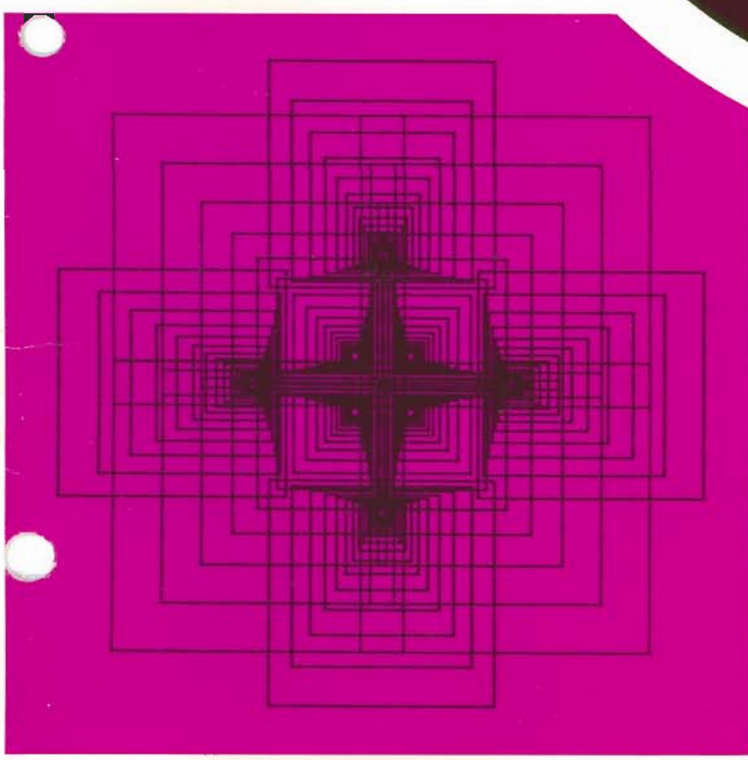
HEWLETT-PACKARD

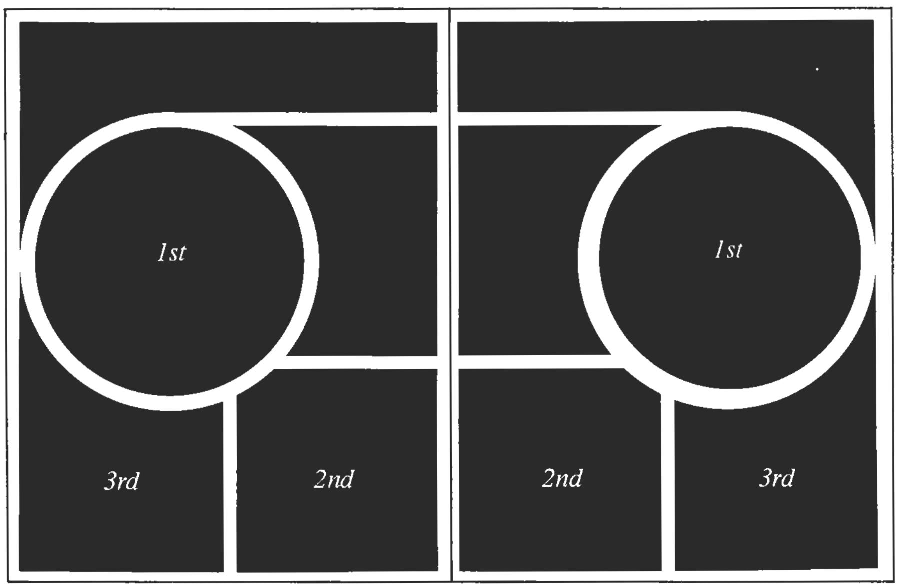
KEYBOARD

VOL. 4 NO. 3



COVER

Winning entries in the 1972 Calculator Art Contest and honorable mentions are reproduced on the cover of this issue. The article on page 9 gives more information on the contestants and their entries.



STUDENT BRANCH

In the student branch, winning entries are reproduced on the back cover. First prize, the upper untitled plot, is by Yali Amit. On the lower right is "Obelix," the second prize winner by Thomas Wetzel and Gaudenz Domenig. The third prize goes to David Cogen for his untitled plot.

GENERAL BRANCH

C. G. Foster's untitled plot, upper right, takes first prize. Mandala II by Dr. Nikolai Eberhardt, lower left, is awarded second prize. The third prize goes to Robert W. Conley for his CUBE.

TO HP *KEYBOARD* READERS

HP *KEYBOARD* is provided free to you--our customer. It is intended to bring you the latest news on calculators, peripherals, and calculator systems applications, as well as descriptions of current programs and program libraries. Programming techniques for all HP Calculators are published to help you maximize the efficiency of your programs.

KEYBOARD welcomes your programs, programming tips, and calculator applications ideas. They will be acknowledged and evaluated for publication. You can send them either directly to Loveland or to the nearest *KEYBOARD* field editor for prompt attention.

All articles submitted for publication should be typed. Programs should include a complete description, user instructions, numerical example, program listing, and a recorded magnetic card, tape cassette, or optical marked cards. *KEYBOARD* will replace or return recorded materials.

NEW--LETTERS TO THE EDITOR

Watch *KEYBOARD* for a new "Letters To The Editor" department to start soon. If you have thoughts you would like to share with other HP Calculator owners, write them down and address to Letters To The Editor, HP *KEYBOARD*, either directly to Loveland or to the nearest field editor.

TABLE OF CONTENTS

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

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

Field Editors:

AUSTRALASIA: Bill Thomas, Hewlett-Packard Australia Pty. Ltd.
61 Alexander Street
Crows Nest, 2065, New South Wales

CANADA: Brian Wiley, Hewlett-Packard Canada Ltd.
275 Hymus Blvd.
Pointe Claire, Quebec

EUROPE: Eberhard Beck, Hewlett-Packard GmbH
Herrenberger Strasse 110
703 Boblingen, West Germany

JAPAN: Akira Saito, Yokogawa-Hewlett-Packard Ltd.
59-1, Yoyogi 1-chrome
Shibuya-ku, Tokyo 151

LATIN AMERICA: Daniel Mazar Barnett, Hewlett-Packard Intercontinental
3200 Hillview Avenue
Palo Alto, California 94304

SOUTH AFRICA: Dennis du Buisson, Hewlett-Packard South Africa (Pty.) Ltd.
30 de Beer Street
Braamfontein

EASTERN U.S.A.: Stan Kowalewski, Hewlett-Packard Co.
W120 Century Road
Paramus, New Jersey 07652

MIDWESTERN U.S.A.: Jerry Reinker, Hewlett-Packard Co.
3460 South Dixie Drive
Dayton, Ohio 45439

SOUTHERN U.S.A.: Bob McCoy, Hewlett-Packard Co.
Post Office Box 28234
Atlanta, Georgia 30328

WESTERN U.S.A.: Robert C. Reade, Hewlett-Packard Co.
3939 Lankershim Boulevard
North Hollywood, California 91604

KEYBOARD

VOLUME 4 NUMBER 3

VELOCITY-RADIUS RELATIONSHIP OF ORBITING BODIES

Mark Metcalf, who is a recent graduate of the Taipei American High School, wrote a research paper as a student which was awarded Honorable Mention in the 1972 Tomorrow's Scientists and Engineers program. Using a Hewlett-Packard 9100B Calculator, he calculated the velocities of all the planets and their satellites in our solar system. In doing this, he has confirmed Kepler's findings about the planets, and has concluded that all satellites in our solar system circle their parent centers in a fixed way; as the radius increases, the velocity decreases. Mr. Metcalf's research paper is reproduced here in part.

INTRODUCTION

In his book entitled "Epitome of Copernican Astronomy," the renowned German astronomer and mathematician, Johannes Kepler states, "... the planets, on drawing near to the sun, are borne more speedily ...," or simply, the smaller the average radius of a planet's orbit the greater the average velocity of the planet. This idea which was based on data from only the known planets of the time (Mercury, Venus, Earth, Mars, Jupiter, and Saturn) also holds true for the rest of the planets in our solar system. But what happens if one wishes to see if there is a velocity-radius relationship for the natural satellites of the planets? In all of my reading I have yet to find a book which states that there is a definite velocity-radius relationship between the satellites of any given planet. In fact, the closest that I have come in finding any satellitaric velocity-radius relationship can be found in the book "Sourcebook on the Space Sciences." In this book, the author says that there is a relationship between the Earth and artificial satellites similar to that of the planets and the sun. No reference is made to natural satellites concerning this relationship. Without such information there are three alternatives open to one who wishes to deal with these satellites in a velocity-radius sense. The first is to generalize by saying that, since the satellites have a similar orbital structure compared to the planets around the sun, a generalization can be made in saying that the satellites will behave in the same way as the planets do. The second method is to forget about the project all together. The third method is to obtain the specific data for each of the satellites, process the data, and come up with a conclusion that either verifies or disproves the idea.

To satisfy my curiosity, I chose the last method.

PROCEDURE

The first part of this project consisted of verifying Kepler's idea concerning the velocity-radius between the sun and the planets. This could be accomplished by finding the average radii and velocities of all of the planets, and seeing if they supported Kepler's idea.

The first to be considered was the problem of uniformity--it would be quite difficult to draw any conclusions from the data unless it was all expressed in the same units of measurement. The Meters, Kilograms, Seconds (MKS) system was used because it is quite widely used in scientific fields. This would allow the velocity to be expressed in meters per second, and the radius in meters.

Now that all of the data was to be unified by the MKS system the next step was to define the formulae to be used. The planets, in their journey through space, travel in a wave-like path by the sun. This motion, as Kepler discovered, can be expressed as an elliptical orbit using the sun as one of the foci. This seemingly elliptical motion can then, by averaging the radius at aphelion and perihelion, be expressed as a circular orbit using the average radius as the given radius. Thus, the orbital circumference could be found by using the average radius in the formula for circumference, $2\pi R$. Now that methods for expressing distance and time (time was given to be in seconds) had been solved for, the velocity could be found.

The next obstacle was that of finding a simple, but reliable, method of solving the problem since it was going to deal with rather large numbers. Four possibilities existed: longhand (manually), slide rule, IBM 360 Computer, Hewlett-Packard 9100B Calculator. Eventually, because of accuracy, simplicity, and availability, the Hewlett-Packard machine was chosen.

Now that the machine had been chosen, a calculator program was devised. The solutions were then printed out on tape. This was the end of part one.

The second part of the experiment dealt with the search for a definite velocity-radius relationship between the planets and their natural satellites. To work with this, a new program would be needed since the raw data was expressed in days, hours, and minutes as time units, and miles as the measurement for distance.

As with the first part of the project, the data would be in the MKS system. This meant that the time must be converted to seconds. To do this the following formula was applied:

$$\text{Time}_{\text{sec}} = ((24d+h)60+m)60$$

with d, h, and m representing days, hours, and minutes, respectively.

Since the radius was in miles, it, too, had to be converted to MKS. The simplest way to change miles to kilometers is to multiply by 1.609; but the distance was to be expressed in meters. This required a change in the constant to 1609, because there are 1000 meters in a kilometer. Because of this the meters could be found by the following formula:

$$R_{\text{av(meters)}} = R_{\text{av(miles)}}1609$$

Then, by substitution, velocity was expressed as:

$$\text{Vel}_{\text{av(m/s)}} = \frac{((1609R_{\text{av(miles)}})2\pi)}{((d24+h)60+m)60}$$

The formula was then translated into a program. The processed data was printed out to be interpreted.

CONCLUSION

The first part of this project has shown that there is a definite velocity-radius relationship between the planets and the sun. The graph (Fig. 1) clearly shows the relationship. The relationship can be expressed by saying that the average radius of orbit of the given planet. Thus, Kepler's idea is verified.

The second part of this project has shown there is also a definite velocity-radius relationship between the planets and their natural satellites (Fig. 2). As before, the relationship is inversely proportional, or:

$$V_{av} = \frac{1}{Rad_{av}}$$

Since, in every case, the velocity decreases as the radius increases, the aforementioned formula can be considered valid. ●

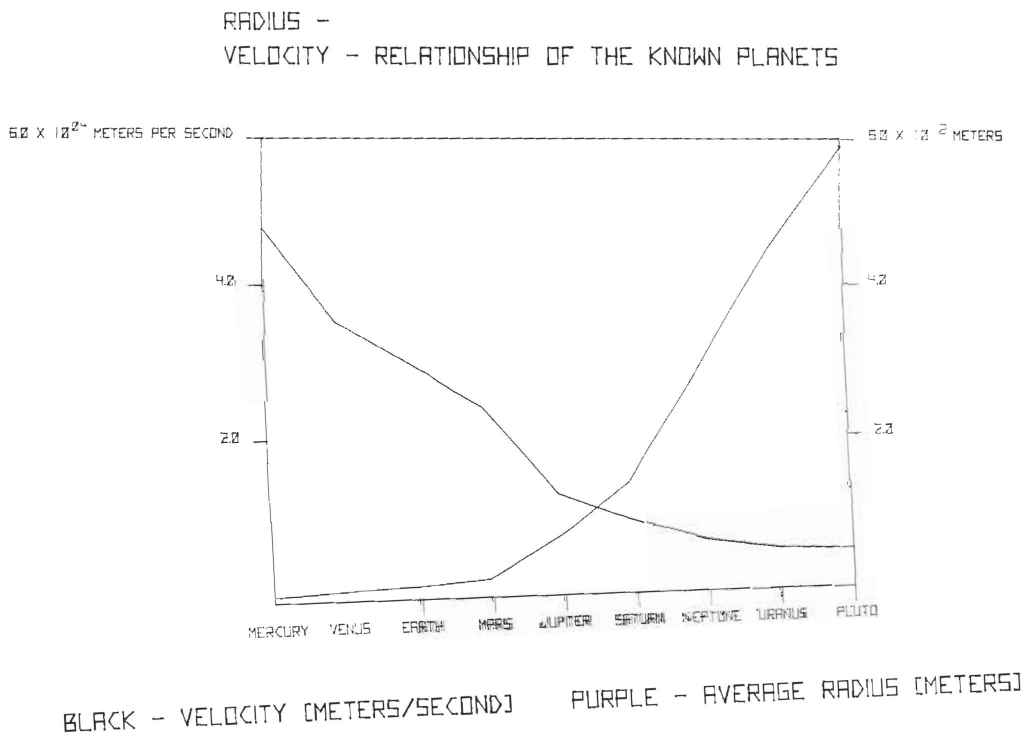


Fig. 1

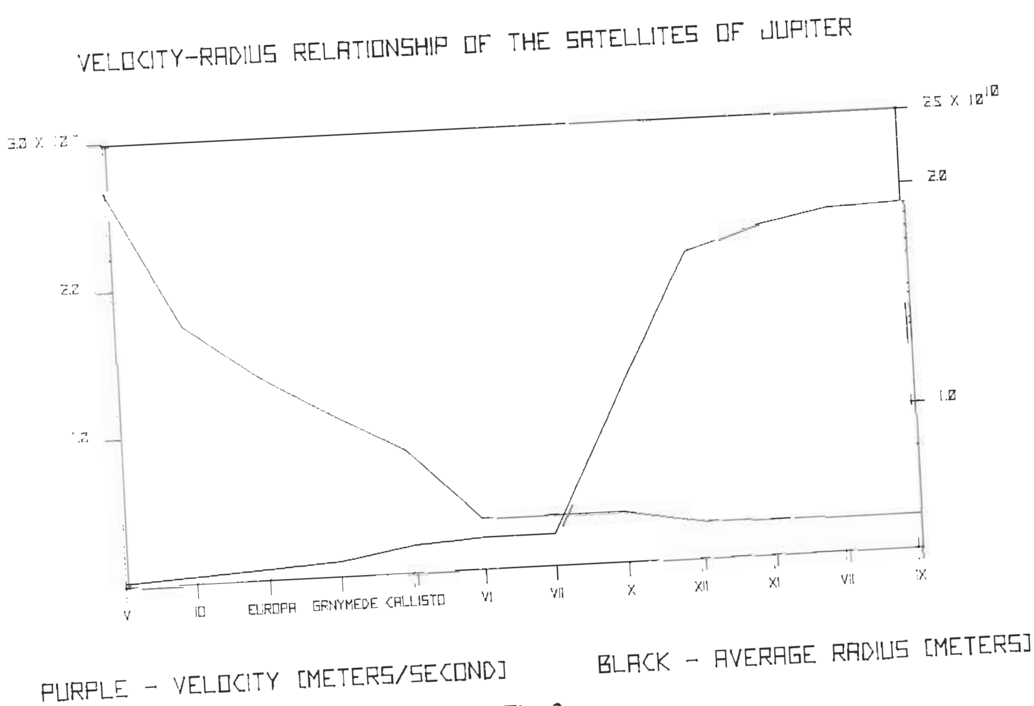


Fig. 2

BIBLIOGRAPHY

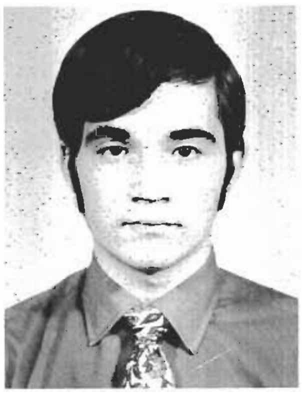
Glasstone, Samuel. "Sourcebook on the Space Sciences." 1965. D. Van Nostrand Company Inc., Princeton, New Jersey. p. 41-44.

Kepler, Johannes. "Epitome of Copernican Astronomy." 1952. Encyclopedia Britannica, Chicago. (Great Books of the Western World, Vol. 16).

Rutherford, F. James. "The Project Physics Course." 1970. (Text) Holt, Rinehart, and Winston, Inc., New York.

Sutton, Richard M. "The Physics of Space." 1965. Holt, Rinehart, and Winston, Inc., New York.

The Project Physics Course. 1970. (Handbook) Holt, Rinehart, and Winston, Inc., New York.



Mark Metcalf, age 16, graduated from Taipei American High School in 1972. He has been accepted to St. Olaf and Pacific Lutheran University, and is also a competition alternate for the U.S. Naval Academy.

Dick Hammond, Chairman of the Science Dept., Taipei American High School, is a graduate of Indiana University where he received his AB, MS, and M.A.T. in Physics and Science. Mr. Hammond has been with Taipei American High School for one year, and has introduced the Project Physics course, which includes a unit on "Motion in the Heavens" that prompted Mark to undertake the study for his project.

Larry S. Wolfley, Chairman of the Mathematics Dept., Taipei American High School, is a graduate of Brigham Young University where he received his BS in Mathematics, and has spent one year doing graduate work toward his MS. He has completed his second year at Taipei American High School. Mark has been a Calculus student of Mr. Wolfley during the past year.

Part No. 09820-71004

MODEL 20

CHEBYSHEV LOW-PASS FILTER DESIGN, UNEQUAL TERMINATIONS

by H. W. Hardenbergh

This program calculates the values for the L's (inductors) and C's (capacitors) of an Nth order Chebyshev low-pass filter, given the order of the filter, the dB ripple, the cutoff frequency, and the source and termination resistances. For odd order filters, the program offers a choice between a capacitive input and an inductive input filter. For even order filters the choice is determined by the ratio of the source resistance (R_S) and the termination resistance (R_T); that is, if $R_S/R_T > 1$, it selects a capacitive input filter; if $R_S/R_T < 1$, it selects an inductive input filter. The program requires, for even order filters, that R_S and R_T differ such that

$$\frac{4R_SR_T}{(R_S + R_T)^2} \cdot \text{dB Ripple} > 1$$

If this criterion is not met, the program requests a new termination resistance. The L and C values are accurate for $|R_S - R_T| < 10^5$.

ROM BLOCKS

1	2	3
	MATHEMATICS	

INTERNAL REGISTERS: [X] 173 [ ] 429

PERIPHERALS

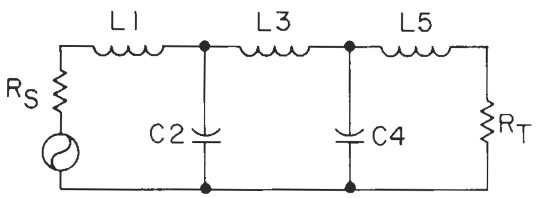
- [ ] 9860A MARKED CARD READER
- [ ] 9861A TYPEWRITER
- [ ] 9862A PLOTTER
- [ ] 9863A PAPER TAPE READER
- [ ] 9864A DIGITIZER
- [ ] 9865A CASSETTE

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	"ORDER OF FILTER"	n = (enter number) RUN PROGRAM
6	"FREQ IN HZ"	FREQUENCY = (enter number) RUN PROGRAM
7	"RIPPLE IN DB"	RIPPLE IN DB = (enter number) RUN PROGRAM
8	"RES IN OHMS"	SOURCE RES = (enter number) RUN PROGRAM
9	"RES IN OHMS"	TERM RES = (enter number) RUN PROGRAM
		After R_T is entered, the display blanks and calculations proceed. Depending on the input, the program may ask for a new R_T or request the user to choose an inductive input or conductive input filter. Finally the L and C values are printed. The first L (or C) printed is the L (or C) closest to R_S.

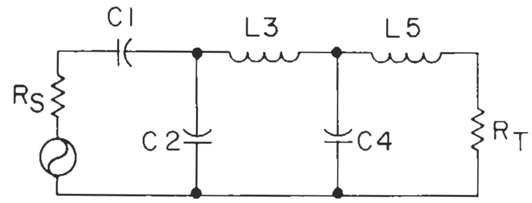
Editor's Note: This complete program is available through the Calculator Program Catalog.

EXAMPLE 1 - ODD ORDER FILTER

Order = 5
Cutoff frequency = 15600 HZ
dB Ripple = .025
Source resistance = 50 ohms
Termination resistance = 75 ohms



Inductive Input Filter



Capacitive Input Filter

```
233-4

THIS PROGRAM
CALCULATES THE
VALUES OF THE
C'S AND L'S
FOR AN NTH ORDER
CHEBYSHEV LOW-
PASS FILTER


N=
               5
FREQUENCY=
        15600.00
RIPPLE IN DB=
          .02500
SOURCE RES=
            50.0
TERM RES=
            75.0


L=
     8.84341E-04
C=
     2.08221E-07
L=
     1.18344E-03
C=
     1.70756E-07
L=
     4.51383E-04
```

```
233-4

THIS PROGRAM
CALCULATES THE
VALUES OF THE
C'S AND L'S
FOR AN NTH ORDER
CHEBYSHEV LOW-
PASS FILTER


N=
               5
FREQUENCY=
        15600.00
RIPPLE IN DB=
          .02500
SOURCE RES=
            50.0
TERM RES=
            75.0


C=
     1.20369E-07
C=
     6.40334E-04
L=
     3.15584E-07
C=
     7.80827E-04
L=
     2.35824E-07
```

EXAMPLE 2 - EVEN ORDER FILTER

Given: Nth order = 6
Cutoff frequency = 15600 HZ
dB Ripple = .025
Source resistance = (see printout)
Termination resistance = (see printout)

```
233-4

THIS PROGRAM
CALCULATES THE
VALUES OF THE
C'S AND L'S
FOR AN NTH ORDER
CHEBYSHEV LOW-
PASS FILTER

N=
                 6
FREQUENCY=
          15600.00
RIPPLE IN DB=
            .02500
SOURCE RES=
              50.0
TERM RES=
              50.0

INCREASE TERM;
RES MISMATCH

TERM RES=
              60.0

L=
       5.63197E-04
C=
       2.78515E-07
L=
       9.91926E-04
C=
       2.92506E-07
L=
       8.46601E-04
C=
       1.30082E-07
```

$$\left.\right\} \frac{4R_SR_T}{(R_S+R_T)^2} \cdot \text{Ripple} \not> 1$$

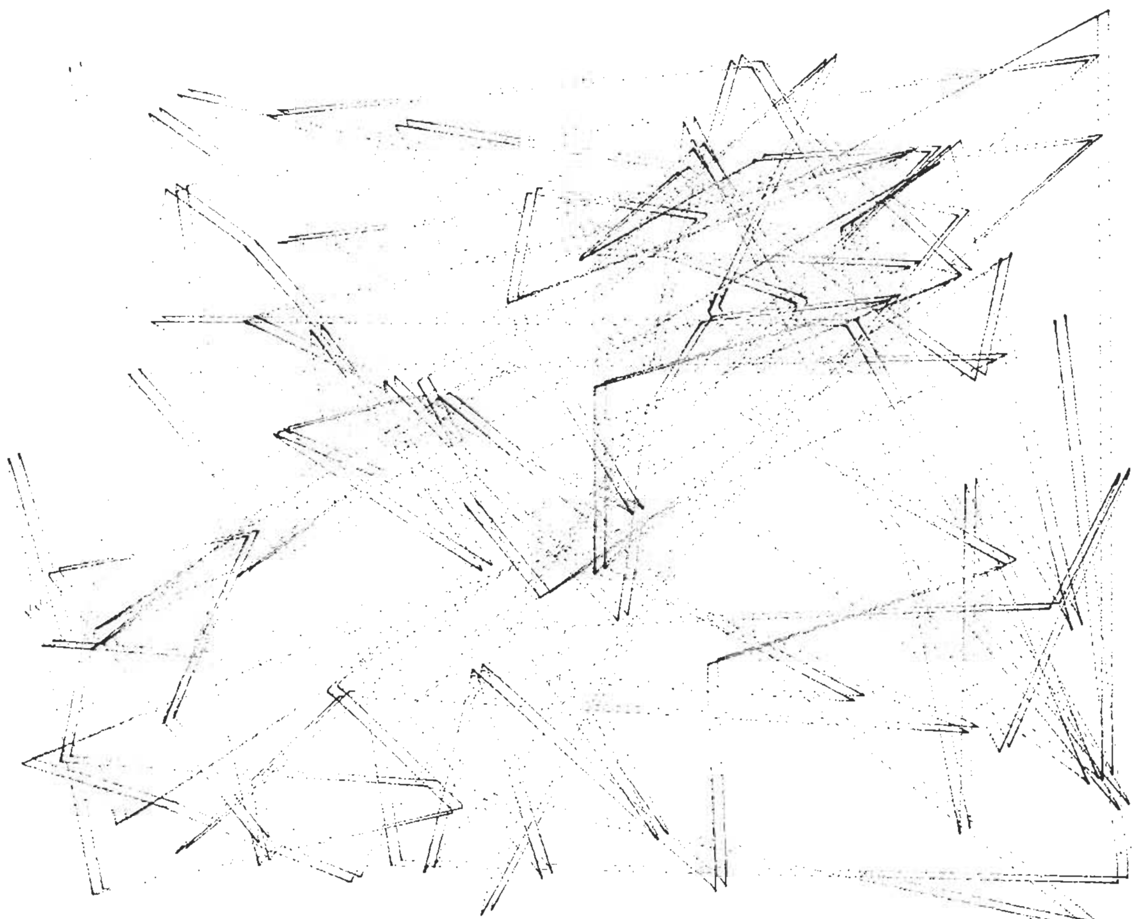
Inductive Input Filter since $R_S/R_T < 1$

```
233-4

THIS PROGRAM
CALCULATES THE
VALUES OF THE
C'S AND L'S
FOR AN NTH ORDER
CHEBYSHEV LOW-
PASS FILTER

N=
                 6
FREQUENCY=
          15600.00
RIPPLE IN DB=
            .02500
SOURCE RES=
              60.0
TERM RES=
              50.0

C=
       1.87732E-07
C=
       8.35545E-04
L=
       3.30643E-07
C=
       8.77517E-04
L=
       2.82200E-07
C=
       3.90245E-04
```

Capacitive Input Filter since $R_S/R_T > 1$

Hal W. Hardenbergh is a freelance circuit designer residing in Santa Ana, California. He attended the University of Southern California, and is a member of Tau Beta Pi, Eta Kappa Nu, and the Audio Engineering Society. His hobbies include designing large speaker systems and weightlifting, as well as some chess.

CALCULATOR ART CONTEST



Brownian Twins

Albert F. Cafiero
New York, New York

The winning entries in the 1972 *KEYBOARD* Calculator Art Contest are shown on the covers of this issue; the general branch winners are reproduced on the front cover and the student branch entries on the back cover. On the following pages are reproductions of as many runner-up entries as space permits.

The contest was announced in *KEYBOARD* Vol. 3, No. 4 and Vol. 4, No. 1. The deadline was extended to September 29 to allow time for entries to arrive from all countries. Seventy-four entries were submitted by fifteen contestants, who used the 9820A, 9810A, and 9100A or B Calculators with their appropriate plotters to produce the artistic designs. Entries were received from Australia, Israel, South Africa, and Switzerland, as well as from the USA.

The prizes for both the general branch and the student branch of the contest consist of three published program pacs of the winning author's choice for first place, two pacs for second place, and one pac each for third place.

The winning entries were chosen by our judges for their artistic appeal. Since the entries as published do not include any of the unusual facts about the contestants or their methods of producing their designs, some of these sidelights may be of interest.

C. G. Foster, research officer in the Department of Mechanical Engineering, University of Queensland, Australia, submitted the first prize winning entry in the general branch of the contest. This untitled entry calculates the solution of the equations $X = A \sin\theta$, $Y = B \sin(N\theta + \phi)$, and $Z = C \sin(M\theta + \psi)$. Made with a 9100B and 9125A Plotter, the program uses twelve entry values controlled by the calculator operator so that a vast number of interesting patterns can be made with the one program.

Dr. Nikolai Eberhardt of the Department of Electrical Engineering, Lehigh University, Bethlehem, Pennsylvania won the second prize in the general contest with his Mandala in Memory of C. G. Jung II. This entry was also plotted with a 9100B Calculator and 9125A Plotter. Among Dr. Eberhardt's eight entries, his Helico Daliana I was selected also for Honorable Mention.

Untitled

Salomon Kamnitzer
Denville, New Jersey

In the student branch of the contest, Yali Amit of Jerusalem, Israel won the first prize with his double eight-pointed star plotted with the 9810A and the 9862A. Yali is 12 years old and in the eighth grade.

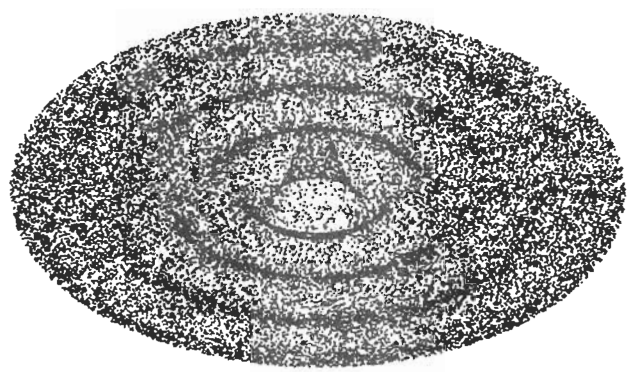
Thomas Wetzel and Gaudenz Domenig of Switzerland won the second prize in the student branch of the contest with their entry, "Obelix." Both students, 16 years old, are enrolled at the Literary Gymnasium, Rämibühl, of the Cantonal School, Zürich, based their program on the comic figure taken from the well-known German book "Asterix and Obelix." The figure was plotted with a series of 9100B programs entered into the calculator with a total of 144 marked optical cards using the 9160A Card Reader.

Robert W. Conley, who is a mathematician for the Air Force Weapons Laboratory at Kirtland Air Force Base, New Mexico, won third prize in the general branch of the contest with his 9810A/9862A design, 'Cube.' This was programmed using three-space points to define the geometry of the figure and a three-space viewing location.

An additional Honorable Mention in the general branch of the contest was awarded to David G. Armstrong of Sudbury, Massachusetts for his Model 9820A/9862A design. This plot is based on a variation of Fermat's spiral, which is a third version of Mr. Armstrong's Figures on a Spiral. Mr. Armstrong submitted a total of 37 entries to the contest.

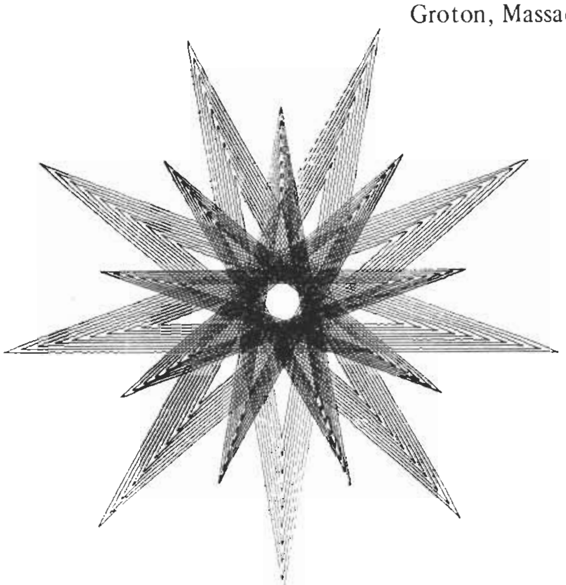
Bloop

R. A. Bruce
Golden, Colorado

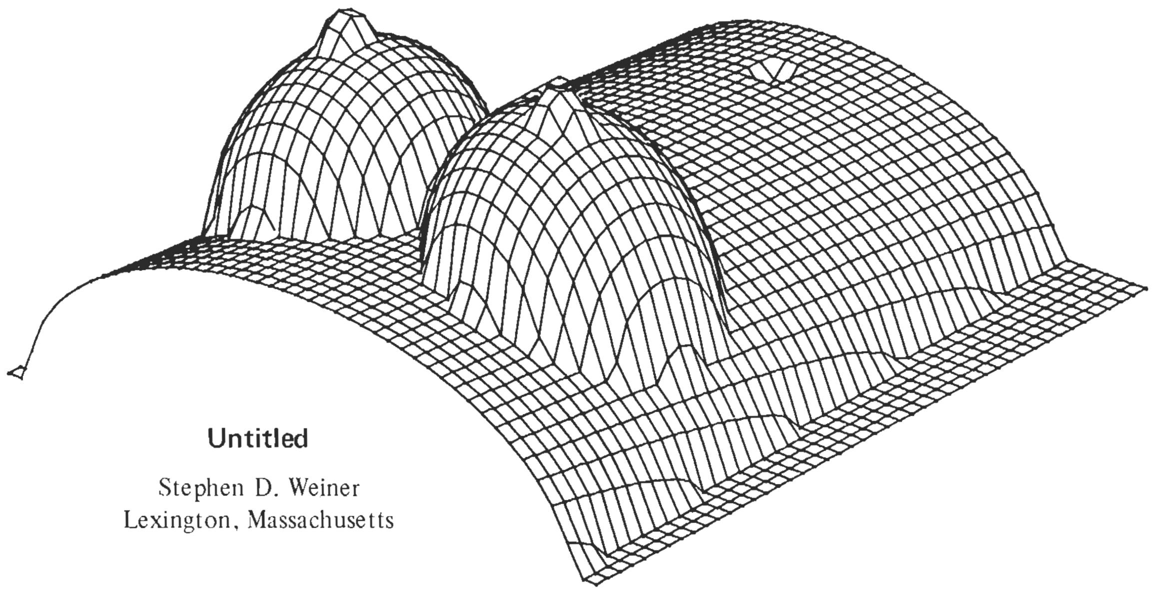


Untitled

David Cogen
Groton, Massachusetts



The third prize in the student branch is awarded to David Cogen of Groton, Massachusetts, the youngest contestant. David, 11 years old, submitted ten designs he programmed for the 9100B Calculator and 9125A Plotter. His designs are variations of an increasing spiral with four variables initially selected by the user to produce different patterns.

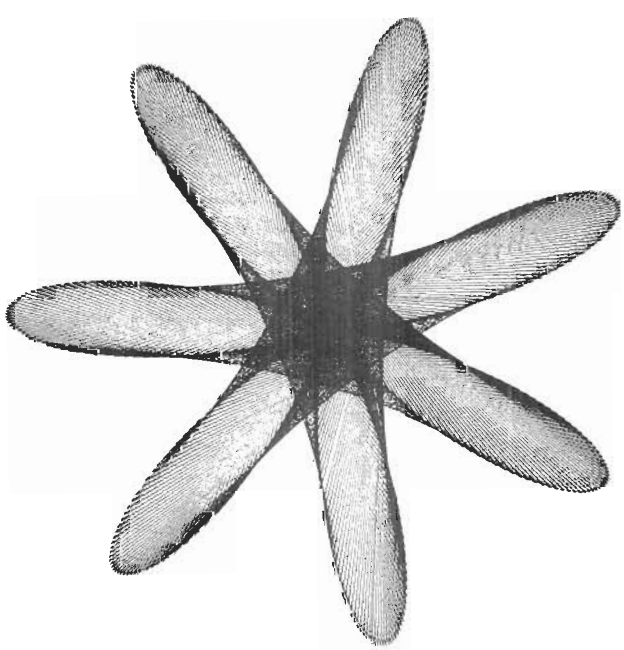


Untitled

Stephen D. Weiner
Lexington, Massachusetts

Polar Plot

Jairus V. Lincoln
Cambridge, Massachusetts



Some clever techniques were used to produce some of the other contest entries, both in mathematics and programming. Mrs. L. V. Wheeler of Kalulushi, Zambia, used an interesting hypocycloid program to plot her designs. This program can duplicate any of the geometric designs produced by the Spirograph toy, which uses a gear rotating in conjunction with a second gear or gear ring.

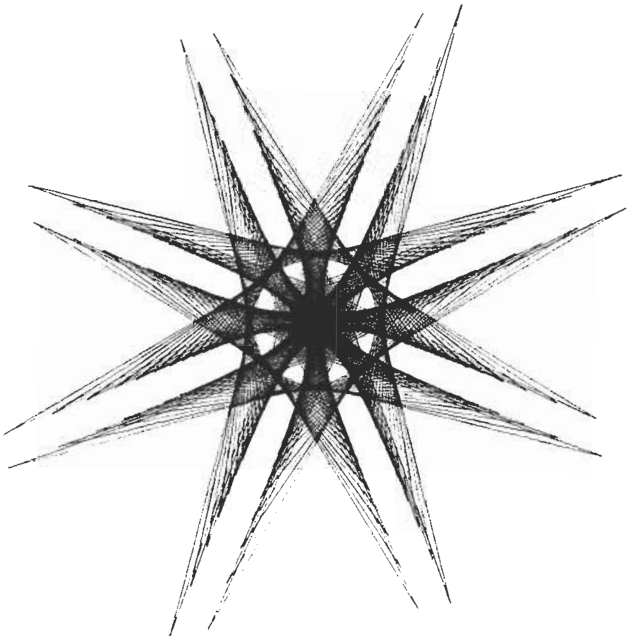
The 3-dimensional plots by Stephen D. Weiner of Massachusetts Institute of Technology, which were made with a Model 10 and a 9862A Plotter, use a sophisticated technique for suppressing hidden lines.

Salomon Kamnitzer used the 9810A and 9862A Plotter to produce his geometric patterns, using the formula $R = \tan 4\theta$, with different increments of θ producing different patterns.

Albert F. Cafiero made his entry using a 9100B and a 9125B Plotter. Using a pseudorandom number generator in his program, Mr. Cafiero produced an attractive design by using the identical random number series twice with a slight offset of the pen origin for the second color.

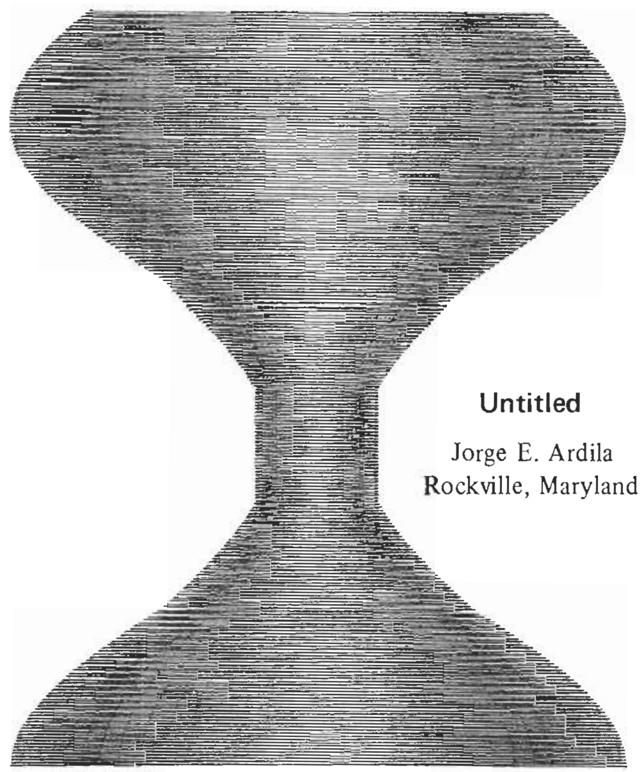
The unusual 'flying saucer' effect of R. A. Bruce's entry, produced with a 9100B and 9125A Plotter, is a perspective view of the function $z = \frac{\sin r}{r}$ in cylindrical coordinates using random points.

Prof. M. Shafig, Department of Statistics, University of Karachi, Pakistan, submitted an interesting entry which arrived too late for the contest, due to his absence from the University. He used a 9100B and a 9125B to plot a fish-like figure which is a modified elipse.



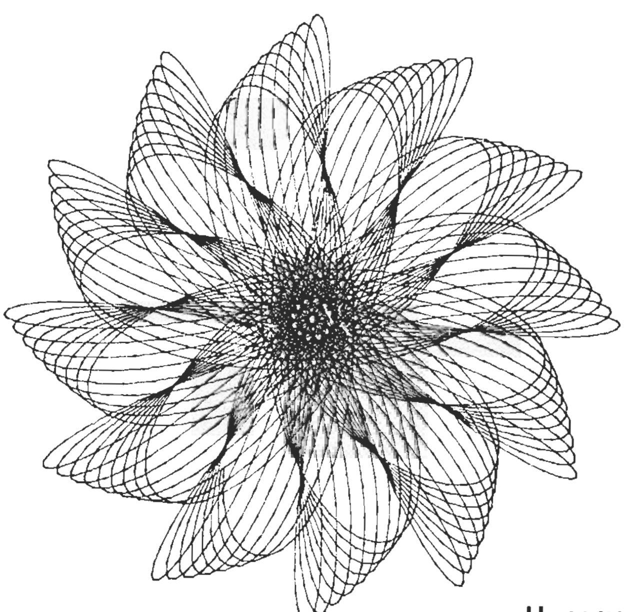
Untitled

David G. Armstrong
Sudbury, Massachusetts



Untitled

Jorge E. Ardila
Rockville, Maryland



Hypocycloid

Mrs. L. V. Wheeler
Kalulushi, Zambia

KEYBOARD extends its thanks to all contestants who participated in the art contest and helped to show some of the versatility of all models of the HP Calculator-Plotter systems. The ability to produce artistic designs, in addition to plotting accurate regression and other curves, is an enjoyable fringe benefit of using the HP Calculator system. Some artistic designs made with HP systems have even been sold at art shows in various parts of the USA.

Part No.
09820-76005

THE GAME OF LIFE

by Glen Worstell and Homer Russell*

Life, as it is called by its inventor John Horton Conway of Gonville and Caius College of the University of Cambridge, is a fascinating solitaire simulation game which exhibits analogies with the rise, fall, and alterations of a society of living organisms. Since its publication in Scientific American,[1] Life has drawn great interest, and even a Life Society has arisen which periodically publishes a newsletter carrying current results of the game.[2]

The game is played on a large checkerboard or piece of graph paper by selecting a simple configuration of counters (organisms), one to a cell, and then observing how the chosen society changes its pattern as Conway's 'genetic laws' for births, deaths, and survivals are applied.

The following excerpt from Scientific American† explains these laws, or rules:

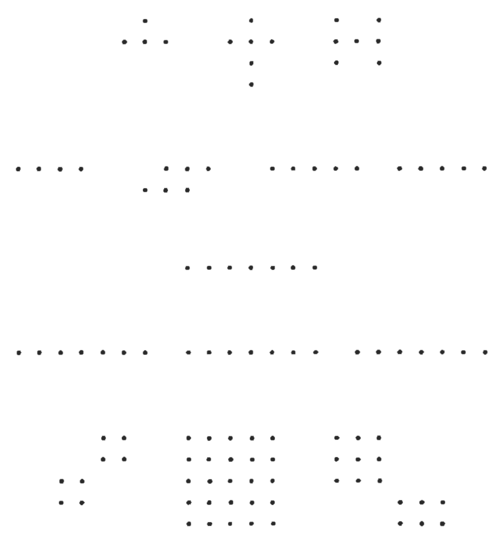
"Conway's genetic laws are delightfully simple. First note that each cell of the checkerboard (assumed to be an infinite plane) has eight neighboring cells, four adjacent orthogonally, four adjacent diagonally. The rules are:

1. Survivals. Every counter with two or three neighboring counters survives for the next generation.
2. Deaths. Each counter with four or more neighbors dies (is removed) from overpopulation. Every counter with one neighbor or none dies from isolation.
3. Births. Each empty cell adjacent to exactly three neighbors--no more, no fewer--is a birth cell. A counter is placed on it at the next move.

It is important to understand that all births and deaths occur simultaneously. Together they constitute a single generation or, as we shall call it, a 'move' in the complete 'life history' of the initial configuration. You will now have the first generation in the life history of your initial pattern. The same procedure is repeated to produce subsequent generations."

Using a list processing technique, the game has been programmed for the 9820A with option 001 and a 9862A Plotter. A 100 x 100 playing grid is used and anywhere from 75 to 150 counters may appear in any particular generation, depending on the nature of the pattern itself. The user keys in coordinates of the counters comprising the starting pattern and this pattern and the pattern of succeeding generations will be plotted. And, optionally, the coordinates of the points may be printed. Patterns which reach the border in their growth will undergo erratic behavior and should be discarded.

Below are some starting patterns which have interesting life histories. Some of them become stable and others reach an oscillating state. Quite often remarkable symmetries will emerge. Names such as beehive, tub, barge, clock, and toad have been given to many of the dot patterns, adding to the color of 'Life.'



* Glen Worstell is a software development engineer at the Hewlett-Packard Cupertino Division, Cupertino, California. Homer Russell is the Product Support Manager at the Hewlett-Packard Advanced Products Division, Cupertino, California.

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

ROM BLOCKS

1	2	3
	MATHEMATICS	PERIPHERAL CONTROL I

INTERNAL REGISTERS

☐ 173 [X] 429

PERIPHERALS

☐ 9860A MARKED CARD READER [X] 9862A PLOTTER ☐ 9864A DIGITIZER ☐ ____

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

STEP	DISPLAY	INSTRUCTIONS
1.		ERASE LOD EXECUTE
2.		END RUN PROGRAM
		Considering the initial counters as elements of a 98 x 98 matrix, specify their i, j locations in the next step.
3.	ROW	i RUN PROGRAM
	COL	j RUN PROGRAM by rows $1 \leqslant i, j \leqslant 98$
		Specify all the counter locations (from left to right) in a given row i_1 before moving to the next row i_2, where $i_1 < i_2$.
		After all counter coordinates have been entered RUN PROGRAM and the patterns in each generation will be plotted, or SFG 3 RUN PROGRAM for printed coordinate values of each generation in addition to the plot.
		When 35 generations have been plotted, proceed with Step 4.
4.	NEW PAPER	Place a fresh sheet of paper on the plotter and RUN PROGRAM. Succeeding generations of the pattern will be plotted beginning again in the upper left corner of the plotter paper.
		Anytime the program is running, SET/CLEAR FLAG N causes control to go to Step 5 upon completion of processing of the current generation.

EXAMPLE

Input: • • • • •   • • • • •

50.44
50.45
50.46
50.47
50.48
50.50
50.51
50.52
50.53
50.54

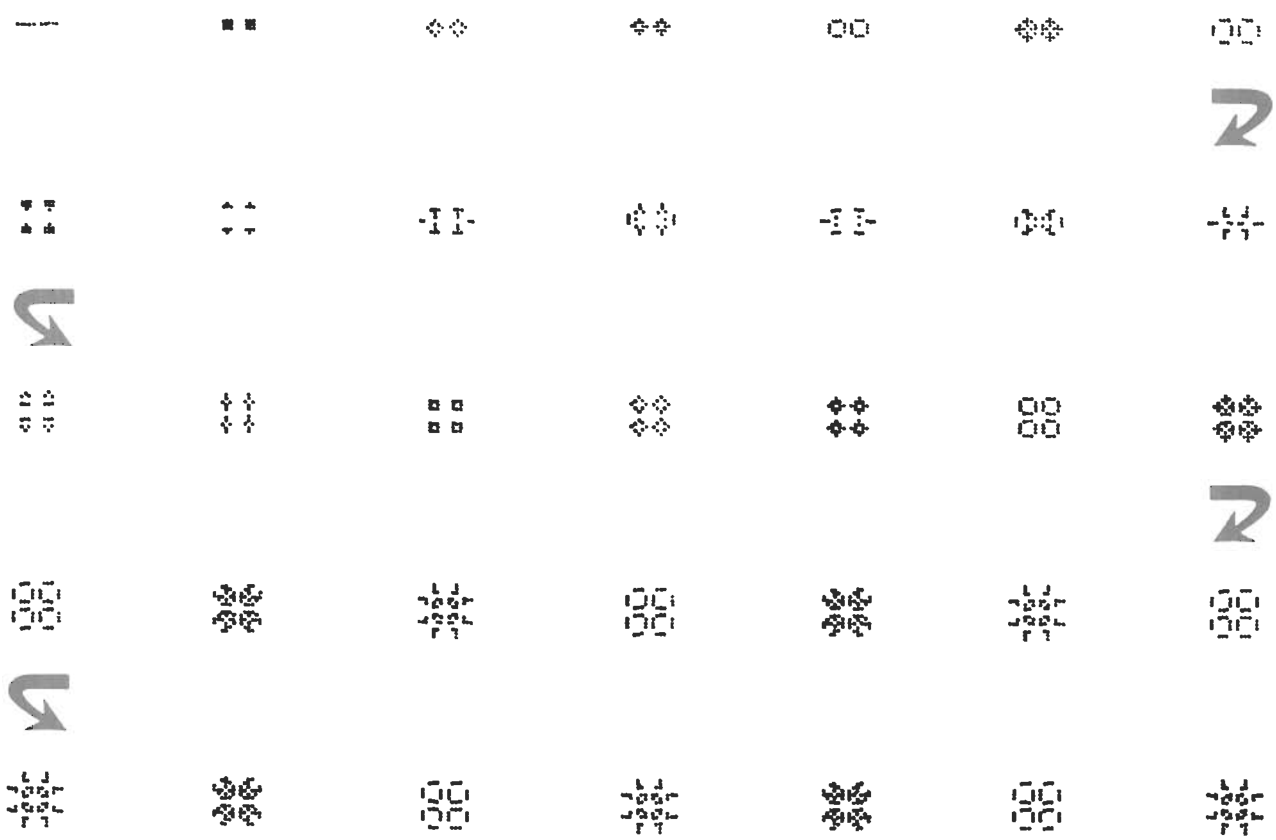
Coordinate values for this example were chosen to approximately center the initial pattern on the playing grid.

Note that each coordinate pair input is printed out with the row number to the left of the decimal point and the column number to the right. The pattern reaches a cyclic state in the fourth row of the plot (period of cycle = 3), and the plot could have been terminated at that point by pressing STOP.

REFERENCE [1] Martin, Gardner, "Mathematical Games" (Scientific American, October, 1970).

[2] Robert T. Wainwright, Lifeline, (1280 Edcris Road, Yorktown Heights, New York).

EXAMPLE (Continued)



MODEL 20 STAT PAC VOL. 1
PROGRAM LISTING

Part Number 09820-70800

1. Basic Statistics
2. Histogram (Basic Memory Configuration with Printer Plot)
3. Histogram (Basic Memory Configuration with Plot)
4. Histogram (Expanded Memory Configuration with Plot)
5. Multiple Linear Regression (Basic Memory Configuration)
6. Multiple Linear Regression (Expanded Memory Configuration)
7. Polynomial Regression (Axis Increment Values Input; Basic Memory Configuration)
8. Polynomial Regression (Axis Increment Values Input; Basic Memory Configuration with Plot)
9. Polynomial Regression (Axis Increment Values Input; Expanded Memory Configuration with Plot)
10. Polynomial Regression (Number of Axis Increments Input; Expanded Memory Configuration)

9800 SYSTEM APPLICATION CONTEST

KEYBOARD is seeking articles describing unusual applications of HP calculator systems. Since the Series 9800 calculators are the most powerful, they are generally used in the widest range of applications. *KEYBOARD* is therefore conducting a contest for the most unusual applications of HP 9800 systems.

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

1. Each entry shall be in the form of an article suitable for publication in *KEYBOARD*, and a publication release shall be included.
2. Entries shall be typed double-spaced on paper approximately 8½ by 11 inches (21,6 cm by 27,9 cm).
3. Pertinent photographs, charts, and other illustrations shall be included. Photographs must be good contrast black-and-white prints between 4 by 5 inches (10,1 cm by 12,7 cm) and 8 by 10 inches (20,3 cm by 25,4 cm). The author's photograph and curriculum vitae should be included.
4. Entries shall be submitted to either a field editor or directly to HP *KEYBOARD*, P.O. Box 301, Loveland, Colorado, 80537, postmarked not later than the deadline date.
5. Entries become the property of Hewlett-Packard and cannot be returned.
6. Winners will be notified in advance of publication. Winning articles will be published in *KEYBOARD* following the contest deadline dates.
7. A proof copy of any article to be published will be submitted to the author for approval prior to publication.
8. Employees of Hewlett-Packard Company, its affiliates and subsidiaries are not eligible to compete.

Part No.
09810-70007

MODEL 10

NUMERICAL INTEGRATION USING GAUSSIAN QUADRATURE

by R. W. Sassman

This program will numerically integrate any function whose integral exists and can be described in the form:

$$\int_a^b f(y)\,dy$$

The iteration to evaluate the integral is as follows:

$$\frac{b-a}{2} \sum_{i=1}^{16} w_i f(y_i); \text{ where } y_i = \left(\frac{b-a}{2}\right)x_i + \left(\frac{b+a}{2}\right)$$

The technique used in this program and the x_i and w_i values can be found in the "Handbook of Mathematical Functions."[1]

Comparing this method to Simpson's One Third Rule program and the Differential Equations (Runge-Kutta-Gill Method) program[2] its ease of use far overshadows both methods. The user's only requirement is to write a subroutine to evaluate the function. Please see the user instructions and the example to clarify this point.

EQUIPMENT NEEDED	TOTAL REGISTERS	TOTAL PROGRAM STEPS	ROM'S
[X] PRINTER			
[ ] 9860A MARKED CARD READER	[X] 51	[X] 500	1 ______
[ ] 9861A TYPEWRITER	[ ] 111	[ ] 1012	2 ______
[ ] 9862A PLOTTER		[ ] 2036	3 ______

STEP	USER INSTRUCTION	DISPLAY x	DISPLAY y	DISPLAY z
	Press: END			
	Load Program			
	Press: GO TO 456			
	Press: PROGRAM			
	Enter the subroutine to evaluate the integrand F(y).			
	The first steps must be: LABEL F			
	The final step must be RETURN			
	Press: RUN			
	Press: END			
	Press: CONTINUE	1	0	0
1.	Enter: a, b	a	b	
	Press: CONTINUE			
2.	Print: a, b, $\int_a^b f(y)dy$			
	To run a new case go to Step 1.			

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

EXAMPLE: $F(x) = \frac{1}{x}$

USER SUBROUTINE

```
--LBL---51     } Required by the program.
-- F ---16
-- 1 ---01     ⎫
-- UP---27     ⎪
--XFR---67     ⎪ Register 37 contains the increment i and therefore
--IND---31     ⎬ the user subroutine finds y_i which was calculated by
-- 3 ---03     ⎪ the program prior to calling the subroutine.
-- 7 ---07     ⎪
--CNT---47     ⎭
--DIV---35
--YTO---40     ⎫
-- 0 ---00     ⎬ The subroutine returns F(y_i) to register 0.
--CNT---47     ⎭
--S/R---77     } Required by the program.
--END---46
```

1. $\int_{1}^{10} \frac{dy}{y} = 2.302585091$

```
1.000000000 00*
1.000000000 01*

2.302585091 00
```

2. $\int_{.1}^{1} \frac{dy}{y} = 2.302585091$

```
1.000000000-01*
1.000000000 00*

2.302585091 00
```

Mr. Sassman is a Senior Engineer at Northrop Corporate Laboratories, Pasadena, California. He has been engaged for the last nine years in the application of computers to the solution of electromagnetic boundary value problems. He is a graduate of the University of Southern California with a B.E. and M.S. in Electrical Engineering.

REFERENCE

[1] M. Abramowitz and I. A. Stegun. "Handbook of Mathematical Functions." 1962. National Bureau of Standards. p. 887, 916.

[2] Dave Cole. "Hewlett-Packard Calculator 9810A Math Pac." 1971. Calculator Products Division, Loveland. p. 27-38.

PROGRAMMING TIPS

MODEL 20--MULTIPLE EXECUTION OF SINGLE LINE

Dr. James N. Shapiro and Dr. Anthony F. Gangi of Texas A&M University, College Station, Texas, submitted the following program tip.

The technique relies on the Model 20's buffer being able to contain a large number of statements at one time, and consists of executing a single line as many times as desired manually. An important feature of this procedure is that it may be performed without modifying program or register memory. Single line execution can often be used to advantage during program execution at an ENTER statement stop.

The single line execution technique is particularly valuable when program memory is full, as it requires no additional storage. It may also be used to advantage during execution of an ENTER statement. In this case program operation need not be interrupted.

Two examples are given below:

(1)The following single line may be executed repeatedly to print out the addresses and contents of sequential non-zero registers. (A suitable register, in this case Z, is first initialized to one less than the address of the desired starting register.)

Z+1; IF RZ ≠ 0; FIXED 0; PRT Z;
FLOAT 9; PRT RZ; SPC.

Each time EXECUTE is pressed the next register will be printed out if it is non-zero. No printout occurs in the case that the register is zero.

(2)The following program will load 1 → R11, 4 → R12, 9 → R13, etc., with Z initialized to 10: Z+1; (Z-10)(Z-10) → RZ. Keep pressing EXECUTE until the last register is filled.

The above technique is a real time saver and in some cases, i.e., when the memory is full, invaluable.

MODEL 20 DATA STORAGE

In many applications the use of magnetic cards in loading and recording data in the Model 9820A is an infrequent occurrence, so a few reminders may help. Aside from the syntax for loading data, LOD "DA" EXECUTE and recording data, REC "DA" R( ) EXECUTE it is useful to know that the highest register specified when recording data should be just the highest one needed. This minimizes the number of magnetic card sides required.

If a blank magnetic card is used accidentally with the load data instructions, this will not change the value of data already existing in the storage registers. This operation will produce a NOTE 14 when the card finishes going through the card reader.

Pressing ERASE or switching the power off momentarily will clear the entire user memory including programs as well as data storage. However, if the Math block is inserted, pressing TBL 4 will clear only the available R( ) registers, leaving intact any programs residing in the memory. TBL 5 clears the A, B, C, X, Y, and Z registers.

A specified number of R( ) registers starting with R0 can be cleared of data by loading a magnetic card which has the desired number of R( ) registers recorded with zeroes. This will not affect the contents of previously loaded R( ) registers above the highest-numbered one zeroed by the magnetic card.

SIMPLE COUNTER FOR 9100 OR 9810A

Sy Ramey of Hewlett-Packard's Microwave Division gave us an idea for the simplest counter for the Model 9100A/B or the 9810A using no storage registers. It uses the Y register for the counter and preserves the contents of the X and Z registers. Starting with zero in the Y register, the instruction sequence is

X
+
DIV
PSE

This gives $y = \frac{xy + x}{x}$ for any value of x such that xy is within the dynamic range of the calculator. The value of x may be either the same value or a different value for each program cycle. X may be positive or negative and need not be an integer. The only disadvantage seems to be that after a number of cycles, non-integer counter values can occur due to cumulative errors when x is a 12-digit number such as π.

9100 STEP-SAVING ROUTINES

M. Claude Cardot of Marcoussis, France, sent these two step-saving sequences for the 9100A/B. They are adaptable for use with the Model 10 with the 11210A Mathematics Block.

The first sequence will calculate $(1-x^2)^{1/2}$ in three steps, not affecting the contents of the Y register, where $|x| < 1$. This sequence, starting with x in the X register, is

arc
cos x
sin x

which gives the answer in the X register.

steps, giving the result in the Y register and a in the X register. This is valid where $|a| > |x|$ and a^2 is within the dynamic range of the calculator. Starting with x in the Y register and a in the X register, the sequence is

DIV
XEY
arc
sin x
cos x
XEY
X

SAVING A REGISTER WHEN CUMULATING UNORDERED DATA IN 9100A/B

This programming tip was 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 in Challenge, California.

Conventionally, temporary storage for either the account number or the value to be cumulated is necessary when unordered values are cumulated into several numbered sums or accounts with a series of y ⇌ ( ) operations. Storage for neither is necessary when the proper cumulation is brought to the operating registers by decrementing the account number by 1.01 instead of 1. The test to select the proper cumulation is "If 1.01 > y," with y containing the remainder of the account number. The system is normalized for the next entry by subtracting (1-(.01 x (the total number of cumulations))) from the balance of the account number remaining in y, and decrementing the remainder by .01 for each additional y ⇌ ( ) cycle until the "If 1.01 > y" test is passed. Few, if any, additional program steps are required to save a register this way. If there are 10 or fewer cumulations, .1 can be substituted for .01 wherever it occurs in the foregoing; but other methods may be more efficient in these cases.

are cumulated into 12 numbered accounts stored in registers 4 through f. For each value cumulated, the user enters the value to be cumulated in the Y register and the account number in the X register, then presses CONTINUE. The value in a desired account is displayed at any time by recalling its corresponding storage register.

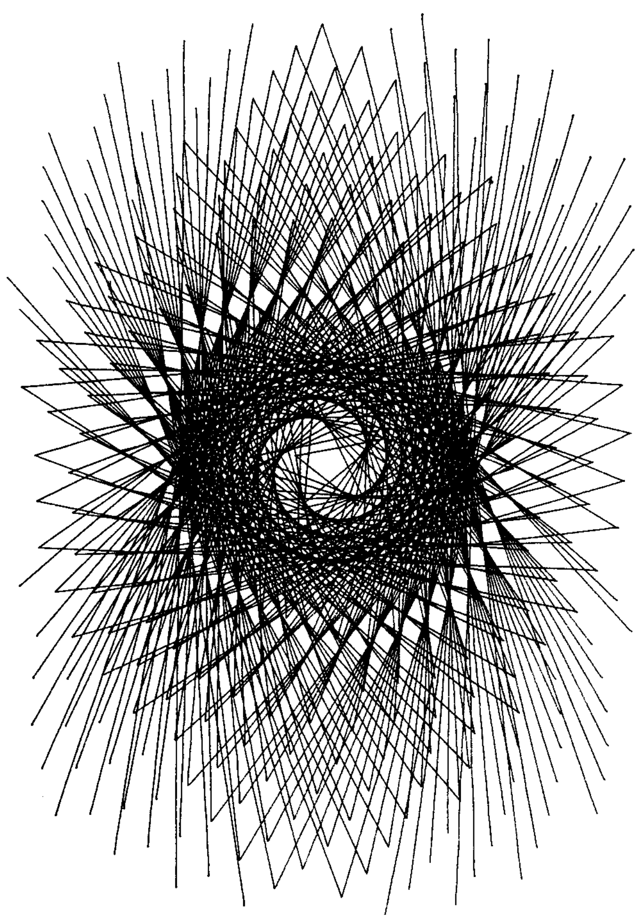
Program Listing

Step	Key	Code	Step	Key	Code
00	UP	27	20	7	07
01	1	01	21	YE	24
02	.	21	22	6	06
03	0	00	23	YE	24
04	1	01	24	5	05
05	X>Y	53	25	YE	24
06	2	02	26	4	04
07	a	13	27	GTO	44
08	-	34	28	0	00
09	YE	24	29	5	05
0a	4	04	2a	IFG	43
0b	YE	24	2b	3	03
0c	f	15	2c	d	17
0d	YE	24	2d	YE	24
10	e	12	30	4	04
11	YE	24	31	DN	25
12	d	17	32	+	33
13	YE	24	33	YE	24
14	c	16	34	4	04
15	YE	24	35	.	21
16	b	14	36	8	10
17	YE	24	37	8	10
18	a	13	38	-	34
19	YE	24	39	SFL	54
1a	9	11	3a	GTO	44
1b	YE	24	3b	0	00
1c	8	10	3c	2	02
1d	YE	24	3d	END	46

CALCULATOR ART HONORABLE MENTIONS

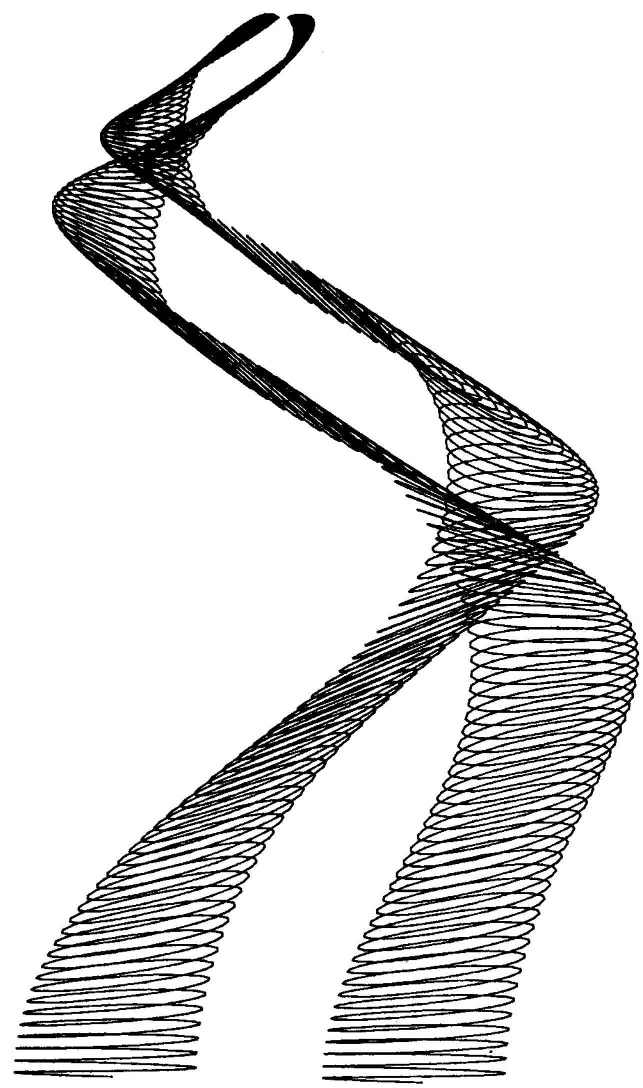
Two honorable mentions are awarded in the 1972 Calculator Art Contest. These are shown below. On the left is Fermat's Spiral, by David G. Armstrong. The other honorable mention goes to Dr. Nikolai Eberhardt for his Helico Daliana I on the right.

See page 9 for more information on the contest results.



FERMAT'S SPIRAL

David G. Armstrong
Sudbury, Massachusetts



HELICO DALIANA I

Dr. Nikolai Eberhardt
Bethlehem, Pennsylvania