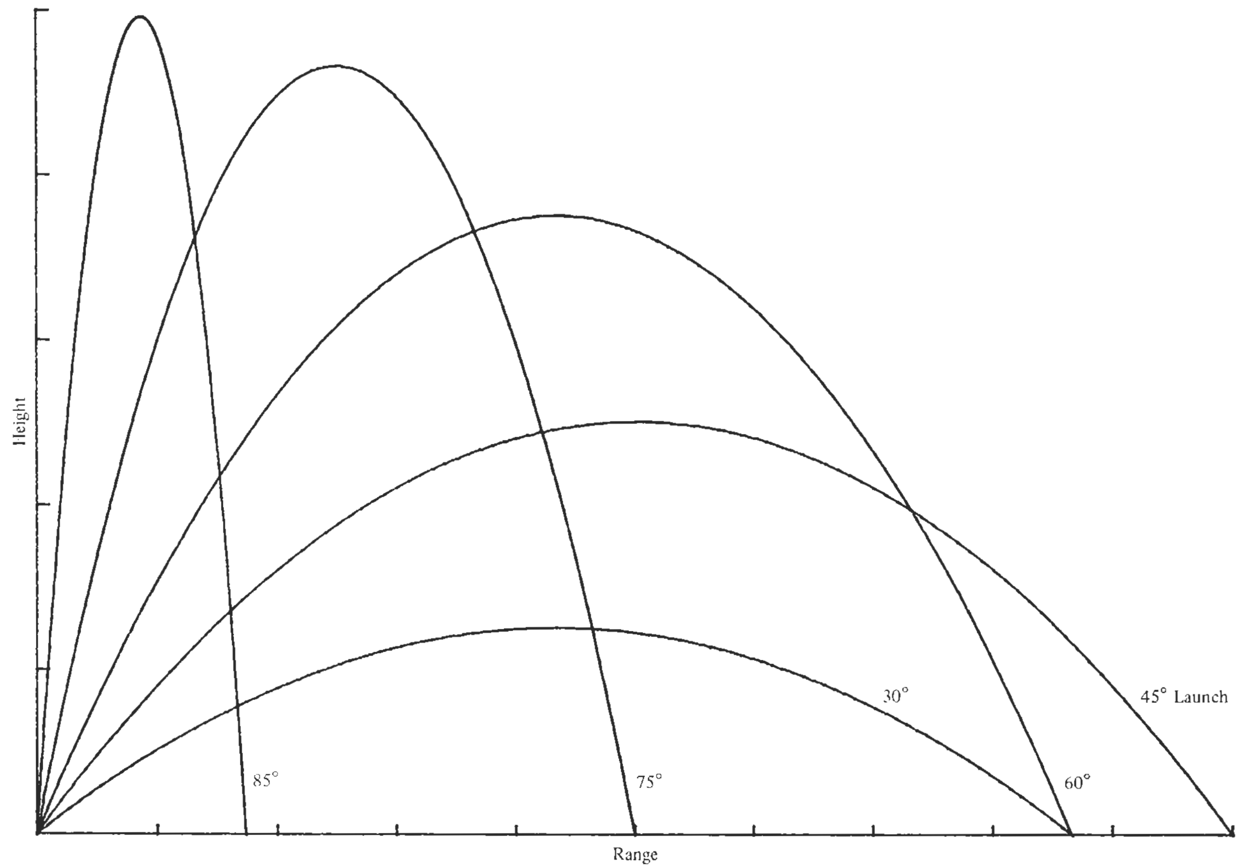
ROM'S: 1 MATHEMATICS; 2 ______; 3 PRINTER ALPHA

STEP	USER INSTRUCTION	DISPLAY X	DISPLAY Y	DISPLAY Z
1	PRESS: END			
2	Load Program			
3	PRESS: END, CONTINUE			
4	Enter Data: V(Speed in ft/sec)	V		
5	PRESS: CONTINUE			
6	Enter Data: θ(Launch angle in degrees)	θ		
7	PRESS: CONTINUE			
8	Plotter draws axes and stops for pen change if desired.			
9	PRESS: CONTINUE			
10	Trajectory is plotted.			
11	Return to Step 6 for new launch angle.			

SAMPLE INPUT/OUTPUT

```
BALLISTIC
TRAJECTORY
PROGRAM


SPEED FT/SEC
           1000.00*
LAUNCH ANGLE DEG
  0 TO 90
             45.00*
MAXIMUM HEIGHT
 FEET
            7771.22

MAXIMUM RANGE
   FEET
           31084.86

TIME OF FLIGHT
  SECONDS
              43.96


ENTER NEW
LAUNCH ANGLE
              60.00

MAXIMUM HEIGHT
 FEET
           11656.82

MAXIMUM RANGE
   FEET
           26920.28

TIME OF FLIGHT
  SECONDS
              53.84


ENTER NEW
LAUNCH ANGLE
              30.00

MAXIMUM HEIGHT
 FEET
            3885.61

MAXIMUM RANGE
   FEET
           26920.28

TIME OF FLIGHT
  SECONDS
              31.08


ENTER NEW
LAUNCH ANGLE
              75.00

MAXIMUM HEIGHT
 FEET
           14501.29

MAXIMUM RANGE
   FEET
           15542.43

TIME OF FLIGHT
  SECONDS
              60.05


ENTER NEW
LAUNCH ANGLE
              85.00

MAXIMUM HEIGHT
 FEET
           15424.37

MAXIMUM RANGE
   FEET
            5397.83

TIME OF FLIGHT
  SECONDS
              61.93
```

PLOTTER OUTPUT



Joseph T. Dobmeier obtained his B.S. degree in Physics from Canisius College, and his M.S., Nat. Sc. (Mathematics) from State University of New York at Buffalo. His main field of endeavor is the analysis of aircraft, missile, and weapon systems. Studies in these areas include aircraft terminal vulnerability, penetration-aid effectiveness, missile guidance and control, trajectory analysis, and spacecraft navigation. Mr. Dobmeier is a research systems engineer at Cornell Aeronautical Laboratory, Inc., Buffalo, New York.

REFERENCE College Physics, Sears & Zemansky, Addison-Wesley Publishing Co., 1953, p. 94-97.

MODEL 10 DIGITIZER PAC
PROGRAM LISTING
Part Number 09810-76050

I-1 Distance Between Digitized Points
I-2 Area Within a Closed Figure
I-3 Digitizer-Plotter Transfer
I-4 Digitized Curve Length
I-5 Polynomial Regression-Degree ≤ 10; Plotter ROM and Digitizer

Model 10 QUANTITATIVE BUSINESS ANALYSIS PAC
PROGRAM LISTING
Part Number 09810-77950

1. Time Series I
   This program analyzes a set of data for trend and seasonal fluctuations.

2. Time Series 2
   This program analyzes a set of data for trend and seasonal fluctuations, and on the basis of these it makes forecasts for a limited period ahead.

3. Brand Switching
   This program determines the market shares of each brand at the end of successive periods.

4. Stock Control (E.O.Q.)
   This program determines the economic order quantity and the cost of this policy. It also works out the cost of the existing policy.

5. Stock Control With Discounts
   This program determines the economic order quantity when a number of discounts are available.

6. Discounted Cash Flow
   This program calculates the internal rate of return, or yield, on an investment.

7. Linear Programming
   This program will maximize a linear objection function subject to a number of "less than" or "equal to" restrictions.

8. Transportation
   This program carries out the standard transportation technique which can be used to find the pattern of distribution which minimizes transportation costs. It also calculates the minimum cost.

9. Assignment
   This program calculates the optimal pairing of men and jobs, where each man is assigned one job, to minimize total cost. Minimum cost is also given.

10. Seasonal Coefficients
    Starting with know turn-over figures of preceding months, the program will forecast the turn-over for the twelve following months.

PROGRAMMING TIPS

The following two programming tips were submitted by Robert L. Neal, Jr., research forester with the Pacific Southwest Forest and Range Experiment Station, Forest Service, United States Department of Agriculture, Berkeley, California. Mr. Neal is stationed at Challenge, California.

DATA ENTRY TERMINATION ON 9100A/B AND MODEL 10

Many programs with provision for the entry of a series of observations of the same thing terminate data entry and initiate the operation of the final program steps with a manual 'SET FLAG' in lieu of another entry. This is an easy step to overlook, often resulting in time lost rerunning the problem or correcting the data in the calculator.

If it is known that there will be no observations with zero value, the program can be written to produce zero in both the x and y registers at data entry points (the entry code, if any, could be placed in the z register). Then 'IF X = Y' following the data entry 'STOP' instruction can be used instead of 'IF FLAG' to branch to the final program steps. If the flag condition will not be tested until later in the program, the flag can be machine-set by the 'IF X = Y' test following the 'STOP' instruction with the series, IF X = Y, SET FLAG, CONTINUE. This procedure eliminates a keyboard operation, will often reduce the keys used to the numeric keys and CONTINUE, and reduces the number and complexity of operator instructions. All these improvements reduce the chances for operator error and confusion. The technique is especially helpful if someone other than the programmer--a clerk, for example--processes the data.

CASCADING 9100B PROGRAMS WITH PROTECTED STORED DATA

Cascaded programs for the 9100B that require the protection of stored data on the plus page can be entered without any keyboard addressing between programs as follows:

(1) Reserve at least the 0 register of the plus page for programming.

(2) Make STOP the first instruction on the minus page of the first program.

(3) Make the final instructions of all programs GO TO, -, 0, 0.

(4) When the operation of successive programs is completed, enter the minus page of the next program without any manual addressing. The program counter will be automatically reset to +00, whether or not the minus page of the new program contains an END instruction.

(5) Enter the plus page of the new program without manual addressing. The END instruction that protects the data again resets the program counter to +00.

(6) Press CONTINUE.

The plus page programming must of course include instructions to go to Step 01 on the minus page. If the plus page contains only programming to get to the minus page, Step 5 above can be eliminated.

All instructions on the minus pages of all programs except the first will be entered one step later than they are written and recorded. This must be kept in mind when writing branching instructions for all but the first program.

This procedure helps to smooth out the processing of multicard programs and reduces the opportunities for error. The process can be smoothed still further when some registers of the plus page are always used for programming by reversing the program *recording* sequence; i.e., record the minus page on the A side of the card and the plus page on the B side. Display codes indicating the next card to be entered smooth the process still further, and further reduce the chance of error.

SPECIAL LABEL SEQUENCE FOR 9810A

Christian Langfelder of our office in Böblingen, West Germany, submitted this useful tip for the Model 10, which demonstrates the usefulness of the 'LBL' key in branching routines.

Up to three normal program steps may be inserted after a conditional branching instruction without canceling the branch condition. In the following sequence:

```
0154--  a  ---13
0155--  UP---27
0156--  0  ---00
0157--X>Y---53
0158--  YE---24
0159--  a  ---13
0160--SFL---54
0161--GTO---44
0162--LBL---51
0163--  π  ---56
0164--  DN---25
0165--XSQ---12
0166--  0  ---00
0167--  0  ---00
```

the 'LBL π' instructions will be ignored if the condition for branching is not met.

SEQUENTIAL 'IF' CONDITIONS - 9810A

This programming tip was submitted by C. D. Goode, University of Manchester, Manchester, England.

Two sequential 'IF' conditions can be used in a Model 10 program to give an instruction to jump only if both conditions are true. As an example, the sequence

IF X=Y
IF FLAG
GO TO
LABEL
4
CONTINUE

causes a jump to LABEL 4 only if both conditions are true. The CONTINUE acts as a no-operation step if the first condition is not true.

This type of instruction sequence is also useful in testing whether the value (X) lies between (Y) and (Z):

IF X > Y
ROLL ↑
IF X > Y
GO TO
LABEL
ROLL ↑
CONTINUE.

If (Z) > (X) > (Y), the program branches to 'LABEL ROLL ↑.' It is convenient to use 'ROLL ↑' as the label because whichever condition is not met the registers contain the same result Z = y, Y = x, X = z.

DEMONSTRATION STOPS - 9100A/B

Dr. R. Butler and Mr. F. Turner of the University of Manchester Institute of Science and Technology, Manchester, England, sent us this useful programming tip for the 9100A/B. It can be applied to the 9810A by inserting no-operation steps to complete the four-step jump when the flag has not been set.

In order to stop a 9100A/B program at suitable points for class demonstration, or other possible purposes, and yet not detract from its usefulness as a normal working program, we have found the inclusion of the instructions:

IF FLAG
STOP
SET FLAG

at the appropriate points very convenient. If SET FLAG is pressed at a suitable point at the commencement of the program then the program stops each time these instructions are encountered, but otherwise runs straight through normally. From any such stop the program can be run to the end without further stops by switching to PROGRAM to find the instruction address in the Z register, switching back to RUN, and advancing control to the next instruction by use of the GO TO key; i.e., jumping round the SET FLAG instruction.

INTEGER X WITHOUT INT X KEY

Joseph S. Madachy, Kettering, Ohio, editor of the Journal of Recreational Mathematics, submitted this programming tip for obtaining the INTEGER X function if an INTEGER X key is not available. This is an extension of the number-rounding technique given in *KEYBOARD*, Vol. 3, No. 4, p. 29.

Given a calculator which operates in n significant digits but not having an INTEGER X key, and a number abc.xyz, the integer abc is obtained by this sequence:

(1) Subtract 0.5 from the number abc.xyz
(2) Add 10^{n-1}
(3) Subtract 10^{n-1}

The result is abc.

For example, to obtain the integer of 123.456 with a Model 20 without the Math ROM, enter 123.456 - 0.5 + EEX 11 - EEX 11, EXECUTE. The result is 123.

'NO-OPERATION' EDITING AID - 9820A

In modifying a Model 20 program containing line-dependent branching addresses, such as GTO +3 or GTO 17, you may wish to include some no-operation lines. These lines can replace active lines which are to be deleted, thus avoiding changes in branching addresses.

To replace an active line by a no-operation one, just address the desired line, such as GTO 2, then press CLR STORE. The resulting line,

2 : ⊢ ,

is a no-operation line which takes minimum memory, replacing the previous line 2.

At the STORE command for this type of line, the line counter does not advance; you must manually address it to the next line. In this case, press GTO 3, followed by CLR STORE if line 3 is to be a no-operation line, or GTO 3 EXECUTE if line 3 is to contain active instructions. During program operation, the line counter automatically steps past the no-operation lines until the next active line is reached.

No-operation lines are most useful in editing existing programs to minimize the number of edits. Using label addresses in writing a new program gives the maximum editing flexibility, since this makes the program independent of line insertion or deletion.

MODEL 10 DATA PRINTOUT

W. J. Butterworth of the Admiralty, Underwater Weapons Establishment, Portland, Dorset, England, submitted this subroutine to print out the contents of the Model 10's data storage registers. A STOP instruction is included so that the user may enter the number of registers required. The total number of registers is limited to 108 for the 9810A with Option 001 (111 registers) or 48 for the basic machine. The labels may, of course, be changed to suit the user.

PROGRAM LISTING

```
0126-- 0 ---00
0127-- 0 ---00
0128-- 0 ---00
0129--LBL---51
0130-- + ---33
0131--CLR---20
0132--FMT---42
0133--FMT---42
0134-- C ---61
0135-- O ---71
0136-- N ---73
0137--XTO---23
0138-- E ---60
0139-- N ---73
0140--XTO---23
0141--YTO---40
0142--CNT---47
0143-- O ---71
0144-- F ---16
0145--CNT---47
0146-- a ---13
0147-- E ---60
0148-- G ---15
0149-- I ---65
0150--YTO---40
0151--XTO---23
0152-- E ---60
0153-- a ---13
0154--YTO---40
0155--CLR---20
0156-- 0 ---00
0157--CNT---47
0158--XTO---23
0159-- O ---71
0160--CNT---47
0161-- 1 ---01
0162-- 0 ---00
0163-- 8 ---10
0164--CLR---20
0165--CLR---20
0166--STP---41
0167--RUP---22
0168--LBL---51
0169-- - ---34
0170--XTO---23
0171-- + ---33
0172-- b ---14
0173-- b ---14
0174--X>Y---53
0175--STP---41
0176--CNT---47
0177--CNT---47
0178--CNT---47
0179--PNT---45
0180--XFR---67
0181--IND---31
0182-- b ---14
0183--PNT---45
0184--PNT---45
0185-- 1 ---01
0186--GTO---44
0187--LBL---51
0188-- - ---34
0189--CNT---47
0190--END---46
```

PARTIAL DATA PRINTOUT

```
CONTENTS OF REGI
STERS
0 TO 108

      0.00
      0.00

      1.00
      9.00

      2.00
     28.00

      3.00
      0.00

      4.00
      8.89

      5.00
    252.00

      6.00
      0.00

      7.00
      0.00

      8.00
     47.22

      9.00
      5.31

     10.00
      0.00
```

ERRATA

KEYBOARD, Vol. 3, No. 3., p. 28, stated that all four step-saving techniques which M. Cardot wrote for the 9100A/B will work equally well on the 9810A. While this is true for step-savers 2, 3, and 4, it is not true for the first one. Since the use of the RCT statement can alter the Model 10's Z-register contents, readers should use step-saver 1 with the 9100A/B only. Our apologies go to M. Cardot for *KEYBOARD's* error, and our thanks to Mr. D. D. Parker, Maidenhead, Berkshire, England, for discovering it.

9800 CALCULATOR AND PERIPHERAL LIST

Here is a list of the hardware and peripheral units now available for the Series 9800 Calculators. This may help you in planning to establish or expand your system to include input/output devices such as the cassette memory featured in this *KEYBOARD*.

MODEL 20

Description	Product Number
Mainframe	
Basic Model 20 Calculator, including 173 registers	9820A
Factory Installed Options	
429 Total Data Registers	Opt. 001
Carrying Handle	Opt. 015
Field Installable Option	
429 Total Data Registers	11228A
Plug-In Function Blocks	
Peripheral Control I	11220A
Mathematics	11221A
User Definable	11222A
Cassette Control	11223A
Peripheral Control II (Instrumentation)	11224A
Peripherals	
Mark-Sense Card Reader	9860A
Typewriter Output	9861A
Plotter	9862A Opt. 020
Paper Tape Reader	9863A
Digitizer	9864A
Cassette Memory (specify Option 020)	9865A
I/O Expander (allows using up to 13 peripherals simultaneously)	9868A
Accessories	
TTL I/O Interface Card	11202A
BCD Input Interface Card	11203A

MODEL 10

Description	Product Number
Mainframe	
Basic Model 10 Calculator, including 51 registers and 500 program steps	9810A
Factory Installed Options	
111 Total Data Registers	Opt. 001
1012 Total Program Steps, or	Opt. 002
2036 Total Program Steps	Opt. 003
Printer	Opt. 004
Carrying Handle	Opt. 015
Field Installable Options	
111 Total Data Registers	11216A
1012 Total Program Steps, or	11217A
2036 Total Program Steps	11218A
Field Installed Printer	11219A
Plug-In Function Blocks	
Mathematics	11210A
Printer Alpha	11211A
Typewriter	11212A
User Definable	11213A
Statistics	11214A
Plotter	11215A
Plotter/Printer Alpha Comb.	11261A
Peripheral/Cassette Comb.	11262A
Peripheral	11264A
Cassette Memory	11265A
Peripheral/Printer Alpha Comb.	11266A
Typewriter/Cassette Comb.	11267A
Peripherals	
Mark-Sense Card Reader	9860A
Typewriter Output (requires 11212A or 11264A or comb's.)	9861A
Plotter (Optional 11215A or combination)	9862A
Paper Tapereader	9863A
Digitizer (requires 11264A or combination)	9864A
Cassette Memory (requires 11265A or combination; also specify Option 010)	9865A
I/O Expander (allows using up to 13 peripherals simultaneously)	9868A
Accessories	
TTL I/O Interface Card	11202A
BCD Input Interface Card	11203A