HEWLETT-PACKARD

KEYBOARD

VOL. 5 NO. 3

Letters to the Editor

Dear Editor,

I want to refer to program III-11, from the Model 20 Math Pac, which finds the roots of f(x) = 0 in an interval.

Sometimes this program fails to terminate, and goes into an infinite loop. The reason is that epsilon is too small.

Take, for example, the function $x^8 - 5 = 0$, and try to find a root between 1 and 2, with $\epsilon = 1E - 10$.

I suggest the following addition to line 12, in order to overcome this situation:

```
12:
(A+R4)/2→X;IF (X
=A)(X=R4);GTO 17
⊢
```

Sincerely yours,

Ram Dishon
Research Engineer
State of Israel
P.O. Box 7063 Tel Aviv
Israel

Dear Sir:

Quite by accident we found an interesting mode of operation for the 9100A Calculator, which allows execution under "interrupt" control. Our system consists of the 9100A, 9101A Extended Memory, and the IBM I/O Typewriter. With the 9101A OFF, I placed FMT π instructions in strategic locations in the program. During execution, the FMT π instruction hangs up the calculator until a typewriter key is depressed. Then, the calculator will continue until the next FMT π instruction and will wait for the next "interrupt" from the typewriter. Cascaded FMT π instructions require a proportional number of typewriter keys to be depressed before execution continues. We found this mode to be very useful in many situations, however, its full implications have not yet been exploited.

Truly yours,

Isaac Ferber
Naval Underwater Systems Center
New London, Connecticut

Dear Sir:

The method proposed by Mr. P. Wright (*KEYBOARD* Vol. 5, No. 1, p. 21) while being simpler than our method (*KEYBOARD* Vol. 4, No. 2, p. 36) has the unfortunate drawback of affecting the running of the program if either the next instruction or the next two instructions are alphameric. This can be seen with the following simple programs.

Program 1			Program 2		
	00	1		00	1
	1	↑		1	↑
	2	+		2	+
	3	if flag		3	if flag
	4	set flag		4	set flag
	5	stop		5	stop
	6	5		6	4
	7	+		7	5
	8	stop		8	+
				9	stop

In program 1 without setting the flag the y-register contains 7 at the end of the program; using Mr. Wright's method it contains 3, due to instruction 06 being missed. In program 2 the results are even more disastrous; if IF FLAG is pressed manually when the program has stopped at 05 then, when program execution is continued, the next two instructions are taken as an address and the program jumps to address 45.

This is why we proposed our original order -

IF FLAG
STOP
SET FLAG

and the jumping procedure.

Ronald Butler, Ph.D.
Frank Turner
The University of Manchester
Institute of Science and Technology
Manchester M60 1QD England

COVER

The cover photograph is through the courtesy of Boettcher and Company, Fort Collins, Colorado.

ERRATUM

A typographical error appeared in *KEYBOARD* Vol. 5, No. 2. On page 20, the fourth line in the "Summing a Series of Numbers" programming tip should read, "The program sums a series . . ." instead of "The program seems . . .."

CONTEST: HOW DO YOU USE $10^{\pm 99}$?

Someone asked us recently how the smallest and largest available numbers in Hewlett-Packard programmable calculators (10^{-99} and $\geqslant 10^{99}$) are used. How do *you* use these quantities? Write and tell us of all your applications. *KEYBOARD* will award a small prize for the best list of practical uses submitted by anyone not employed by HP. Entries will be accepted if they are received at our Loveland office by December 20, 1973.

TO HP *KEYBOARD* READERS

Once again *KEYBOARD* is proud to publish descriptions of two powerful but economical new calculators--the Model 45 Advanced Scientific Pocket Calculator and the Model 46 Desk-Top Calculator. The article appears on page 12.

Winners of the two branches (U.S.A. and OTHER COUNTRIES) of the HP 9800 System Application Contest are announced in this *KEYBOARD*. See page 18 for information on all entries. The two winning articles appear on pages 3 and 16; additional entries will appear in future issues as time and space permit.

If you have developed a program or a programming technique for any HP calculator which would be useful to other calculator operators, please send it to us for evaluation. Some of these are selected for publication in *KEYBOARD*; some others are added to the Calculator Program Catalog. Program Submittal Forms are included in most program pacs.

A.B.Sperry

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HP Calculators are in Business

Traditionally, Hewlett-Packard has designed and marketed electronic products to solve scientific and technical problems. Starting with electronic measuring instruments, HP has diversified into a number of related fields. Among them are medical instrumentation, analytical products such as gas chromatographs, precision short- and medium-range distance measurement equipment, computers, and electronic calculators. When the first HP calculator with its powerful transcendental function capability but limited memory was introduced, the applications emphasis based on this and HP's previous experience in the scientific and technical field was naturally along the same technical lines.

Modern calculator design techniques have allowed improving both memory and built-in function capability of the newer products. You may have noticed that as Hewlett-Packard introduces its new calculators some of them are designed primarily for dedicated business applications. An increasing amount of both business-oriented hardware and business-oriented software for the general purpose calculators is becoming available. *KEYBOARD* Vol. 4, No. 4 featured the new Model 30 BASIC Calculator with memory up to 8K available to handle complex business as well as scientific problems; a description of an investment analysis program for the Model 30 was published in the same issue. The Model 80 Pocket Calculator with its bond and investment analysis capability was described in Vol. 5, No. 1.

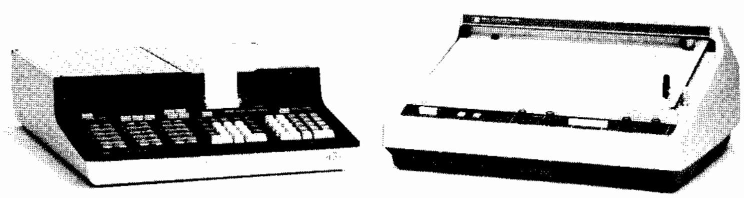
Starting with this *KEYBOARD*, we will include a regular section of business application features for HP calculators, such as the article on real estate multiple regression and the stock market analysis article by Clyde Lee (winner of the U.S.A. branch of the HP 9800 Systems Applications Contest), on the following pages. Additional business-oriented products will be announced in *KEYBOARD* as they become available.

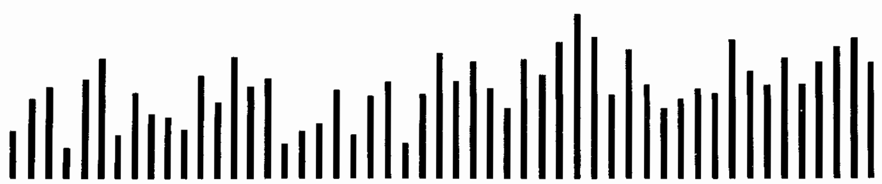
If your primary application is in the scientific or technical areas, you may find the increasing amount of business-oriented information will increase the utility of your calculator to handle more types of problems in your everyday operations. HP's entry into the business calculating area is an added activity to enhance the usefulness of your problem-solving machines; it will not detract from our endeavors to continually broaden the range of scientific and technical problems solved by our calculator products.

For additional information on any calculating applications you presently have or wish to add to your repertoire, please contact your local Hewlett-Packard sales office or describe your needs on the reply card enclosed with this *KEYBOARD.*

STOCK MARKET ANALYSIS SYSTEM

by Clyde Lee





INTRODUCTION

Edwards & Magee (Technical Analysis of Stock Trends, John Magee 1958), define technical analysis as "the science of recording, usually in graphic form, the actual history of trading (price changes, volume of transaction, etc.) in a certain stock or in 'the averages' and then deducting from that pictured history the probable future trend."

Significant advances in this concept have been made through the extensive use of computers but it is apparent that as we attempt to predict "the probable future trend," a significant amount of human "interpretation" is still required to be most successful. The most obvious reason for this certainly must be the failure, to date, to develop a satisfactory mathematical model of the "market" behavior.

J. M. Hurst (The Profit Magic of Stock Transaction Timing, Prentice-Hall, 1970) has made a significant contribution toward the development of such a model with "X MOTIVATION."

In his study of the Dow Jones Industrial Averages (DJIA) from 1921 through 1965 he has found evidence of a "Line Spectral Model" which demonstrates consistent characteristics of definite "line-spacing" and "magnitude-duration" relationships.

For the professional analysts there appears to be only one solution to remain competitive--lease a computer or buy computer time. NOT SO!! Perhaps the best solution to date for extensive analysis lies in the use of modern calculators.

Primary reasons for the above conclusion are:

1. Excellent graphic capability.
2. Extensive storage capability.
3. Ease of interaction with developed programs.
4. Ease of modifications for existing programs and subroutines.
5. Speed of processing.

Item 5 above requires some explanation. Speed in this case does not necessarily refer to "high" speed but rather to the fact that the processing rates of the system fit very well into the rate at which an analyst can evaluate results and make decisions as to what procedure to follow next. The author has had prior experience in working with large-scale third-generation machines in this area and has experienced the dilemma of too much output to properly evaluate the results.

SYSTEM DESCRIPTION

The system to be described was designed for the following hardware:

1. HP 9820A Calculator - Option 1 - Total 429 registers.
2. Read-Only-Memories
   a. Peripheral Control I
   b. Mathematics
   c. Cassette/Special Programs
3. HP 9865A Cassette Memory
4. HP 9862A Calculator Plotter

In any analysis system certain areas are critical in the system design. In this particular type of system the data and storage formats are most critical. The following specifications were initially defined and have been found satisfactory in all applications.

Tape Files: Fixed length - 200 registers
Working Registers: Alpha registers plus R(0) thru R(29)

Data Format: Generally price and volume data are reported on a daily and/or weekly basis for markets of this type. We have chosen to file data in the following form in each data register.

```
H  H  H T L L C C V V V V
11 10 9 8 7 6 5 4 3 2 1 0
```

H = three digits indicating high price for period in units (i.e., dollars, cents, points, etc.).

T = single digit representing either tenths or eighths of a unit as applicable.

L = tenths or eighths difference in low price for period from the high price.

C = tenths or eighths difference in closing price for period from high price.

V = volume data in shares, contracts, etc. for period.

Note that in cases where the price in units exceeds three digits the system operates in a manner such as to truncate the volume (the least significant of all elements) data to three or less digits significance while maintaining proper range.

Generally a system of this type must include the following:

1. Data Entry -- initial entry of parameters related to each stock as well as price/volume data initially and updated.
2. Data Display -- bar-chart and/or price-time display. Volume data in conventional manner also must be displayed.
3. Data Compression (Re-Sampling) -- for long series of data to be handled it is necessary to combine files by resampling data from one unit of time to n units of time.
4. Data Analysis -- the ultimate aim of the system is to provide a capability to "predict" the direction of market movement, consequently the selected analysis techniques are all pointed in this direction. Three types have been programmed.
   a. Spectral (Fourier) Analysis
   b. Exponential Smoothing
   c. Moving Average Analysis

In addition to the HP-supplied special program for named files "N = ?", the following programs (listed by names under which they are stored) are implemented.

PROGRAM DESCRIPTION

DATA -- this program provides the basic data entry function. An initialization section provides for entry of parameters used by this and other programs in the system.

Each of the required entries is prompted by use of alphanumeric display capabilities of the HP 9820A. In many cases a recommended "default" value is indicated. For data entry each item is prompted. Initially the item number is displayed by use of the DSP function. Then the volume "VOL?", "HIGH?", "LOW?", and closing "CLOSE?" prices are prompted and entered. A self-checking feature requires that the low and closing prices be less than or equal to the high price for the period. If this test is not met, reentry of these data is prompted.

To facilitate data entry for prices reported in units and eighths of a unit, the fractional portion is represented as a decimal fraction in which the divisor is 8. (e.g., 23¼ is entered as 23.2, 39¾ is entered as 39.6.)

LABL -- convention dictates that labeling of transaction price data contain key elements. These include:

1. Price Scale
2. Volume Plot and Identification
3. Security/Commodity Identification
4. Time Identification

Of several unique aspects of this system, possibly the most interesting is a calendar routine which plots linear divisions by months and identifies each month with a single letter alphabetic character.

PLOT -- this program simply plots a data file in "bar-chart" form along with applicable transaction volume data. Provisions to plot all or selected portions of the recorded data have been provided. The latter is particularly useful in connection with "updating" of previously plotted charts. Figure 1 is a plot of the Dow Jones Industrial Average (weekly) from July 1970 to February 1973.

SPEC -- the most powerful and certainly the most useful tool in market performances prediction to date has been found to be the Fourier series. In time series where it can be shown that there are definite *cyclic* elements underlying the fundamental behavior pattern of the series (for the stock market refer to Hurst, 1970) spectral

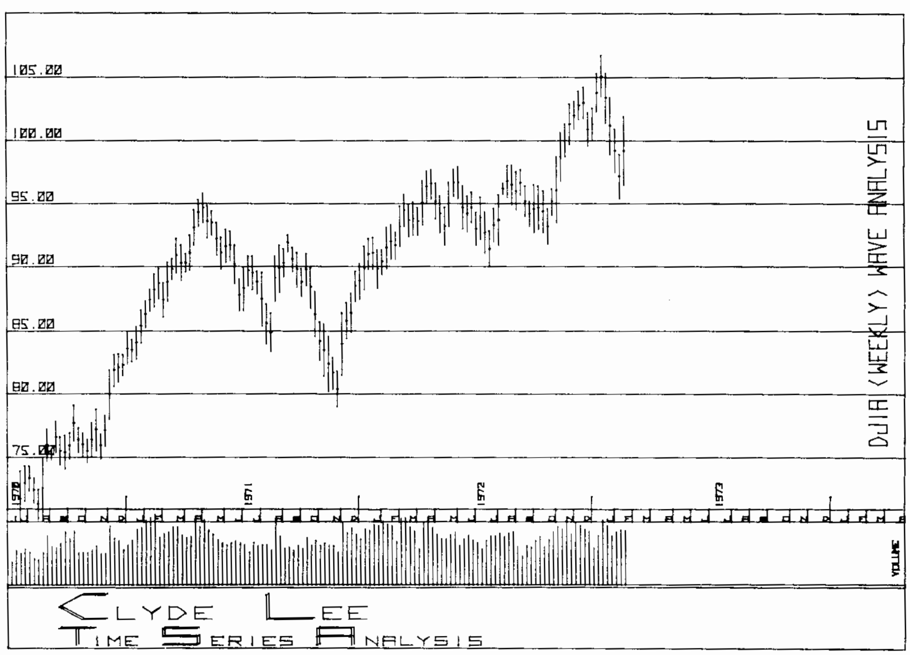


Figure 1

analysis provides a method of determining such *cyclicality*. In cases where the detection of cyclic elements is of prime importance, rather than just definition of the series, the concept of analysis in terms of units of angular frequency has little application. We are well aware of the minor mathematical errors which occur in analyses at frequencies which are not reciprocals of data length divided by integers. We are also aware of the characteristics of the data which make it mandatory to evaluate a time-price series *in terms of any selected period* desired. Consequently "SPEC" has been designed to analyze data in terms of selected PERIODS.

SPEC provides the user with the ability to transform data from the "storage" format to the "working" format (see PRED), if necessary, plot the data as a line function of price versus time and also plot a periodogram of the power-spectral-density function (PSD) between an initial period and a maximum period at a selected increment of time.

The PSD is plotted at an amplitude equivalent to the proper "price" located at the equivalent time index for the analyzed period.

Figure 2 demonstrates the usefulness of this approach in identifying strong cyclic lines in the spectrum.

Data analysis with SPEC requires approximately 10 seconds per spectral line computed and plotted for a data length of 150 points. Since the program is arranged to allow continual updating of the "Initial Period", "Increment", and "Final Period" parameters, proper selection of increment at various portions of the spectrum will greatly reduce the overall time for a complete analysis.

WAVE -- since SPEC only presents graphically the "amplitude" of a particular spectral element, this program provides a display of the cosine wave representing selected spectral lines, and a printer output of the amplitude and "lag" (phase) characteristics of these lines. The program allows for displaying as many elements as required. Each "wave" can be plotted relative to any selected datum.

WAVE and SPEC both provide the capability to subtract a "trend" from the data prior to analysis. This is accomplished by defining the beginning and ending "price" for the trend at the initial and final data point in the series. The trend to be removed is plotted to indicate its relation to the data. Automatic removal (and later reinsertion) of either residual or initial bias (mean) in the data is accomplished.

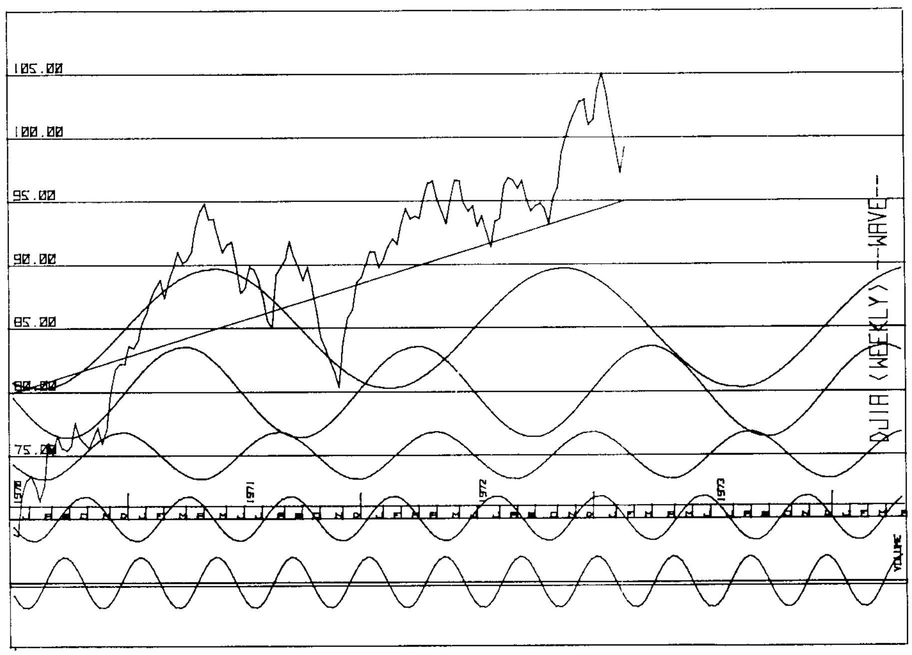


Figure 3

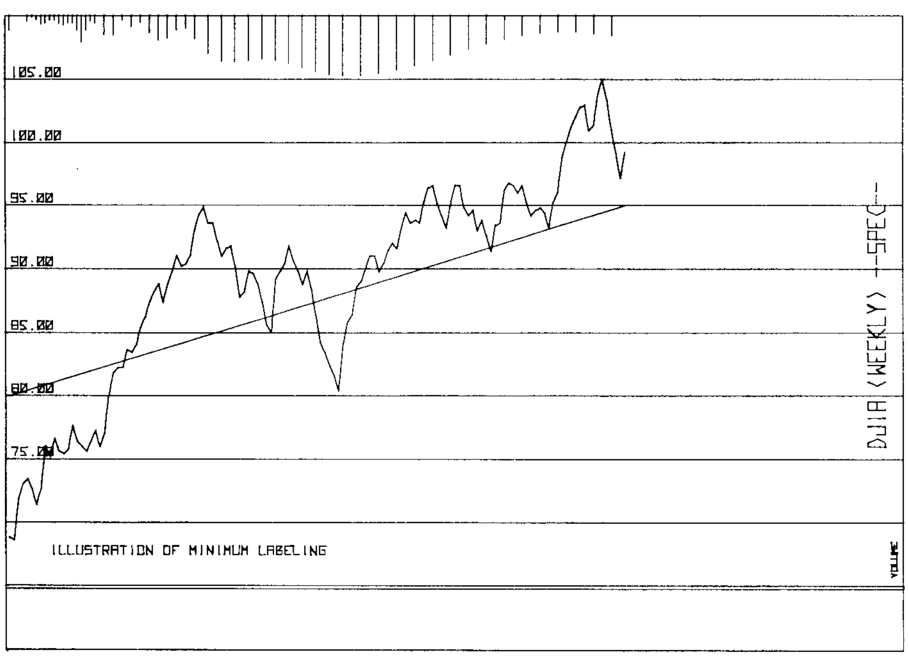


Figure 2

Examination of the phase relationships of these "waves" allows the analyst to select the time points which have the highest probability of prices making significant moves in the selected direction. Such an examination likewise will indicate how well the most recent action of the market fits with respect to prior action.

Figure 3 presents a WAVE analysis displaying the most prominent *cyclic* components pointed out in Figure 2 by use of SPEC.

PRED -- this program is extensive and allows the user to:

1. Convert data from file storage format to working storage format. Since several programs require the storage of intermediate arrays along with the original data, the work format calls for treating each register as though it were three 4-digit registers. The selected original data (high, low or close) is rescaled by a scaling factor determined from the maximum price. This rescaling maintains maximum significance available in four digits. The rescaled original data is stored in the most significant four digits of each applicable register.
2. Store an arbitrary function of arbitrary length in working storage format. This function may include as many fourier elements as required. However, for each component over four included, three data points are lost at the start of the generated time series. Necessary parameters required (maximum price, minimum price, etc.) needed by other programs are entered as prompted.
3. Generate a function as in 2 above and plot but do not store it and do not modify the data in working storage format.
4. Generate a function as in 2 above, plot the function and subtract the generated function from the stored data.
   NOTE: In all the above functions a *trend* (see WAVE) may also be included.
5. Plot the residual developed in 4 above at an arbitrary datum and shift the Y scaling (price) parameters so that this datum is now assigned a value of zero.

Figure 4 illustrates the results of such a "prediction" based on the coefficients determined by use of programs SPEC and WAVE.

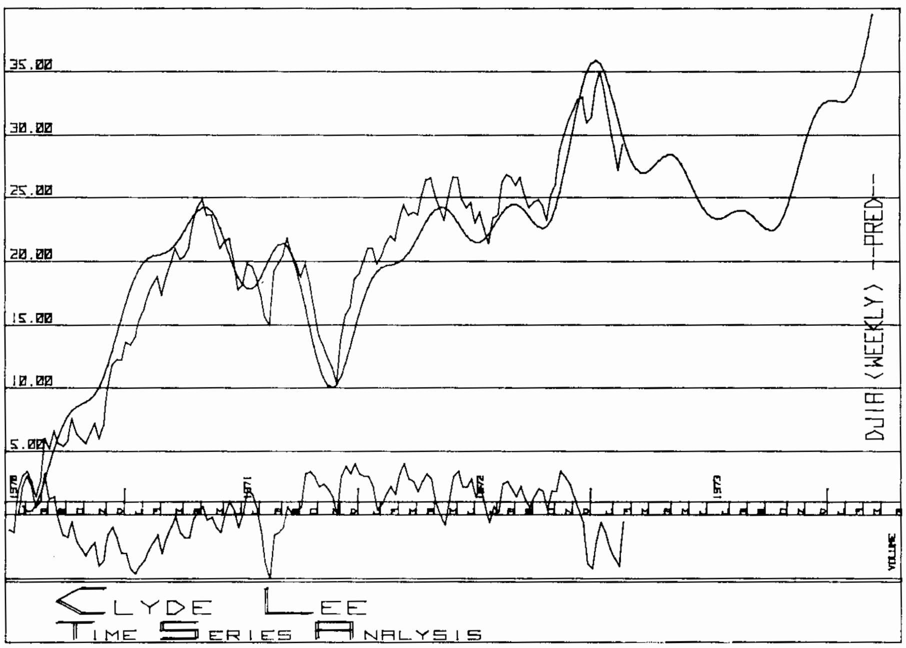


Figure 4

MOVA -- Hurst also called attention to significant applications of the moving average concept which were not widely known. By properly locating the moving average with respect to the data (Hurst's term is "centered") and examining the frequency response of the function, he has shown the output of a moving average operation to be the equivalent of a "zero-phase" low-pass digital filter. Likewise he points out the high-pass characteristics of the "inverse" centered moving average.

MOVA provides the ability to compute *two* "centered moving-averages" of odd length from 1 to n. The output data from such computations are stored as the other two four-digit time series provided for in the "work" storage format.

These two series, along with the selected input data (High, Low or Close) are plotted as a continuous price versus time-function.

Capability is also provided to plot the difference between the two moving averages around some selected datum. This function allows the analyst to effectively perform a "cheap" (in terms of number of computations) band-pass filter function on the input data. By this operation the analyst can compare the "instantaneous" performance of a selected cyclic component to that derived from the Fourier analysis.

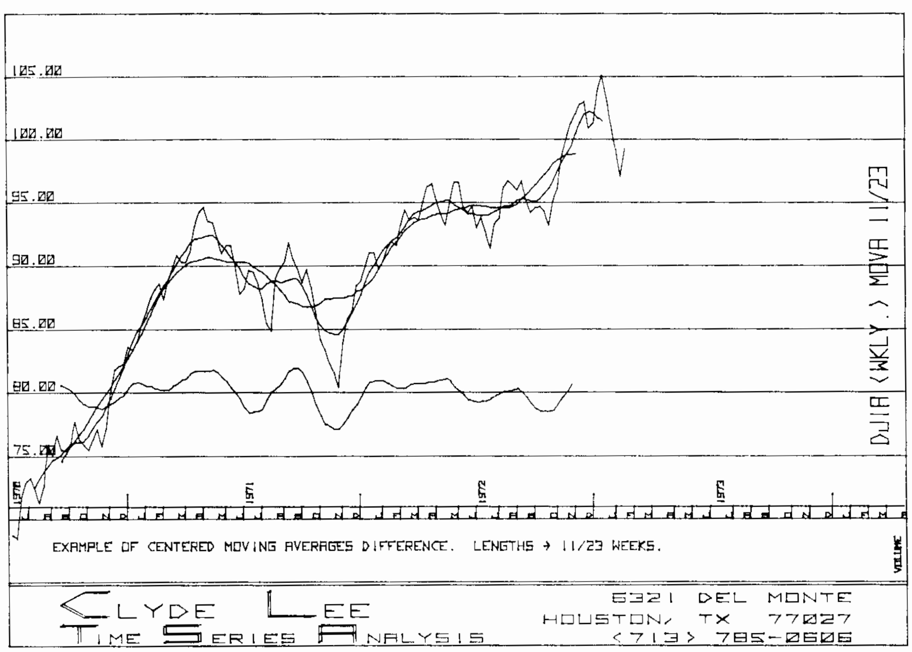


Figure 5

Figure 5 demonstrates these capabilities on the DJIA series for moving averages of *11* and *23* length.

DBLX -- Robt. G. Brown (Smoothing Forecasting and Prediction of Discrete Time Series, Prentice-Hall, 1962) develops the concept of "exponential smoothing" as a method of continuously updating the estimates of proper values of coefficients in "forecast" equations. He develops the mathematics necessary to such operations for various time series models from simple constant models through complex multi-point periodic functions.

DBLX is an implementation of this technique for a linear model in the form $F(t) = C_0 + C_1 t$.

For compatibility with MOVA, this program likewise provides for computation and storage of two different smoothed time series.

The capability is also included to plot the difference of these smoothed series about a selected datum.

Since the estimated coefficients $\widehat{C}_0$ and $\widehat{C}_1$ of the forecast model $E(t) = \widehat{C}_0 + r\widehat{C}_1$ (r = prediction period) may be of importance in determining the specific behavior of the time series at critical "turning points" in the series, an ability to plot the selected coefficient to any desired scale about any selected datum has been implemented.

Figure 6 demonstrates the capabilities of DBLX showing $\widehat{C}_1$ plots along with the difference in the smoothed series. The smoothing length used is the same as in the MOVA example shown in Figure 5.

TPLX -- this program extends the capability of the system to cover a quadratic model of the form:

$$F(t) = C_0 + C_1 t + C_2 t^2 .$$

In addition to the capability to plot the selected coefficients and smoothed series differences as discussed in DBLX, both programs have the ability to plot the "error" function which derives from the difference in the predicted values and the real values.

Initial values for the estimated coefficients may be entered as data or may be estimated from a "least-squares" fit of the first n points of the series.

COMB -- this program allows one to either:

1. Combine data by selecting the high and low values over n periods to effect a compression of data. Volume data is averaged over the selected interval; or
2. Select specific data from one or more files. Data may be selected over any interval m thru n.

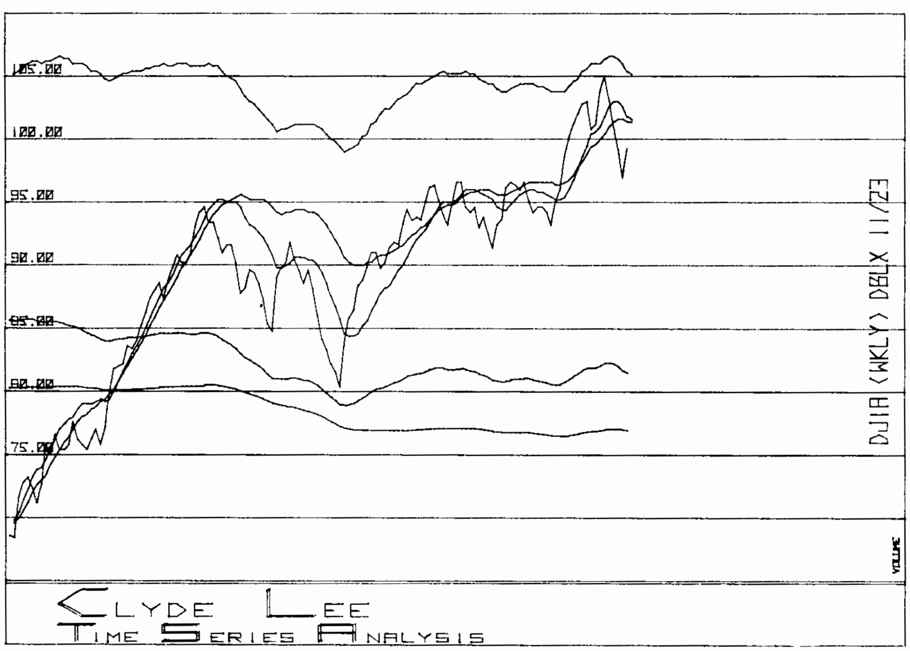


Figure 6

In either case the data is transferred to a new file which includes all proper parameters relating to the new file. Elements of initial and final dates along with price range, etc., are included.

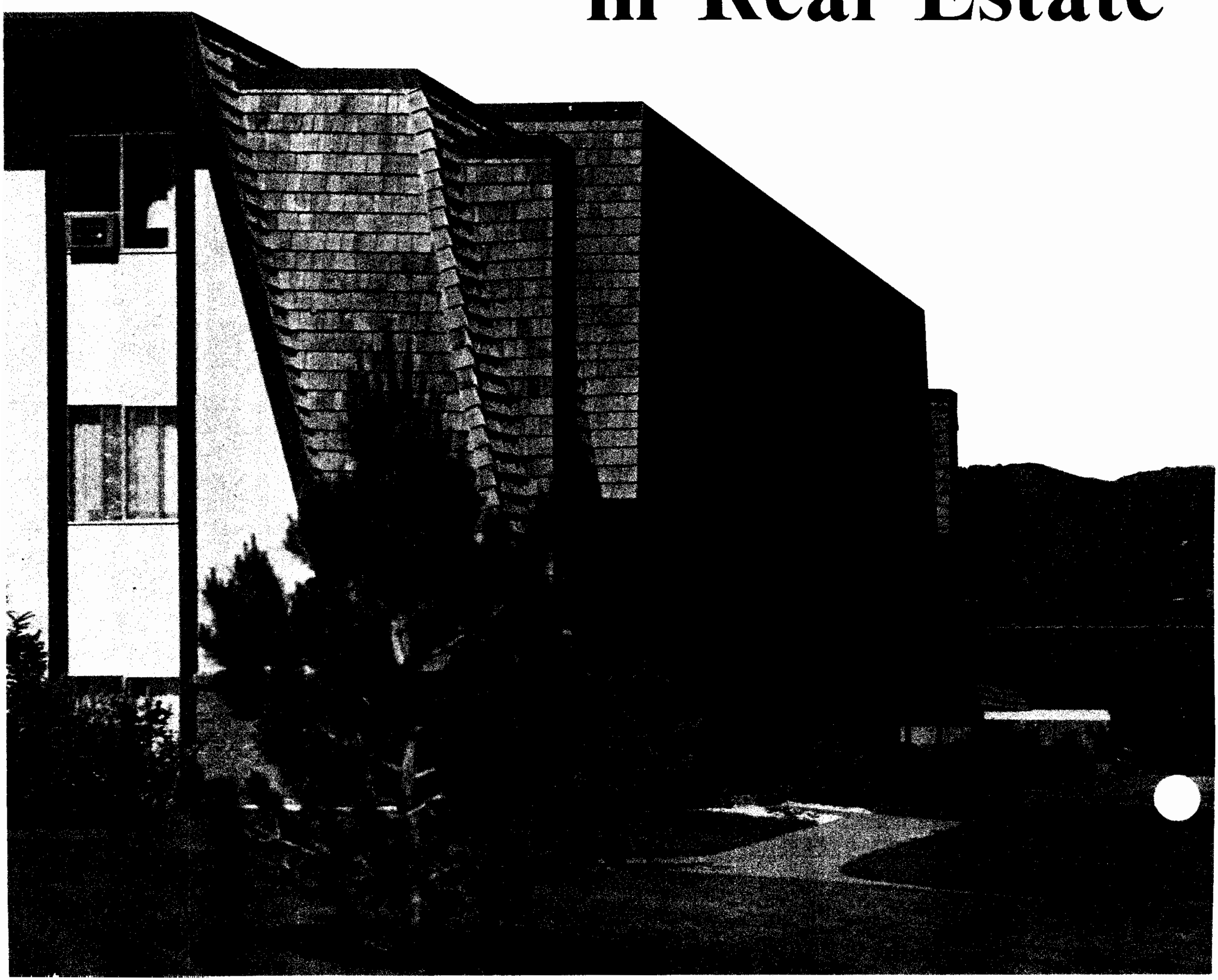
Clyde Lee is the head of a private consulting firm specializing in the application of time-series analysis techniques to exploration seismic and electroencyphlographic data, including all areas of financial management.

The author majored in finance at the University of Georgia prior to his service in the armed forces from 1950 to 1955. He served on various "field parties" for several geophysical exploration companies from 1955 through 1960. In 1961 he joined a consulting firm in Houston so that he could participate in graduate studies at the University of Houston in computer science and higher mathematics.

In 1964 Mr. Lee and the head of the consulting firm organized MAGNETAPE (a seismic data processing firm) in Lafayette, La. This firm eventually became a part of Scientific Resources Corporation and Mr. Lee served as Vice-President of the Petroleum Services Group for SRC. ●

Editor's Note: The application of the Model 9820A described here won the prize in the U.S.A. branch of the *KEYBOARD* 9800 Systems Application Contest. Other entries will be published in future *KEYBOARD* issues. For further information on programs described in this article, contact Mr. Lee at 6321 Del Monte, Houston, Texas, 77027.

Multiple Regression in Real Estate



In Real Estate, there are three generally accepted methods of determining value: the Cost approach, Income approach, and Market approach.

In the Cost approach, property is valued at its replacement cost. The Income approach is the most mathematically sophisticated method of appraisal being used to date. In this approach income and equity investments are compared via the rate of return. The Ellwood tables were written to simplify the mathematics of this approach. Ellwood techniques and cash flow analysis are used extensively to determine value.

The last of these three, and for our purpose here the most important, is the market approach to valuation. This is the method of determining value based on a best guess as to what the actual market value is, and what property will command in the marketplace.

The method most commonly used for this determination is to examine the history of other similar properties and use judgment and experience to place a value on the subject property from these sales. In the terminology of the appraiser these are called "comparable sales."

In a typical appraisal, many comparable sales are examined and three or four are selected as being most representative of the subject property. This selection necessitates a large amount of subjective decision making.

Once three or four suitable comparable sales have been selected, the process of determining value of the subject property proceeds. Value obtained must be derived from characteristics of the subject property which are similar to those of comparable sales. Examples of this would be a similarity of construction and number of rooms. From this information the appraiser uses his best judgment and values the subject property.

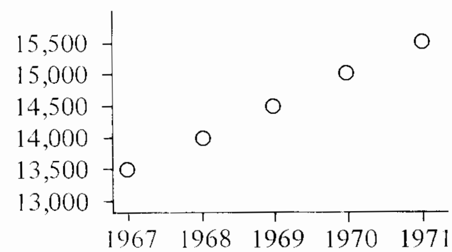
What appraisers need and want, and what we now offer, is a method of reducing subjectivity and increasing objective determinations of factors which affect market value of comparable sales. This method is Multiple Regression.

Multiple Regression is used in Real Estate to examine many comparable sales in an objective manner and arrive at an approximation of market value. Furthermore, this method can provide the appraiser with a positive measure of explained variation between actual sales and the same sales predicted with the derived equation.

To see how Multiple Regression is being used, let's assume that we have a list of five properties which have all been sold in the last 8 years. We will assume these houses are exactly alike except each one sold for a different price in a different year. Looking at the information, we discover that if we arrange sales according to when they were sold, they look like this:

YEAR	SELLING PRICE
1967	$13,500
1968	14,000
1969	14,500
1970	15,000
1971	15,500

If we were to draw this relationship on a graph it would look like this:



From this analysis it is obvious the best fit of a line through the points is a straight line. This means a linear relationship exists between sale price and date of sale. Using regression terms, price, Y, is dependent upon the variable X, called date. A most important result of this equation or relationship is the fact that to predict a sale price, all you need is the year of sale. This is the basis for single linear regression.

When we remove the somewhat naive assumption that all properties are exactly alike except for date of sale, other factors are found to affect the price.

In reality many variables affect market price. The interaction among variables and dependence of price on these variables is Multiple Regression. It is always assumed in this method that dependence is a straight line relationship, i.e., a "linear" Multiple Regression.

In Real Estate, effectiveness in using Multiple Regression is directly related to the user's ability to properly choose his variables. This is where judgment and experience are invaluable and can save many trial and error guesses. Trial and error can be minimized with knowledgeable selection of variables. And just because one set of variables has been found to give very good results in one location does not mean these same variables will work in another. Even within the same town or subdivision, different factors can affect price.

Some of the independent variables being used for analysis for Multiple Regression include:

1. Size of the lot
2. Living area
3. Number of baths
4. Number of bedrooms
5. Number of fireplaces
6. Condition of dwelling
7. Maintenance cost per month
8. Age when sold
9. Date of sale
10. Interest rate on mortgage
11. Garage existence
12. Carport existence
13. Construction method
14. Location factor

HP has a 9830 Multiple Regression software package designed specifically for this application. This program is currently being used by the Society of Real Estate Appraisers to calculate regression equations and to demonstrate this new technique of appraisal to their members. Comparable sale data and resulting equations have been presented at workshops sponsored by the Society and conducted by their experts. Hewlett-Packard was privileged to be a guest at these workshops to demonstrate the HP-80 and Model 9830A Calculators and this program.

MULTIPLE REGRESSION ON THE 9830A

Part No. 09830-73004

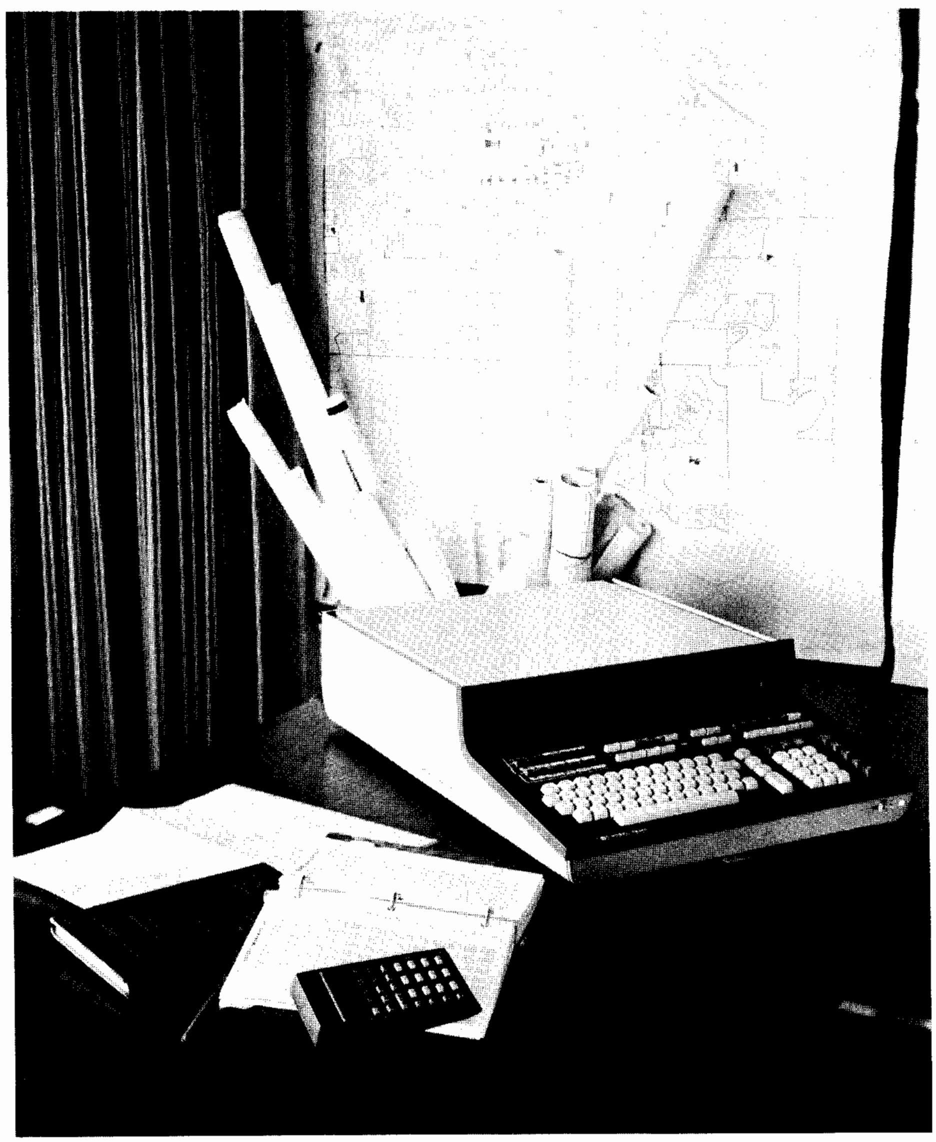
This multiple regression program has been written to handle analysis of up to twelve independent variables. In practice this has been found to be adequate. The number of variables found to influence sale price can usually be reduced to something below twelve, and still yield a very good equation.

Comparable Sales are entered via the "New Cases" key. Once a data base has been established it is preserved on tape cassette by pressing "End of Data." If at a later date one or more comparable sales are to be added to the existing data base, it is very simple. "Add Case to Old Data" key does this, and the "End of Data" key updates the completed data base and stores this on tape. A tape will accept up to 200 comparable sales.

If the user requires a list of comparable sales he has stored, he simply keys "List Data."

Analysis available to the user includes:

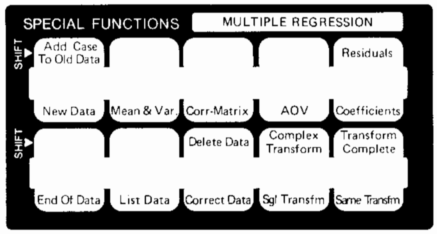
1. Calculation of mean and variance for each of the variables, including dependent.
2. A complete correlation matrix is printed for all variables. This shows the amount of correlation between each of the variables.
3. Complete analysis of variance is available showing sum of squares, mean square, and F ratios. A most important single item, the r^2 coefficient, is also printed. This is called the Multiple Correlation Coefficient, though to be more statistically precise it is the coefficient of multiple determination.
4. Available by a single keystroke are coefficients of the regression equation, variances, and T-values. These coefficients can now be used to determine value of the subject property, with value the unknown dependent variable.
5. A complete tabulation of sale price, calculated price, and difference is printed when "Residuals" key is pressed. This calculated price is what the regression

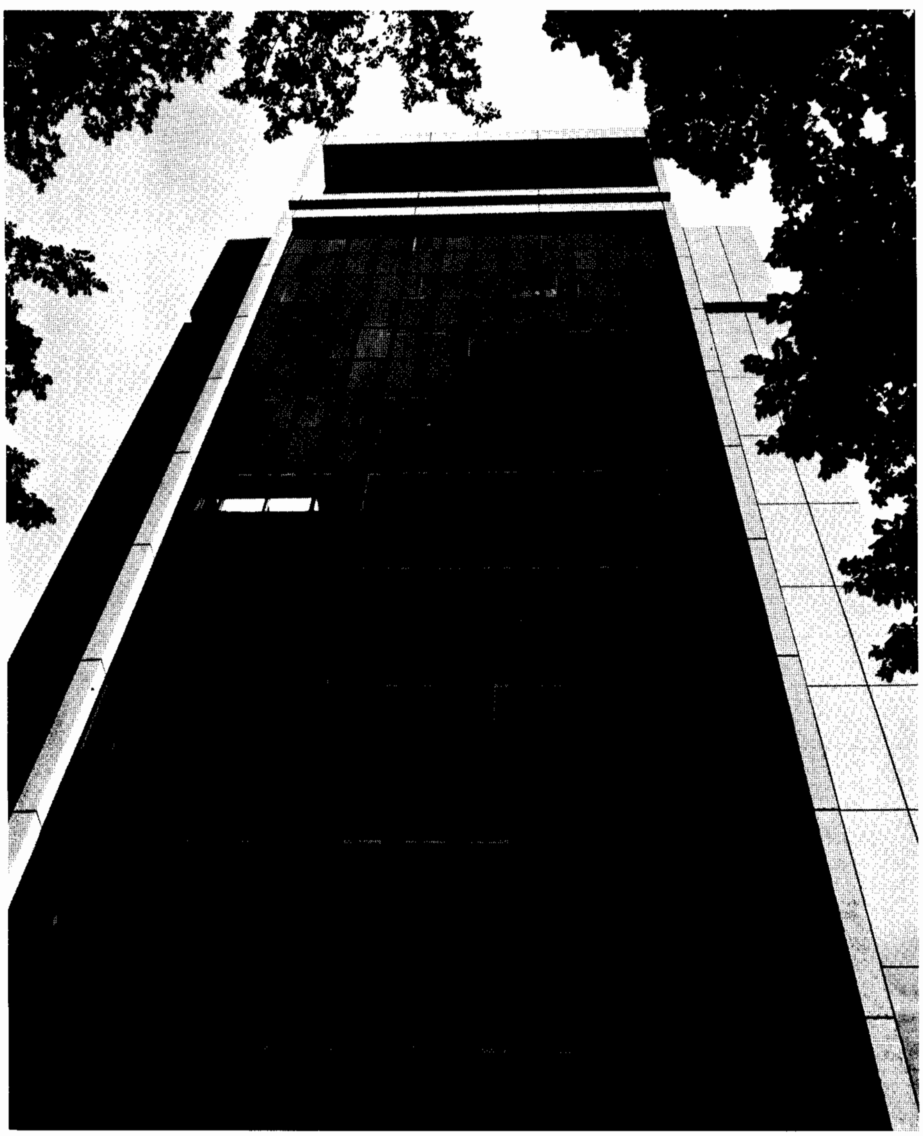


equation will yield when all variables for a particular sale are introduced into the equation. It is important to compare the two prices, sale and calculated, because it gives a way to find those comparable sales which for some reason do not conform to the equation as well as others.

6. Transformations or transgenerations of variables can be done. A table of 15 common transformations is provided, and the user may select the change desired. Four numbers are entered to define each transformation. If only one change is desired, the "Single Transform" key is pressed. For the same change to all variables, "Same" is pressed. When more complex transformations are required the "Complex" key is used.

7. Many times in the analysis of comparable sales, some sales show a very high residual. These can be eliminated from the data base very easily by pressing the "Delete" key.





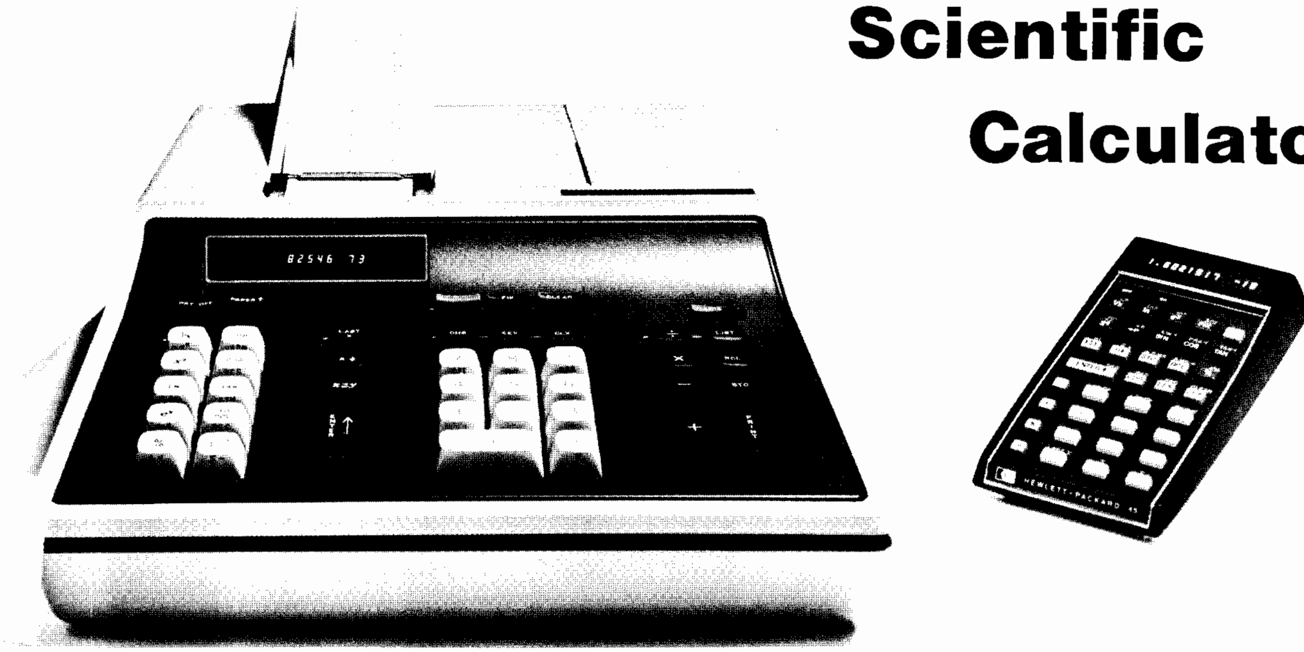
8. Mistakes sometimes are made, and when bad information enters the data base it can often seriously affect answers. Any data set can be easily corrected by pressing the "Correct" key. This automatically updates the complete data set with newly corrected comparable sale information.

Once the user establishes his data base of comparable sales and has calculated his regression equation, he is in a position to very easily determine market value of any new subject property that fits his comparable sale selection criteria. He simply enters new variables into his equation and solves for price.

This method of statistical analysis, while certainly not new, is finding a new application in Real Estate. It has been used only to a limited extent so far, but is one of the fastest growing areas in Real Estate analysis.

HP-45&HP-46

Advanced Scientific Calculators



In May 1973, Hewlett-Packard introduced two new advanced scientific calculators: the HP-45 Pocket Calculator and the HP-46 Desktop Calculator. Both devices provide identical computing capabilities, including the four functions +, -, X, ÷, reciprocals, squares, and square roots of numbers; integer and noninteger powers of integer or noninteger numbers; logarithms to the natural base or base 10 and corresponding antilogs; and trigonometric functions sin, cosine, tangent, and their inverses.

Additionally, these new calculators provide decimal rounding from zero to nine places in both fixed decimal and scientific notation; angular calculations in decimal degrees, grads, or radians; conversion between decimal degrees and degrees, minutes, and seconds; conversion between polar and rectangular values; and conversion between metric and English measures of liters/U.S. gallons, centimeters/inches, and kilograms/pounds.

Some of the extended arithmetic operations performed on both the HP-45 and HP-46 include register arithmetic involving the contents of any of the nine storage registers; vector arithmetic; and recovery of the last argument or entry, allowing checking and correction of entries and calculations.

Statistical functions built into the HP-45 and HP-46 include summation of entry values; sum of the squares of entries; total number of entries; mean and standard deviation; n-factorial; percent; and difference in percent between two values.

HP-45 vs. HP-46

The pocket-sized HP-45 Advanced Scientific Calculator is identical in dimensions and weight to the HP-35 and HP-80 (see *KEYBOARD* Vol. 5, No. 1). It is operated from self-contained rechargeable batteries which give from three to five hours of continuous operation when fully charged. A low-battery indication is given by illumination of the decimal point in all positions of the LED display when the batteries need recharging. When this occurs, a few minutes of operating time remain to allow recording pertinent values before connecting the charger. Operation can be resumed while the battery is recharging. The HP-46 Calculator operates from a power line of either 120 or 240 volts AC (-16% to +5%) with a frequency of 48 to 66 Hz.

The LED display, which is an integral part of the HP-45, can include up to 15 characters: mantissa sign, a 10-digit mantissa, decimal point, exponent sign, and a 2-digit exponent (Fig. 1). An improper operation with the HP-45 causes the display to flash until the user presses CLx.

```
-1.234567809-45
```

Figure 1. LED Display

The printout from the HP-46's built-in impact printer gives a permanent hard-copy record of your calculations. This printout includes easily-understood symbols showing the operations performed, as well as various alpha messages. Some of these messages identify functions. TO POLAR shows conversion to polar values, for example. Other alpha messages may indicate what type of improper operation has been attempted; NOTE 2 results from trying to take the logarithm of zero or a negative number, or to compute a power of a negative number.

An LED display identical to that of the HP-45 is optional on the HP-46. When added, it may be used either in conjunction with or instead of the printer. Data entries and results are shown on the display; the operator can obtain a record of any displayed quantity by pressing the PRINT key. The printer can be switched off by pressing PRT OFF if the operator wishes to use only the display.

```
CLEAR
     45.00000    ↑
                 lg
      1.65321    ◊

     10.00000    ×
      2.14000    +
      6.21500    ÷
      3.14159
                 ×
      9.43849    ◊
```

Figure 2. Sample HP-46 Printout

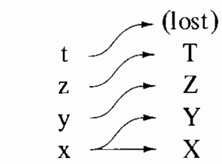
DATA MANIPULATION

The HP-45 and HP-46 have four temporary storage registers labeled X, Y, Z, and T. They are arranged in a 'stack' as shown below.

Contents	Register
t	T
z	Z
y	Y
x	X

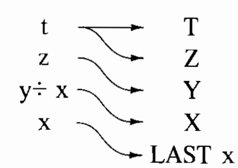
To avoid confusion between the name of a register and its contents, the name is designed by a capital letter, and its contents by a small letter. Thus x, y, z, and t are the contents of registers X, Y, Z, and T.

Every number keyed in goes into X. The contents of X always appear in the display. Pressing ENTER↑ causes this number to be reproduced in Y. At the same time y is transferred to Z, z is transferred to T, and t is lost (see below).

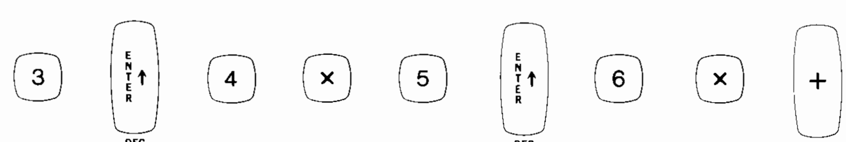


The contents of the stack can be viewed on the HP-45 by successively pressing R↓, or printed out on the HP-46 by pressing ■ STK.

Pressing +, -, ×, or ÷ causes x to operate on y. The stack drops, as shown below; x is transferred to LAST x in register 0, as explained later.



The characteristics of the operating stack and the language used in the HP-45 and HP-46 allow the easy performance of combined operations, such as serial calculations and chain calculations.' As an example, the sequence in Fig. 3, shown with stack listings, will evaluate the expression (3 x 4) + (5 x 6). First press CLEAR.



T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Z	0.00	0.00	0.00	0.00	0.00	12.00	12.00	0.00	0.00
Y	0.00	3.00	3.00	0.00	12.00	5.00	5.00	12.00	0.00
X	3.00	3.00	4.00	12.00	5.00	5.00	6.00	30.00	42.00

Figure 3. Evaluation of (3 x 4) + (5 x 6)

DATA STORAGE REGISTERS

Pressing the addition key adds the contents of X and Y. The stack drops; t is reproduced in T and Z, z transfers to Y, and the sum x + y transfers to X. The number previously contained in X is transferred to LAST x in register 0. It can be recalled with the LAST x key for checking or further use.

In addition to register 0 and the operational stack, there are nine storage registers, numbered 1 through 9. Registers 1 through 4 are always available for data storage. Registers 5 through 8 are available except when calculating with the Σ +, ■ Σ -, and ■ $\bar{x}, s$ keys. Register 9 is available except when trigonometric functions or polar/rectangular conversions are being performed.

Data in the X register (or display) can be stored in a specified location or recalled from it. Arithmetic operations can also be performed on x using the contents of a storage location. The result of the operation can be placed in the storage register or in X.

To store data from X into register 5, press STO 5. This also leaves the data in X. To recall the data later into X, press RCL 5. The same storage and recall procedures apply to the other numbered data registers.

To divide 22 by the contents of register 1, with the result appearing in register 1, press 22 STO ÷ 1. Alternately, if you wanted the result to appear in the display, you would press 22 RCL ÷ 1.

The data in all storage registers can be examined with the HP-45 by pressing RCL 1 RCL 2 . . . RCL 9. The same data can be printed out on the HP-46 by pressing LIST.

GENERAL PURPOSE FUNCTIONS

The value π is a constant provided in the HP-45 and HP-46. This value is placed in the X register by pressing ■ π whenever it is needed in calculations.

The keys 1/x, x^2, ■ $\sqrt{x}$, and ■ n! operate directly on the contents of the X register, and return the result to that register.

Raising a number to a power is performed with the ■ y^x key. With y in the Y register and x in the X register, the power is calculated by pressing ■ y^x.

A percentage of a number is found by keying in the base number, pressing ENTER↑, then keying in the percent rate and pressing %. The percentage difference between two numbers is found by keying in the base number, pressing ENTER↑, keying in the second number, and pressing ■ Δ%.

METRIC/ENGLISH CONVERSIONS

Conversion constants are provided for:

■ C/I (centimeters/inches)

■ K/L (kilograms/pounds)

■ L/G (liters/U.S. gallons)

To use these constants, merely enter the measure to be converted, press ■ and the desired conversion key, followed by the applicable operator: 'X' if converting *to* metric equivalents; '÷' if converting *from* metric equivalents.

STATISTICAL FUNCTIONS

Summation calculations use the Σ+ key to total numbers for use in other calculations. This accumulates data in registers 5 through 8, so it is necessary to first clear these registers by pressing ■ CLR. Since y values as well as x values can be accumulated, this function is also useful in vector arithmetic. In the summation process, the following data are stored:

Register	Data
5	# of entries
6	Σx^2
7	Σx
8	Σy

Pressing RCL Σ+ recalls the data in registers 7 and 8 to X and y for examination; these are printed out in the HP-46. Incorrect entries can be corrected by using ■ Σ- after reentering the incorrect values.

The mean and standard deviation of a group of numbers is calculated after totaling them with the Σ+ key by pressing ■ $\bar{x}, s$.

TRIGONOMETRIC OPERATIONS

The user has a choice of three angular units in making trigonometric calculations with the HP-45 and HP-46: degrees, radians, and grads. Decimal angles can be converted from any angular units to degrees-minutes-seconds in the form dd.mmss by pressing ■ DM←. Similarly, angles in degrees-minutes-seconds can be converted to their decimal equivalents for easy addition or subtraction by pressing ■ DM→. Keys are provided for calculating sine, cosine, tangent, arcsine, arccosine, and arctangent.

VECTOR ARITHMETIC

Polar magnitude and angle can be converted to rectangular coordinates and vice versa using the following two functions: TO POL converts the x coordinate and y coordinate, in X and Y, respectively, to the corresponding magnitude and angle in the designated units.

■ REC converts the polar coordinates of magnitude and angle, in X and Y, respectively, to the corresponding x and y coordinates.

After a vector has been converted to rectangular coordinates, it can be added to or subtracted from another converted vector by using the Σ+ and ■ Σ- keys.

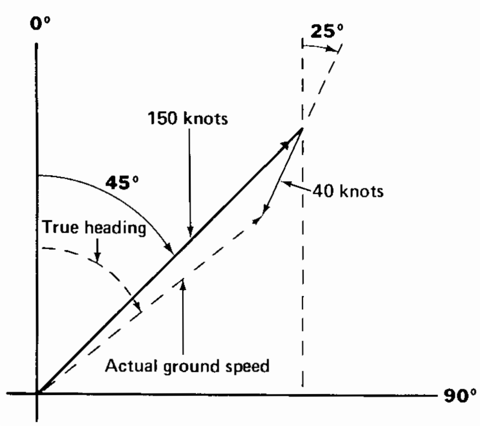
For an aircraft having a true air speed of 150 knots and an estimated heading of 45°, and a head wind of 40 knots and 25°, find the actual ground speed and true heading.

Solution: The true heading and actual ground speed are equal to the difference of the vectors:

45°, 150 knots
25°, 40 knots

The true heading is 51.94°; actual ground speed is 113.24 knots.

EXAMPLE



Press: ■ CLx (CLR)

45 ENTER↑ 150 ■ TO POL (REC) Σ+

25 ENTER↑ 40 ■ TO POL (REC)

■ Σ+ (Σ-)

RCL Σ+ TO POL

```
CLEAR
       45.00    ↑
      150.00
TO  RECT
      106.07    ◇
      106.07    ◇
               Σ+
       25.00    ↑
       40.00
TO  RECT
       16.90    ◇
       36.25    ◇
               Σ-
       89.16   AC◇
       69.81   AC◇
TO  POLAR
       51.94    ◇
      113.24    ◇
```

GENERAL

The dynamic range of the HP-45 and HP-46 is $\pm 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$. The operator selects the format of the printout or display, so that numbers can be rounded anywhere from zero to 9 digits to the right of the decimal place in either decimal or scientific notation. However, the display or printout format does not affect the calculation accuracy, since calculations are all made using scientific notation internally with ten significant digits.

The HP-46 printer uses standard 2¼ inch adding machine paper and standard red and black adding machine ribbons. Printout of positive numbers is in black, negative in red.

For additional information on either the HP-45 or the HP-46, fill out and mail the reply postcard enclosed in this *KEYBOARD*. ●

The Model 20 as an Aid to Wreck Location

by R. J. Walsingham

My interest is in diving and particularly marine archaeology, including modern shipwreck.

Even when the position of a wreck site is accurately known, it is still very difficult to place a diving boat directly over a wreck. To carry this out an accurate position fixing system has to be established, one of the most suitable for small craft operating in coastal waters being the Horizontal Sextant Angle method. This involves measuring, from the boat, the angle subtended by two known landmarks by means of a sextant used on its side. As all angles subtended by a chord in the same segment of a circle are equal, the position of the searching boat must lie on the arc of the circle which contains the observed angle (Figure 1). If at the same time a second observer in the boat measures the angle between another suitable pair of landmarks, thereby providing a second circle, then the boat's position will be at the point of intersection of the arcs of these two circles.

At sea in a small inflatable craft some 12 ft long, being tossed about by the waves, obtaining reasonably accurate sextant angles is difficult enough and it is obviously not practical to plot the arcs from these angles on the chart due to all the geometric construction that this would entail. The solution is to prepare a plotting diagram[1] for the area to be searched by drawing the arcs of circles for the range of angles subtended by the chosen landmarks (Figure 2). This in turn raises more problems. The area of interest may be only 200 yards square and yet the landmarks may be in the order of miles distant. If the plotting diagram is to be of a reasonable size, the scale distance of the landmarks and the centres of the position circles may well be not only off the chart table, but outside the work room. This is where the Model 20 and associated 9862A Plotter came to the rescue.

A program was prepared, based on the co-ordinates of the National Grid, that accepts the limiting values of

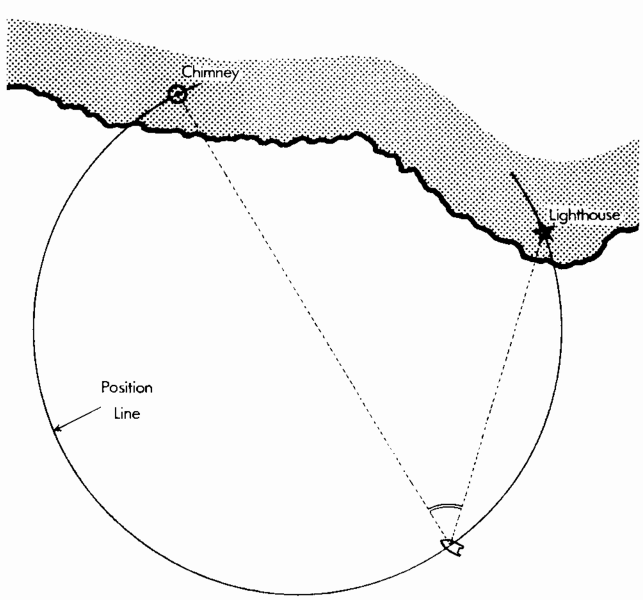


Fig. 1 POSITION LINE BY HORIZONTAL SEXTANT ANGLE

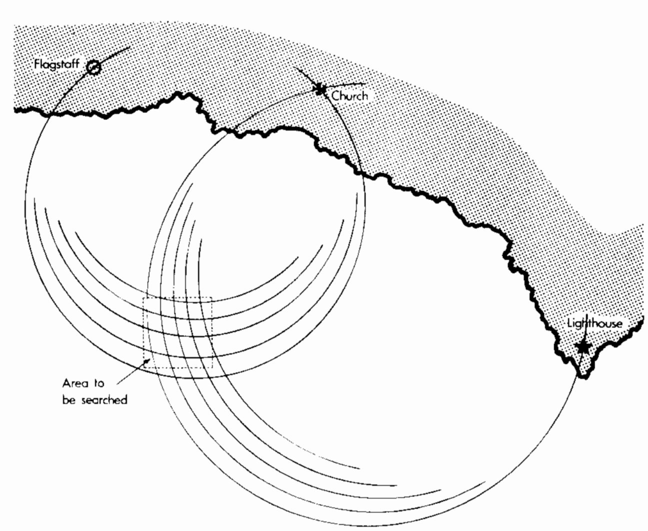


Fig. 2 LATTICES OF CONSTANT SUBTENDED ANGLES

Easting and Northing for the area of plot required, together with the grid references of the landmarks to be used, and produces a complete plotting diagram (Figure 3). The tick marks on the axes relate to the National Grid enabling a grid reference to be obtained for any item located, in the example the marks being at 10 metre intervals. The best known position of the wreck is marked on the diagram by keying in its grid co-ordinates. The whole process is completed in minutes compared with the many hours that it would take to prepare by the customary manual methods. This technique has permitted quick trial plots to be made to compare the manner in which the position circles for various landmarks cut, so as to select the best combination.

It is frequently found that the position of a wreck, or a landmark such as a lighthouse, is quoted in terms of Latitude and Longitude and here the Model 20 is used to perform the otherwise laborious conversion from these geographical co-ordinates to grid Eastings and Northings.[2] Once we had acquired the Model 20 habit further programs came into frequent use dealing with problems such as True North to Grid North corrections and calculation of times and heights of Tides.

Armed with the search diagram, usually plotted directly onto a waterproof plastic drawing material, together with the results of the other necessary navigational calculations, the search team can put to sea. With two observers taking the sextant angles the boat's position may be directly plotted on the diagram by interpolating between the pre-drawn lattice lines of constant subtended angle. With a well practised team fixes may be obtained at a rate approaching two a minute. Detection of a wreck can be by Recording Echo Sounder or Magnetometer.

The plot, providing an accurate record of the ground which the boat and its echo sounder have covered, ensures that no part of the search area is missed. With careful, Model 20 assisted preparation, plus a share of good fortune, we expect to be rewarded by seeing the distinctive trace of a wreck on the echo sounder (Figure 4), the example reproduced being that of the steamship 'Maine' lying in over 100 ft of water.

Editor's Note: The application of the Model 9820A described here won the prize in the other-countries branch of the *KEYBOARD* Systems Application Contest. Other entries will be published in future *KEYBOARD* issues. ■

REFERENCES

1) Admiralty Manual of Hydrographic Surveying, Vol. 1, p. 437-441. Hydrographer of the Navy, 1965.
2) Constants, Formulae and Methods Used in Transverse Mercator Projection, p. 12-16. H.M.S.O., 1950.

Richard J. Walsingham is a Research Engineer with Thorn Lighting Limited, Leicester, England. Interests are underwater exploration, photography and the theatre. He is also a Sub-Lieutenant in the Royal Naval Reserve.

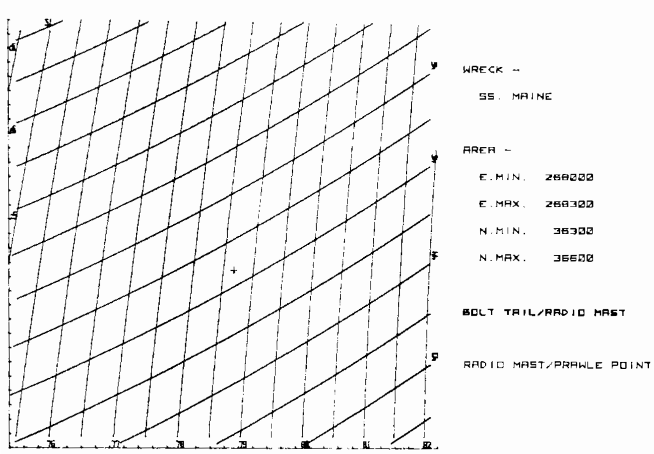


Fig. 3 LATTICES PLOTTED FOR AREA OF WRECK OF 'S.S. MAINE'

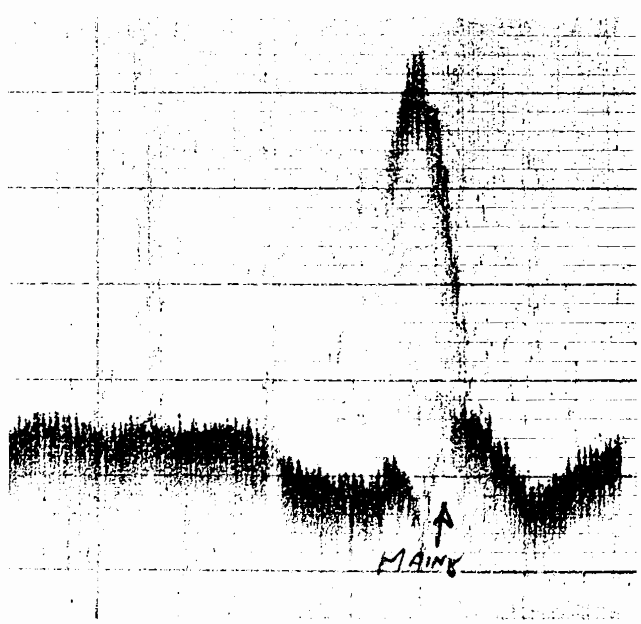


Fig. 4 ECHO SOUNDING OF 'S.S. MAINE'

Application Contest Winners

The *KEYBOARD* contest for unusual applications of HP Series 9800 Calculator systems was an unusual event in itself for several reasons. First, this was the first contest of its type for 9800 calculators, and probably the first for any programmable calculators. Second, it was world-wide, with a branch for U.S.A. contestants and another for those in all other countries. Third, although entries were submitted by only nine contestants in five countries, most of them were sufficiently well prepared that selecting winners was a difficult task.

We extend our thanks to all contestants, and wish that each one could have been a winner.

Clyde Lee of Houston, Texas, won a Hewlett-Packard Model 45 Advanced Scientific Calculator in the U.S.A. branch with his application, "Stock Market Analysis System" described in the article on page 3. Mr. Lee is the head of a private consulting firm specializing in the application of time series techniques to exploration seismic and electroencyphlographic data.

In the other-countries branch of the contest, Richard J. Walsingham of Leicester, England, won his choice of a plug-in read-only-memory or a Model 45 Calculator with his entry "The Model 20 as an Aid to Wreck Location." This article appears on page 16. Mr. Walsingham is a research engineer with Thorn Lighting Limited, Leicester.

All of the runner-up contest entries for both contest branches are abstracted below.

U.S.A. BRANCH

Title: HP 9810A Takes Over Swim Meet Officiating
Author: Robert J. Deffeyes, Arlington, Texas
Equipment: 9810A, 2036 Steps, 111 Registers, Printer, Printer Alpha ROM.
Description: This program is used to keep scores at swimming meets or similar competitive events. Results are printed out. Up to 80 contestants per event and 14 teams can be accommodated.

Title: A Teaching Program on Counter-Current Distribution
Author: George Houghton, Cornell University, Ithaca, New York
Equipment: Basic 9820A, Peripheral Control I ROM, 9862A, 9865A.
Description: This program simulates chromatographic separation methods. A counter-current method is used because it consists of discrete steps. Results of separation steps are plotted to help the student understand the separation process.

Title: Marine Corps Manpower Historical Summary
Authors: Major John D. Lanigan and L/Cpl Kent Kreamer, U.S. Marine Corps, Washington, D.C.
Equipment: 9820A, 429 Registers, Definable, Mathematics, and Peripheral Control 1 ROMs, 9861A, 9862A .
Description: This system of programs is used to measure the results of USMC manpower management actions including structure space allocation and classification of Marines. Twelve months of data can be typed and plotted as output.

Title: Program for Information Retrieval from the Cassette Memory
Author: Dr. Rodes Trautman, U.S. Department of Agriculture, Greenport, New York
Equipment: 9810A, 2036 Steps, 111 Registers, Printer, Mathematics and Printer Alpha ROMs, 9865A .
Description: This program provides a means for simulating certain information retrieval systems, as well as for retrieving information from an index file representing any source group of data. Up to 3000 file items on a tape can be retrieved, each item having up to seven subject descriptors.

OTHER COUNTRIES BRANCH

Title: Investment Criteria
Author: Ignacio Pomar Gomã, Madrid, Spain
Equipment: Basic 9810A, Printer, Printer Alpha ROM .
Description: This program calculates for a given initial investment the "internal rate of return" for successive approximations, and the present value, the increased value, the cost-benefit relation, and the payoff period for each rate of discount desired.

Title: Correlation Program for the HP-20
Author: Dr. John F. C. McLachlan, The Donwood Institute, Toronto, Ontario, Canada
Equipment: Basic 9820A.
Description: This program computes Pearson product-moment correlations among up to 10 variables. Statistics printed out include number of observations, means, standard deviations, variances, and correlations with the remaining variables.

Title: The Number π Determined by Monte Carlo Methods
Author: Dr. Kurt Tanner, Gymnasium, Immensee, Switzerland
Equipment: Basic 9810A, Printer, Mathematics ROM .
Description: This program calculates the approximate value of π using 1) the Buffon needle problem, 2) Number theory, and 3) Area of a circle.

Ge(Li) GAMMA SPECTRUM PROGRAM FOR ENVIRONMENTAL SAMPLE ANALYSIS

by R. E. Wood, Ph. D.

ABSTRACT

A program named CETUS has been written for a desk-top calculator interfaced to a multi-channel pulse height analyzer used in a radioecology project. The spectrum is scanned for photopeaks and the outputs include picocuries per unit volume with the associated errors. Provision is also made for charcoal air filter analysis for I^{131} activity in picocuries per unit volume of air.

Cetus is a program useful for data analysis of Ge(Li) detector spectra -- in particular, spectra taken of low-level samples collected in the course of performing an environmental impact study of the Barnwell Nuclear Fuel Plant for Allied-Gulf Nuclear Services. The program is written for a Hewlett-Packard 9810A Calculator equipped with 2036 total program steps, 111 total data registers, printer, mark-sense card reader, and Mathematics, Printer Alpha, and Peripheral Control function blocks. The calculator is interfaced to a Nuclear Data 2200 pulse height analyzer through an Applied Physical Technology 2298 data transfer unit.

The value in the program is that it effectively interfaces the operator into the data analysis process where he may make decisions regarding how the analysis is progressing. Many instructions and labels are provided by the program to remind the operator of the procedures. Very few key strokes are required to analyze a spectrum having relatively complex problems. A seasoned operator should be able to handle a 2000 channel spectrum with 50 peaks in 20 minutes if he knows what he is looking for. (The program can scan at the rate of about 10 channels per second.) Peaks may be viewed on the Scanmaster and the program sequence interrupted at any time during an analysis. The program may be restarted quite simply at any channel number in the MCA memory. Since the entire program is stored in the machine, any part is available without having to reload. It must be emphasized that no capability is provided for spectrum stripping.

The opinion of this laboratory is that proper use of this program yields accuracy as good as that obtained with hand calculations with considerable savings in time.

The heart of the program is the peak detector. The data is scanned sequentially from low channel numbers to high channel numbers for three consecutive points whose average value is s standard deviations above the average (denoted by $\bar{N}_C$) of the three consecutive points immediately preceding the test area. Here s is the sensitivity of the peak detector which is entered when the program is run. This procedure requires six memory locations for storage of the points to be compared and for use if a peak is detected. If no peak is present, these data points shift through storage one increment, the next consecutive point is read in, the channel counter is advanced, and the test reapplied.

If a peak is found, consecutive data points are stored until one is found whose magnitude is less than $(\bar{N}_C + s\sqrt{\bar{N}_C})$; it is called the last point in the peak and the next three points are stored to serve as continuum for the high-energy side of the peak. Up to thirty-three storage registers may be used to store the peak and two blocks of three channels for continuum calculation. This means the program will handle peaks as wide as twenty-seven channels. If the last point has not been found after twenty-seven have been transferred, the twenty-seventh

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

point is declared the last one and the calculation continues. This prevents absorption edges and backscatter peaks from ruining a scan. If one of the high-energy continuum data points exceeds $(\bar{N}_C + s\sqrt{\bar{N}_C})$, "B.G.?" is printed on the output to call attention to the fact that the normally monotonic decreasing continuum in low-level counting spectra is not present. This may be due to the presence of a nearby peak, poor statistics, or some other cause. The operator must decide if the program has treated the peak properly. At this point the calculator has a photopeak and three channels on each side in storage.

Location of the peak position is accomplished in one of two ways. Depending on which form of the program is used, either a least squares fit to a gaussian or the algebraic centroid is determined. For the gaussian determination, a straight line is fitted to the continuum as it is determined by the two sets of three channels stored at either side of the peak; this straight line is then subtracted from the stored photopeak channel by channel. The gaussian is then linearized,[1] and a least squares fit to a straight line[2] is performed with the peak position and full width at half-maximum as outputs. For narrow (i.e., four or five channels wide) photopeaks with poor statistics, which are characteristic of many peaks found in environmental gamma spectra, this procedure, by its nature, diverges in about 20% of the cases. The more reliable approach is to leave the continuum present and find the algebraic centroid of the stored photopeak excluding the six continuum channels. If the *i*th data point is N_i, the centroid, C, is given by

$$C = \sum_i iN_i / \sum N_i . \qquad (1)$$

The peak position and the number of channels used in its determination is the output. The full width at half-maximum or number of channels used is a clue to the presence of doublets or false peaks due to poor statistics or a continuum with a positive slope.

An option in the program allows a branch to an energy versus channel number calibration. When this option is exercised, the calculator displays the peak characteristics without printing them. If the operator chooses to use the peak in the calibration, the premarked card containing the energy is passed through the card reader which initiates a printout of the energy-channel number pair, inclusion of the pair in a cubic regression,[3] and continuation of the search for additional peaks. The operator may choose to ignore the peak and search further. When the last peak to be included is considered, the operator so indicates and the regression is completed with four a_i's as outputs where the energy E is determined from the channel C by

$$E = \sum_{i=0}^{3} a_i C^i . \qquad (2)$$

This procedure normally gives 300 eV accuracy for the calibration using 780 eV per channel and either the gaussian or algebraic centroid peak positions. This is providing no biased amplifier is in the linear signal circuitry. The four a_i's are stored in the calculator and may be put on a magnetic card for later use by recording the memory. At this point any channel number may be entered from the keyboard to determine the corresponding energy. This provides an opportunity to verify the fit.

If the a_i's are properly stored and the energy calibration branch is not taken, the energy of the centroid found by the peak detector is computed and is an output. The number of counts in the photopeak is computed from the raw data stored in the calculator and makes no use of the gaussian fit or peak position. The six continuum data points are added to give ΣN_C, and the points in the peak are added to give ΣN. If k is the number of points in the peak, the intensity I is given by

$$I = \Sigma N - (k/6)\Sigma N_C , \qquad (3)$$

and the statistical error ΔI is given by

$$\Delta I = \sqrt{\Sigma N + (k/6)^2 \Sigma N_C} . \qquad (4)$$

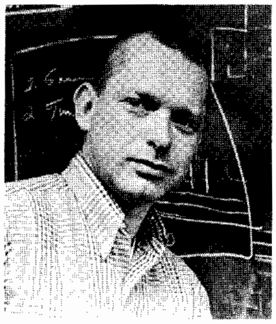
I and ΔI are outputs.

The calculator now takes the last three continuum points and shifts them to the place of the first three in preparation for further search. This allows accurate analysis of peaks with only four continuum data points between them.

At this point the calculator stops and the operator decides from the energy either to ignore the peak and search for the next one or to analyze further. In the latter case the background peak counting rate and its associated error at this energy, which have been determined prior to the analysis, are passed through the card reader and stored. A second card which contains the limits of sensitivity at this energy for a 1000 minute counting time and a number containing the photopeak efficiency, gamma fraction for the isotope, and a conversion factor is entered. The program contains a constant representing the fractional error in the photopeak efficiency; no account is taken of decay scheme errors. The counting time and sample volume are read into the calculator during the first exchanges with the multichannel analyzer. The activity, its errors, and the limits of sensitivity for the measurement are all output in pCi/vol. Next the peak detector begins searching for another peak.

When charcoal air filters are counted for I^{131}, the program can find the peak and print out the centroid, number of channels in the peak, energy, intensity, and error in the intensity as for a normal spectrum. However, when the calculator stops, the operator may branch to a subroutine which uses the counting time, the collection time, the elapsed time since the sample was collected, and the pump speed to compute the I^{131} activity and associated error in pCi/m^3, which are outputs.

Additional options are provided in the program.



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Dr. Wood is a member of the American Physical Society, American Association of Physics Teachers, American Association of University Professors, and American Association for the Advancement of Science. He also belongs to Sigma Xi and Sigma Pi Sigma honorary societies.

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4. Supported in part by Allied-Gulf Nuclear Services and an NIH Biomedical Institutional Grant to Emory University. I thank Dr. John M. Palms for assistance with the documentation and Ms. Betsy K. Tanner for verifying the program.

PROGRAMMING TIPS

CLEARING MODEL 10 DATA REGISTERS

Our thanks go to John A. Beaujean, Continental Can Company, Augusta, Georgia, U.S.A., for this programming tip.

The step sequences shown below will clear the Model 10 data registers for the basic machine or with Option 001. Actually this would be the first section of a larger program which requires cleared registers before starting entries, summations, etc. The remainder of the program would start at Step 0015 (0016 for the Option 001 illustration), but a digit could not be used there. The undesirable termination of program execution by a status condition is avoided.

Editor's Note: Dr. Rudolf H. Eisenhardt of the University of Pennsylvania, Philadelphia, Pa., is also credited with a similar programming tip which he submitted some time ago. It was not published at the time due to space limitations.

```
 THIS PROGRAM
  CLEARS ALL
  REGISTERS
  INCLUDING
A, B, X, Y, + Z.


0000--CLR---20
0001-- 4 ---04
0002-- 8 ---10
0003--XTO---23
0004-- + ---33
0005-- α ---13
0006--YTO---40
0007--IND---31
0008-- α ---13
0009-- α ---13
0010--X>Y---53
0011--CHS---32
0012-- 1 ---01
0013--GTO---44
0014-- 3 ---03
0015--STP---41
```

```
 THIS PROGRAM
  CLEARS ALL
  REGISTERS
  INCLUDING
A, B, X, Y, + Z.

 (OPTION 001)

0000--CLR---20
0001-- 1 ---01
0002-- 0 ---00
0003-- 8 ---10
0004--XTO---23
0005-- + ---33
0006-- α ---13
0007--YTO---40
0008--IND---31
0009-- α ---13
0010-- α ---13
0011--X>Y---53
0012--CHS---32
0013-- 1 ---01
0014--GTO---44
0015-- 4 ---04
0016--STP---41
```

PROGRAMMING TIPS (continued)

ECONOMICAL "IF Y = 0" TEST - MODEL 10

This programming tip was submitted by Professor L. Glasser, Chemistry Department, Rhodes University, Grahamstown, South Africa.

The test "if y = 0" may be economically applied on the Model 10 Calculator by adding the contests of x and y-registers into the y-register, and testing the resulting x and y-register contents for quality.

Thus, with y containing the quality to be tested, and any quantity to be operated on in x, include in the program:

```
-- + ---33
--X=Y---50
-- X ---36
-- X ---36
-- X ---36
-- X ---36
```

If y = 0, then the equality will be satisfied, otherwise not.

The same technique will suffice to provide "if y > 0" and "if y < 0", tests with the "x = y" key being substituted by the "x < y" and "x > y" keys, respectively. These operate correctly whatever the x-register contents, except where the inequality between x and y is large enough so that one of the numbers is lost by rounding. The test will generally work for magnitude differences up to 10^9.

TRANSFERRING 9820A PROGRAM LINES

This programming tip for transferring entire program lines in Model 20 programs was submitted by Professor Anthony F. Gangi, Professor of Geophysics, Texas A&M University, College Station, Texas, U.S.A.

An important operation in editing programs in the Hewlett-Packard 9820A Programmable Calculator is not specified in any of the operating manuals. This is the operation of moving lines from one part of the program to another without rewriting them. If lines are long or a large number of lines are to be shuffled, it is time consuming (and error producing) to rewrite the lines to insert them in the proper place.

It has been found that it is possible to reshuffle lines on the HP 9820 without rekeying the lines. This is performed in the following way: Consider the simple program shown on the listing; assume we wish to take line 4 and insert it in front of line 1 of the program; that is, we wish to make line 4 into line 1, line 1 into line 2, etc. without rekeying line 4 into the calculator. The operation GTO 4 is executed from the keyboard and the line is *recalled* to the display. The *back* key is pressed once to eliminate the *end of line* (⊢) symbol and the instructions ;GTO 1 are keyed into the machine. At this point the display is:

4: 4 → R4; GTO 1

This line is then executed by pressing the *execute* key and then the *back* key; the display then becomes

4 → R4; GTO 1

but now the program line counter is at line 1. Now the *back* key is pressed three times to eliminate the symbols (; GTO 1) and then *insert* and *store* keys are pressed in succession.

If the program is listed now (after *end* and *execute* are pressed) the program will be modified as shown. It can be seen that line 4 has been inserted in front of the original line 1 which has now become line 2.

Some precautions must be observed in transferring complex lines. For example, when a line contains a JUMP statement, replace it with DISPLAY until the line is transferred. Lines containing IF statements may be transferred using this technique by either satisfying the IF conditions before the line is transferred or by inserting the line readdressing command preceding the first IF statement, then deleting it after execution.

NORMAL MODE

```
ORIGINAL
PROGRAM

0:
0→R0⊢
1:
1→R1⊢
2:
2→R2⊢
3:
3→R3⊢
4:
4→R4⊢
5:
5→R5⊢
6:
END ⊢
R417
```

TRACE MODE
RECALL LINE 4

```
GTO 4⊢
4:
4→R4⊢
```

MODIFY LINE 4
AND EXECUTE

```
4→R4;GTO 1⊢
            4.00
```

PRESS BACK (3 TIMES)
PRESS INSERT STORE

```
1:
4→R4⊢
```

```
MODIFIED
PROGRAM

0:
0→R0⊢
1:
4→R4⊢
2:
1→R1⊢
3:
2→R2⊢
4:
3→R3⊢
5:
4→R4⊢
6:
5→R5⊢
7:
END ⊢
R416
```