HEWLETT-PACKARD

KEYBOARD

VOL. 7 NO. 3

HVAC Made Easier

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APPLICATIONS INFORMATION
FOR HEWLETT-PACKARD CALCULATORS
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COVER

Wingate personnel are shown working on the increasingly complicated job of designing and installing heating, air conditioning and ventilating equipment. Like most companies, they are looking for ways to uncomplicate the job and have chosen a 9830 System to help them toward that end.

OVERVIEW

In this issue we have articles geographically ranging from Japan to Romania, from integrated circuit chips to mandolins in subject matter. This broad spectrum clearly demonstrates the versatility of HP calculators, which perhaps will give you added insight on new ways your calculator can be used, and gives us a better chance of reaching more of our audience, which is as versatile as are our machines and their applications.

From Romania comes an article on integrated circuit design using the LAYOUT-3 programs developed by and used at the R&D Center for Electronic Components ICCE in Bucharest. The importance of IC's is still growing, as evidenced by their increasing usage in new products.

Another important product these days is fertilizer. In 1974, the year most Americans finally came to realize raw materials (and thus finished goods) were not limitless, there was much concern and speculation about a fertilizer shortage. Ken W. Lessey's article on the Reichhold Chemical, Inc. operation is an excellent example of how one company has refined its resource use and planning procedures for best utilization.

Dr. Akira Sakuma writes about drug testing at the Medical Research Institute Department of Clinical Pharmacology of the Tokyo Medical and Dental University. The primary application through the four phases of testing is data analysis. Concerned with the safety of drugs currently on the market and drugs proposed for the market, the Department of Clinical Pharmacology makes an important contribution to the health and well being of the people of Japan.

Wingate, a small business, submits an article on the variety of ways their 9830 System works for them. Estimating, inventory control, payroll, accounts payable, and promotional pieces are some of the applications. The system has a number of users doing a number of jobs, and none of the users, except the consultant, has any background in programming or programmable calculators.

"Don't Fret" is an article for music lovers. Just as it was considered a rather technical article for the original publication in which it appeared, some may consider it less than technical for *KEYBOARD*. But, as you can see from the introductory paragraph, it was first published "in the spirit of fun," and that's why we're publishing it also. Nobody wants to live by bread alone.

"Forum," in its second appearance, contains a discussion of an article previously published in *KEYBOARD*. "Crossroads" will not appear this issue but will be back with us in Vol. 7, No. 4.

Nancy Sorensen

Forum

COMMENTS ON "THE EIGEN-SOLUTION OF LINEAR SYSTEMS"

Dr. James N. Shapiro was guest editor of "The Crossroads" for Vol. 6, No. 5, in which he discussed the method of eigen-solution applied to linear equations. Following are Mr. H. Kishan's comments on this article and Dr. Shapiro's response.

We hope you find these two points of view interesting and informative.

Dr. Shapiro's article is commendable for drawing the attention of users of programmable calculators and desk-top computers to the method of eigen-solution of linear simultaneous equations. The writer feels, however, that the suggestion that increased accuracy in results is obtainable for error-prone input data by rejecting part of the eigen-solution could be misleading if generalised for all cases. The term "input data" here refers to the vector on the right-hand side of the equations. This is shown in the following by reconsidering the illustrative example and by solving the equations for another set of input data.

In a physical sense the simultaneous equations (Eq. 1) describe a system which is one hundred times more flexible in the second natural mode compared to the first ($\lambda_1/\lambda_2 = 100$)*. The true input data $\bar{b}$ is parallel to the first natural mode — and therefore orthogonal to the second natural mode — while the input error $(\bar{b}' - \bar{b})$ contains components parallel to both the modes. The second-mode component of the input error shows up in the results with hundred times relative magnification, and hence very large errors in the results. In general, however, both the true input data and the input error would contain components parallel to both the modes. Consider such a case with:

$$\bar{b} = \begin{bmatrix} 110 \\ 410 \end{bmatrix} \text{ and } \bar{b}' = \begin{bmatrix} 109 \\ 411 \end{bmatrix}.$$

The following solutions are obtained by any ordinary method: $y_1 = 8.088$ and $y_2 = 2.353$ corresponding to the vector $\bar{b}$, and $y_1 = 6.914$ and $y_2 = 2.654$ corresponding to the vector $\bar{b}'$. The latter corresponds to the eigen-solution:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \frac{4.251}{\sqrt{17}} \begin{bmatrix} 1 \\ 4 \end{bmatrix} - \frac{6.063}{\sqrt{17}} \begin{bmatrix} -4 \\ 1 \end{bmatrix},$$

and, on rejection of the component parallel to the second mode as suggested by Dr. Shapiro, one obtains $y_1 = 4.251/\sqrt{17} = 1.031$ and $y_2 = 17.004/\sqrt{17} = 4.124$. It is obvious that the last solution, rather than being an improvement on the ordinary solution corresponding to the vector $\bar{b}'$, is nowhere near either of the two solutions (corresponding to the vectors $\bar{b}$ and $\bar{b}'$, respectively). The writer obtained similar results for many other sets of input data.

It appears therefore that in general the eigen-solution of linear simultaneous equations may not always be effective in increasing the accuracy of results for error-prone data. The method remains a powerful tool nevertheless, mainly because (1) the generalised equations are uncoupled on the left-hand side and (2) for many physical systems output results corresponding to the lower (stiffer) modes are negligibly small; therefore it is sufficient to include a smaller number of higher (more flexible) modes in the analysis, thus reducing the total number of generalised equations required for the solution.

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*Notations used by Dr. Shapiro have been adopted here.

I read with great interest Mr. Kishan's comments on my article, "Eigen-solution of Linear Systems" (*KEYBOARD*, Vol. 6, No. 5, pp. 11-13). Mr. Kishan's interpretation in terms of natural modes is a good one. Those familiar with the normal mode solution of mechanical systems will recognize the eigen-solution method as an application of the normal mode technique to general linear systems.

However, nowhere in my article did I say or try to suggest that "increased accuracy" would result from an eigen-solution or partial eigen-solution as opposed to other methods for solving linear systems. I did say that "for consistency (we should) neglect the contribution to the solution which arises from those small eigenvalues λ_i, for which $\lambda_i/\lambda_{max} \lesseqgtr$ relative error." The point is that when the contribution to the solution from the eigenvectors associated with the small eigenvalues gets magnified to such an extent that the error in the input data changes the partial solution by an amount of the same order as the partial solution, we should not include these contributions.

I intended my example to be simple but not misleading, so I chose $\bar{b} \cdot \hat{u}_2 = 0$. More generally, if $\bar{b} = (b_1, b_2)$, the solution is:

$$1700 y_1 = (b_1 + 4b_2) - 400(-4b_1 + b_2),$$
$$1700 y_2 = 4(b_1 + 4b_2) + 100(-4b_1 + b_2),$$

where, in each equation above, the first term arises from the component of $\bar{b}$ along $\hat{u}_1$ ($\lambda_1 = 100$) and the second term arises from the component of $\bar{b}$ along $\hat{u}_2$ ($\lambda_2 = 1$). If the error in b_1 and b_2 is large enough, around one part in a hundred or 1%, the magnification caused by the small eigenvalue can cause the error in the solution to become as large as the solution itself. Without an eigenvalue analysis, it is impossible to separate the solution into its eigen-components y_{λ_1} and y_{λ_2}. Lanczos* has developed a very clever and powerful algorithm for successively solving linear systems iteratively so that the smaller eigenvalues are brought into play gradually.

Also, Mr. Kishan's last comment is irrelevent to the general eigenvalue problem where the eigensystem is dictated by the problem.

I hope that my article stimulated others to consider linear systems in terms of eigensystems, as this is the only method which offers a complete solution to linear systems.

Dr. James N. Shapiro
Assistant Professor of Geophysics
Texas A&M University
College Station, Texas

*Lanczos, C., *Iterative Solution of Large Scale Linear Systems*, SIAM 6, 91, 1958.

WINGATE AND THE 9830A

Small Business Finds Many Uses for Calculator System

by Fred A. Butler
Butler Advertising
Riverside, California

Small companies face many of the same problems large companies face but with the added problems of more limited money, space, and people. Wingate Air Conditioning and Wingate Air Conditioning Service in Riverside, California, are two small, mutually owned companies. They've been in business for 46 years. Total employment for both companies is 42, and yearly revenue is something over $2,000,000. The problem Wingate faced was how to update several office procedures in an affordable, cost-effective, and usable manner. Some form of computerization seemed to be the answer.

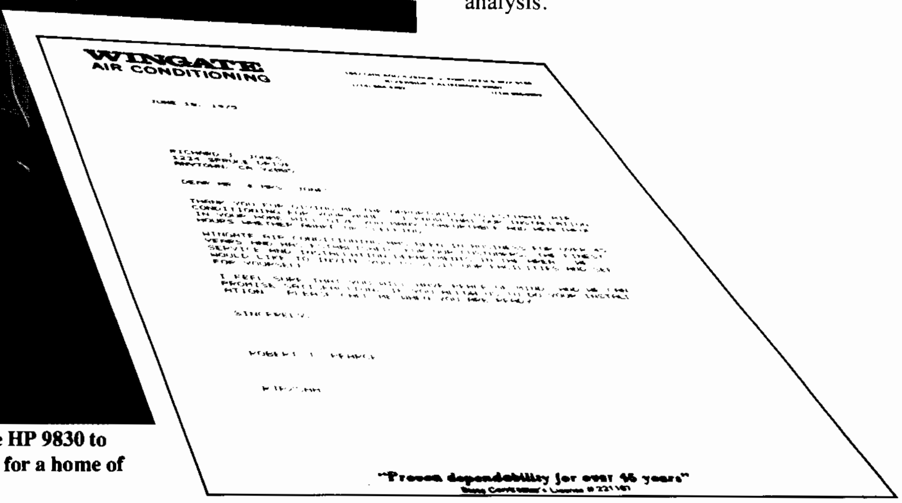
John Wingate, Jr. became interested in using computers during an estimating seminar he attended in 1971. After two years of studying the products available from the many major computer and calculator manufacturing companies, John chose a Hewlett-Packard calculator. The equipment was priced within reach, it had the expansion capability to be properly considered a minicomputer, and it was an outright purchase, an especially attractive advantage to John.

John originally bought a 9830A Calculator and a 9866A Thermal Page Printer and started writing programs for sheet metal estimates. Then he added a String Variables ROM, an Advanced Programming I ROM, and a 9865A External Tape Cassette and wrote a round-and-rectangular-duct estimating program that includes cost of materials and labor from a single job input. The program is coupled with a material cost printout and a cost update program using the definable keys. Then a water and refrigeration piping estimating program was written that has the ability to compare installed costs using various materials and coupling techniques.

In January, 1975, Wingate purchased a 9880B Mass Memory, a Matrix ROM, and an Advanced Programming II ROM, which have added the capability of doing all the accounting functions for both companies. Wingate Air Conditioning Service is using this equipment to post approximately 900 monthly service invoices and write weekly payroll checks. In addition, this same equipment gives labor job costing and flags indirect and unapplied labor costs. An accounts payable program is being written that will furnish data for the other half of the job costing program. Wingate is also working on a program for individual inventory for each service truck and their total backup inventory.

The service and construction business is using the printer as a sales promotion tool. Personalized letters are written to customers reminding them of maintenance due dates for planned service on their home or business heating and air conditioning equipment. Each letter is an original, and the customer response has been well beyond expectations. There is even a choice of type faces to be used for emphasis or to attract reader attention.

Wingate Air Conditioning is using a modified version of the Hewlett-Packard HVAC Pac to engineer heating, ventilating, and air conditioning requirements. This series of programs includes heat-loss/heat-gain calculations, by the hour and by the month, for their design and build work. This has great potential because of the national concern for energy saving and system analysis.

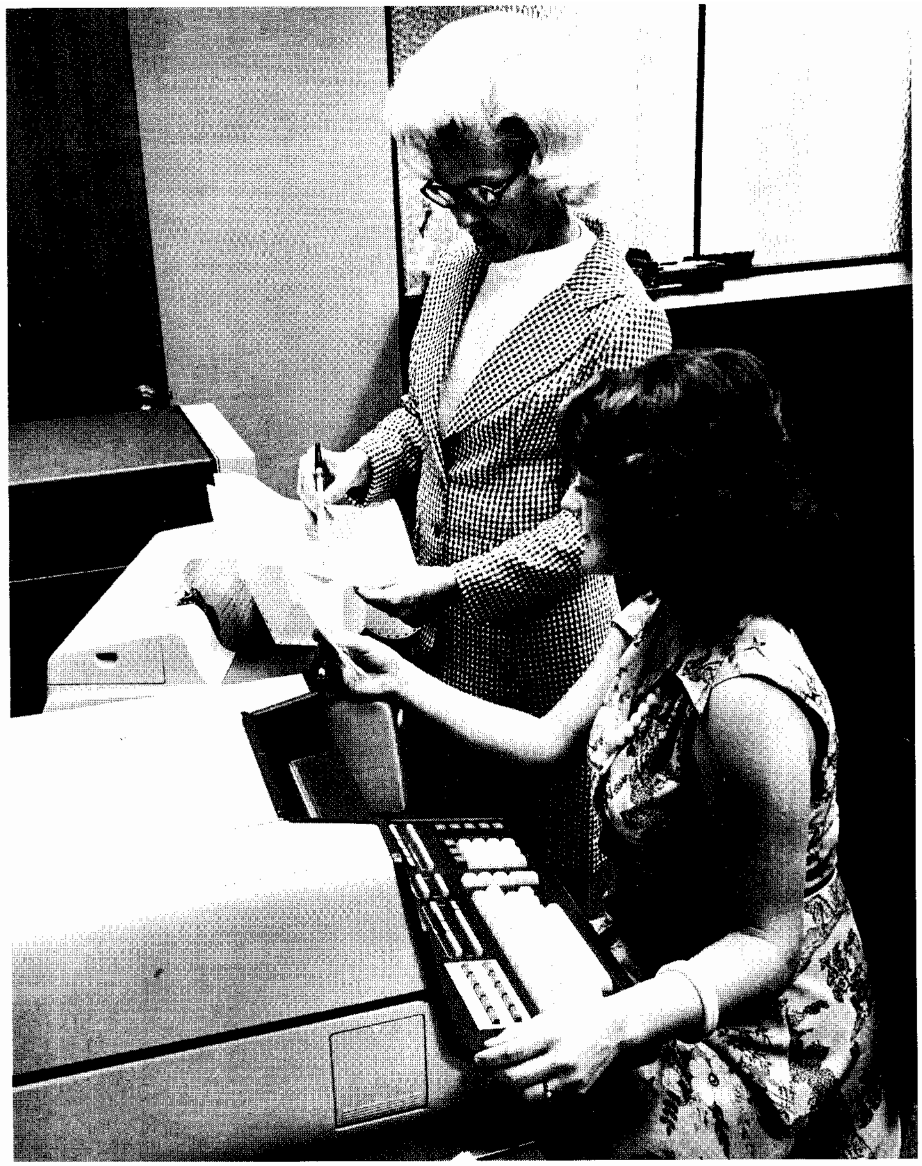


Residential Sales Manager, Harold Weingart, uses the HP 9830 to determine the size of an air conditioning unit required for a home of a potential customer.

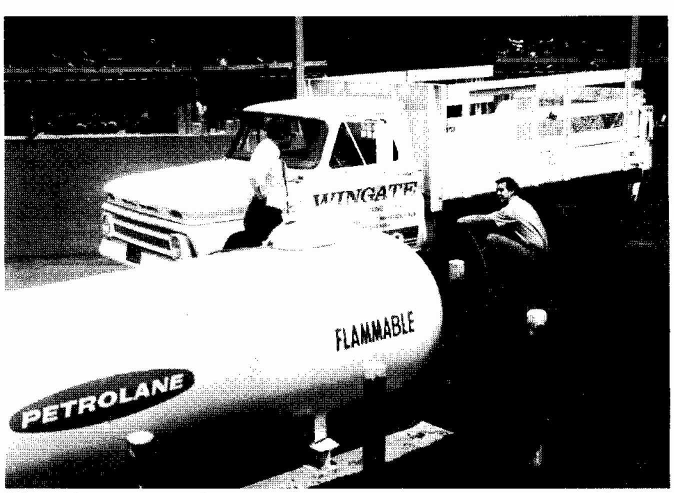
Ten people on the office staff, from Engineering, Sales, Service, and Accounting, use the 9830 System to accomplish their particular jobs. John Wingate says, "This is one of the advantages of the programmable calculator system. Anyone can sit down at the keyboard and do any of several functions because the display works as a prompter. Yet it has big computer advantages such as tape drive, mass memory, and BASIC language." The employees can see the advantage of speed, accuracy and efficiency, and everyone enjoys using this equipment because of its simplicity of operation.

In 1974, Robert J. Pearce joined Wingate Air Conditioning as a private consultant. He programmed the accounting applications and is now programming accounting functions for other companies also. Pearce does all training operations and all scheduling of calculator time.

Jack Wingate, who founded the company in 1929, says, "It means a lot to me to see John and the others looking ahead and doing things that mean continued good service for our customers. The calculator keeps us in step with today's modern technology." The 9830 System has doubled the quantity of work the Estimating Department is able to bid without increasing personnel. Wingate Air Conditioning can state with certainty that accuracy has increased and paperwork flow is faster, helping the company meet the demanding and competitive needs of the future.



Service Department invoices are being entered by Lisa Rodriquez seated at the HP 9830 Calculator while the actual document is being used to check against the original information by Gloria Edwards.



Most of the company's fleet has been converted to clean burning fuel to help protect our environment.

An inventory control program will be used in the calculator for the parts in each vehicle and the backup inventory in the parts department.

DRUG EVALUATION

by Akira Sakuma, PhD

During its initial year of operation, the Department of Clinical Pharmacology at the Medical Research Institute, Tokyo Medical and Dental University, the first of its kind in Japan, has been widely occupied in helping the clinical investigators engaged in the assessment of both available and new drugs. Assisting in designing these clinical trials and statistically analyzing the data from them is a Hewlett-Packard 9830A Calculator System.

The goals of clinical pharmacology include evaluating the efficacy and safety of drugs and what specific good they can do for the patient, and providing the clinicians with the processed information concerning the right selection and appropriate usage of the drug which will bring forth the best benefit to the patient.

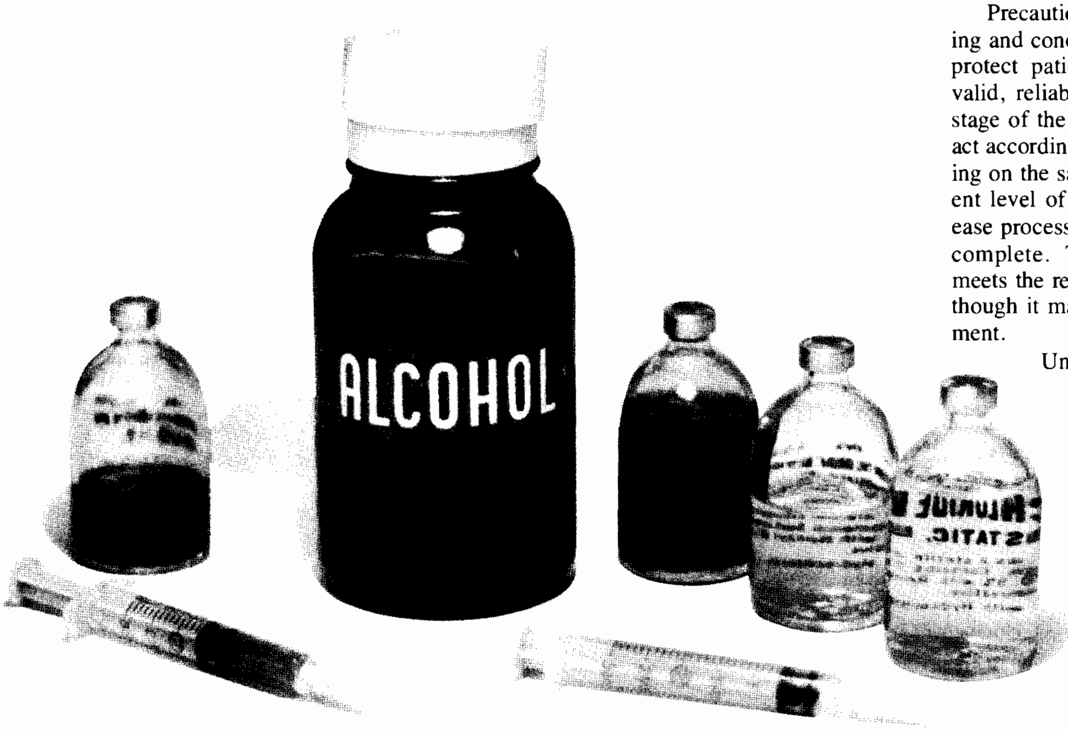
CLINICAL TRIALS

Each new drug goes through three phases in the clinical field during development before approval for manufacturing and marketing. Following the preclinical examinations in a variety of animal models, Phase 1 consists of the very first stage of trial of the drug on human beings. It involves a rather small number of healthy volunteers or patients and is intended mainly to examine the safety of tolerance of the drug in human beings at a given dose range. In Phase 2, the pharmacokinetics and pharmacodynamics of the drug are studied. The drug is tested for absorption, distribution, biotransformation, and excretion, as well as for the possible mechanisms of pharmacologic actions as presumed by the animal studies. Late in Phase 2, more realistic considerations about the clinical condition where the new drug is to be applied are thoroughly exercised.

In the clinical study, a patient ϕ may be compared to a transformer which converts the input (drug) into the output (response): $R = \phi (D)$. Here, (1) classical pharmacology lays stress on the internal mechanism of drug response, and (2) the statistical approach widely utilized in the clinical pharmacology gives weight to the variability of drug response. To be complete, the results obtained by these two approaches should be compatible with each other, and one should recognize that the statistically extracted conclusion is not directly applicable to the individual patient.

In Phase 3, the test drug is assessed according to a specified manner known as the controlled trial. The controlled clinical trial is structured on the principles of experimental design attributed to R. A. Fisher; namely, increasing the size of experiment, random allocation of the treatments, and the lócal control or utilization of stratification technique. In the simplest form, a group of well-defined patients is randomly divided into two subgroups, one of which is given the test drug and the other an adequate standard drug. This concurrently-used standard may be an active available drug, or it may be an inactive placebo, depending on the condition and the purpose of the trial. The test drug should always be assessed in comparison with the standard in order to avoid the distortion due to the variety of sources of bias. Furthermore, when the psychological influence of the patient, as well as that of the investigator who knows the drug used, is liable to contaminate the comparison, the controlled trial is to be conducted according to the double-blind technique in which neither the patient nor the investigator knows whether the test drug or the standard is being used until the completion of the assessment.

Precautions must be taken in approaching and conducting the clinical trial, both to protect patients and to achieve medically valid, reliable and sensitive results. At any stage of the clinical investigation, one must act according to the decision given by standing on the safer side, realizing that the present level of medical knowledge on the disease process and the drug action is far from complete. This seemingly timid attitude meets the requirement of medical ethics, although it may retard the new drug development.



Until approval for selling, the new drug is used by the selected investigators for the selected patients under professional controls. After approval, however, the drug is placed on the market and the number and complexity of patients taking the drug rapidly increases. This is when the drug may cause unwanted effects due to interaction with other drugs or even with diet, careless use by the patients, and some imprudent prescribing habits of physicians. This postmarket phase is currently referred to as Phase 4.

In Phase 4, the monitoring of adverse reactions to the drug is thus mandatory for wise usage of the drug. It is also important to assess the utility of the drug concerning the final clinical endpoint. For many types of drugs, the length of the clinical trial is rather short in Phase 2 or 3. Long-term observation is possible only in Phase 4 according to the current system of drug development. The present situation on this final phase is far from ideal in Japan.

DATA ANALYSES

Random allocation of patients to drug groups in the controlled trial is efficiently carried out with the aid of the HP 9830 Calculator, which generates a balanced series of randomized drug codes in a table form.

The clinical data are generally of a multivariate nature. The data of a single patient consist of: (1) background descriptions (age, sex, etc.); (2) baseline data (initial blood pressure, heart rate, etc.); (3) changes in the target symptoms (blood pressure fall, decreased number of attacks, etc.); and (4) global judgments (patient impression, doctor's general assessment, etc.). One way of examining the validity of the doctor's global judgment and the importance of the target symptoms is the stepwise regression analysis with the help of the HP 9830 System. The HP 9830 (8k) can easily process the data consisting of 25 symptoms of 100 patients; it may process more with some changes in the program. The doctor's global assessment, as the response variate, is plotted against the value predicted by the calculator to find out some peculiar assessments. If the set of the selected explanatory variables according to the regression analysis explains the majority of the variation in the global assessment, or in other words, if the multiple correlation coefficient R is 0.9 or larger, then the set of the variables may be safely utilized in similar trials. Quite often the number of variables thus selected is much smaller than that of the original variables deemed necessary in the protocol.

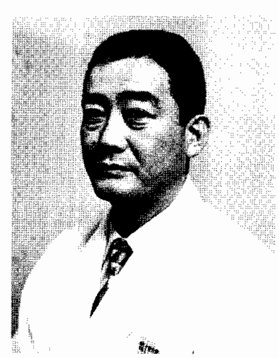
In the case of comparing two drugs, A and B, one may take the response variable as 0 or 1 depending on the drug. This type of regression analysis is equivalent to a linear discriminant analysis, which is helpful in contrasting the profile of action of each drug.

From the preclinical phase to the postmarket phase of drug evaluation, the HP 9830 Calculator with the HP 9861A Typewriter, the HP 9862A Plotter, the HP 9865A External Tape Cassette, and the HP 9866A Thermal Page Printer can do a fine job on the data analyses. Some selected examples are parallel-line bioassay, nonlinear curve fitting in pharmacokinetics and enzyme kinetics studies (see Figure 1), block design analyses, parametric and nonparametric routines, analysis of covariance, time-series analysis, logistic model analysis, and multivariate analyses.

```
NONLINEAR FITTING BY NEWTON-RAPHSON METHOD

WRITE FUNCTION WITH VARIABLE X, PARAMETER A(I)
      EXAMPLE: Y(X)=A(1)*X+EXP(A(2)*X)

FUNCTION :  Y=A1*A3/(A1-A2)*(EXP(-A2*X)-EXP(A1*X))

          BLOOD LEVEL, MCG/ML, BETA-BLOCKER F

 1) FETCH SFK1
 2) PRESS BACK & COMPLETE LINE 10
 3) PRESS END-OF-LINE
 4) PRESS RUN & SFK1

% PRECISION 0.1

PARAMETERS, P = 3    OBSERVATIONS, N = 7

DATA
     1          1              71
     2          2              85
     3          4              77
     4          6              62
     5          8              48
     6          12             33
     7          24             10


RESIDUAL SS (    0     )= 236.9810929
 1     0.1   100

RESIDUAL SS (    1     )= 10.2805395
 1.119281182    0.111828979    110.2051652

RESIDUAL SS (    2     )= 6.490091762
 1.193143836    0.108666479    108.3486547

RESIDUAL SS (    3     )= 6.366072140
 1.208830570    0.108143718    108.0497889

RESIDUAL SS (    4     )= 6.366197345
 1.20952104     0.108119901    108.0360985

     *****END*****
```

Figure 1. Nonlinear curve fitting example.

CURRICULUM VITAE



Akira Sakuma received a Bachelor of Pharmacy in 1953 and a PhD in Pharmacy in 1958 at the University of Tokyo. In 1960, after two years of postdoctoral study at the University of Michigan, Department of Pharmacology, Dr. Sakuma returned to the University of Tokyo, Medical School, Department of Pharmacology, as an assistant professor. In 1963, he moved to the Tokyo Medical and Dental University, Institute for Cardiovascular Diseases, Department of Pharmacology, as an associate professor. In this capacity, he worked in 1969 and 1970 in Switzerland for the University of Basel, Department of Internal Medicine; he was located in the Scientific Computing Center (WRZ) in the J. R. Geigy Company. The system of the institutes annexed to the Tokyo Medical and Dental University was reorganized in 1973, and the Medical Research Institute was set up. In 1974, Dr. Sakuma took professorship of the Department of Clinical Pharmacology at this institute, the first of its kind established in Japan.

INTEGRATED CIRCUIT LAYOUT DESIGN WITH HP DESK-TOP CALCULATORS

by Andrei Vladimirescu and
Dorel Prisecaru

Design, drawing, and digitizing of integrated circuit layouts are tedious tasks usually accomplished with the aid of a computer or a minicomputer. LAYOUT-3, a set of programs, enables the design of bipolar and MOS IC's, both analog and digital, on the HP 9100 Desk-top Calculator System consisting of a HP 9100A Calculator, HP 9101A Extended Memory, HP 9125A Plotter, HP 9160A Marked Card Reader, and, optionally, an IBM typewriter (with interface) or a HP 9120A Printer.

LAYOUT-3 can handle geometries (which will be referred to also as items) of transistors, resistors, and other components used in IC's. The items may have the shape of closed rectangular polygons, circles, or straight lines closed by circular arcs. The stored geometries (referenced to an arbitrary origin) can be moved to a specified point, rotated through 90°, 180°, or 270°, or mirror-imaged about the X or Y axis. The same item can be drawn in different sizes on the layout if a magnification or a reduction of that item is required.

The output of the program is a list of coordinates and a drawing of each mask separately or of the whole layout. The listed coordinates are given in mm and represent the processed initial data (in μm) multiplied by the desired scaling factor for the operation of a manually-driven cut and strip machine. It should be noticed that the drawing is made on an enlarged scale, which is suited to the plotter.

OPERATION MODE

The operation mode of the LAYOUT-3 program will be outlined for a bipolar IC, which contains more transistors with the same geometry (see Figure 1). The origin of the reference is chosen for more convenience on the isolation diffusion mask (the exterior rectangle in Figure 1). The circuit layout can be designed by means of an optimum arrangement of the isolation diffusion geometries.

The coordinates (in μm) of the vertices are input via marked cards, referred to as "coordinate cards," four data on each card. The four coordinates are separated by three instructions that are compulsory for all cards (see Figure 2). Each coordinate may contain five digits and a decimal point.

The vertex coordinates must be input in the order x_1, y_1, x_2, y_2,...x_n, y_n, following the edges of the polygon and always starting with a horizontal edge (see Figure 1). Any rectangular polygon with n vertices will be described by n coordinates.

After all the different geometries of the isolation diffusion mask have been stored, every geometry as many times as it occurs on that mask, a control card is input for each item. The first two data of this card are the coordinates in μm of the point on the layout where the origin of the geometry must be

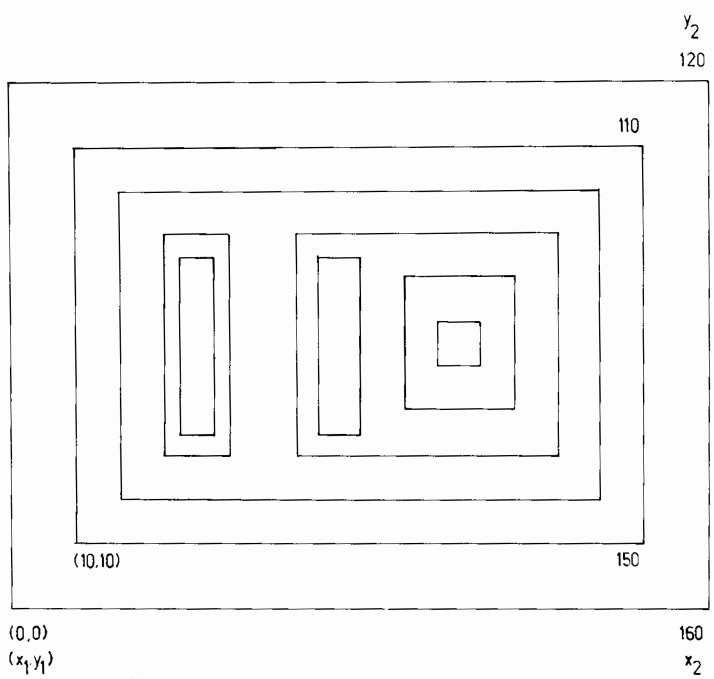


Fig. 1 The geometry of the bipolar transistor Q1.

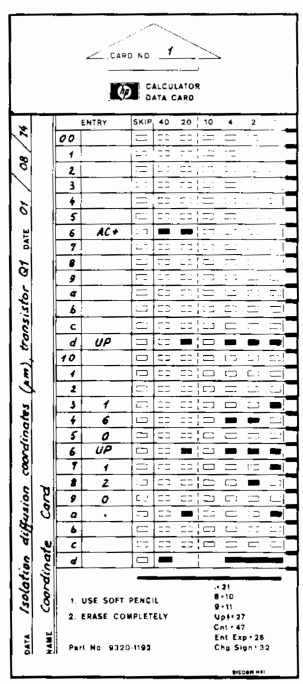


Fig. 2 Coordinate card of the diffusion isolation of transistor Q1.

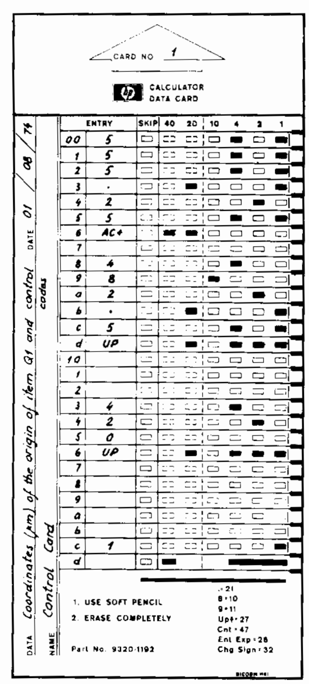


Fig. 3 Control card of transistor Q1.

moved. The third data is a string of two integers; the first represents the number of vertices of the rectangular polygon and the second, the transformation code (two digits). Figure 3 shows the control card for all masks of the transistor of Figure 1. This transistor, which contains only rectangles (four vertices), will be rotated through 90° (transformation code 20), as described by the third data equal to 420; the origin (around which rotations are always performed) is then moved to the point x = 555.25 μm, y = 482.5 μm.

Program execution proceeds with the plot of the processed geometry. At this time the final coordinates are stored in the place of the initial coordinates input through marked cards. The coordinates for the cut and strip machine are printed or output on the plotter (if no printer is available) after completion of the drawing of stored geometries.

The remaining geometries are further processed until all masks are plotted and digitized. The number of coordinates processed at one time varies from 100 to 160, depending on the number of loaded programs. The program is segmented in such a way that a number of subprograms can be deleted, e.g., if no rotation and no circles are needed, more memory registers are available for data storage.

The metalization mask usually contains oblique lines also. A convenient mode for designing this mask is to start from the contact mask and digitize the metalization contours (in μm). The LAYOUT-3-POLYPLOT programs, which can process any closed contour, are then used for the drawing, verification, and listing of this mask. Each vertex of the contour must be described by two coordinates (x and y) on the data cards. No control cards are used in this program.

PROGRAM DESCRIPTION

The flowchart of the LAYOUT-3 program is given in Figure 4. Coordinates and control data are input as described in the previous section. The scale d for the drawing is computed as shown in the following example. For a 250-times-larger plot than the circuit chip, the C coordinate (expressed in units on the plot) corresponding to c (in μm) on the chip is

$$C = 250 \bullet 20 \frac{\text{units}}{\text{mm}} \bullet c \bullet 10^{-3}\ \text{mm} = 5c \text{ units}. \quad (1)$$

The scaling factor is

$$d = \frac{C}{c} = 5. \quad (2)$$

In Eq. (1) the coordinate c, which is stored in μm, is expressed in mm, and 20 $\frac{\text{units}}{\text{mm}}$ represents the accuracy of the HP 9125 Plotter.

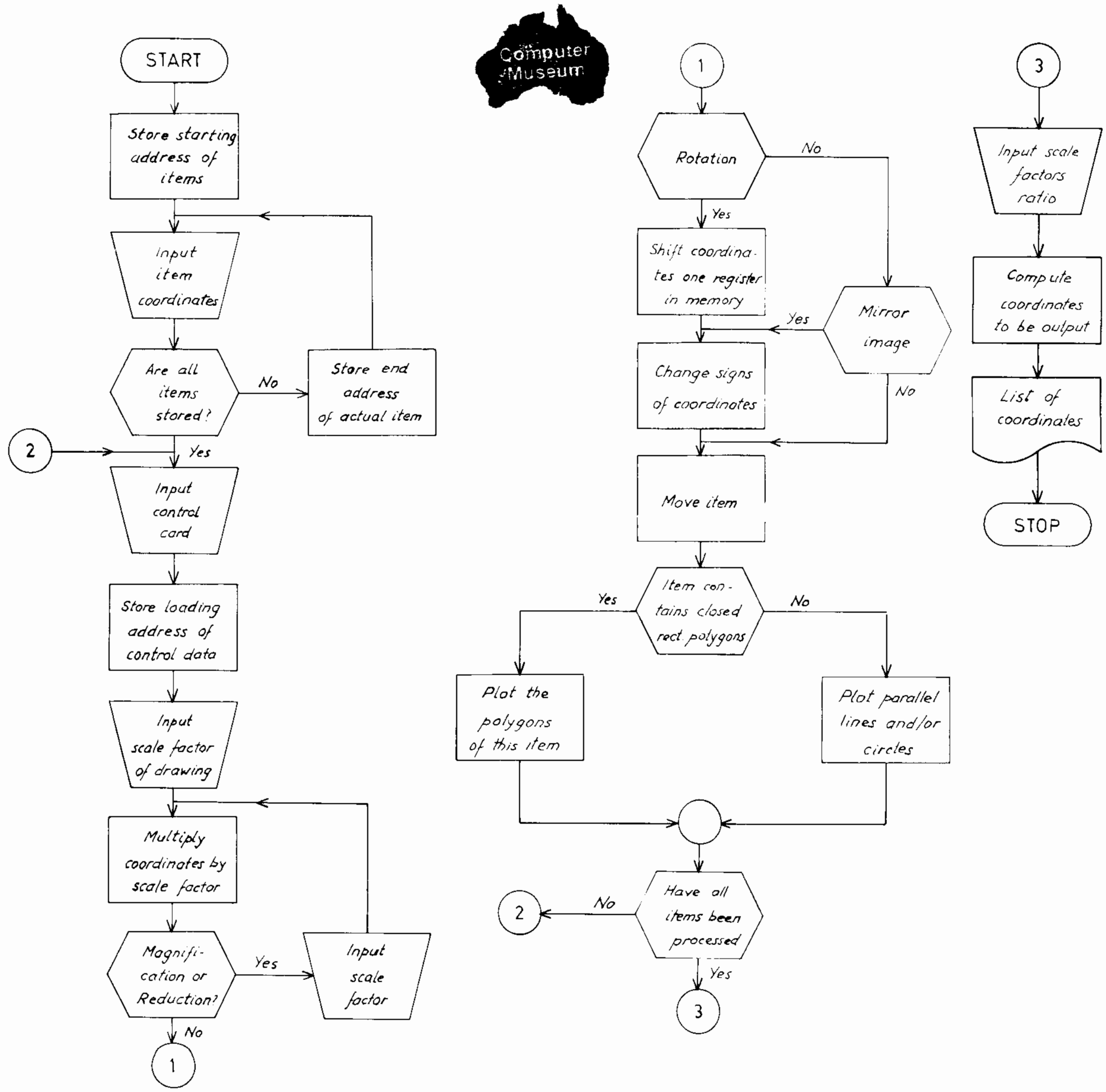


Fig. 4 **Flowchart of the LAYOUT-3 program.**

An interesting feature of the program is the algorithm that performs rotations. For a rotation through 90°, the new coordinates x′ and y′ can be expressed as functions of the given x and y using polar representation.

$$x' = \rho\cos(\theta + 90^\circ) = -\rho\cos[180^\circ - (\theta + 90^\circ)] = -\rho\cos(90^\circ - \theta) = -\rho\sin\theta = -y, \quad (3)$$

$$y' = \rho\sin(\theta + 90^\circ) = \rho\sin[180^\circ - (\theta + 90^\circ)] = \rho\sin(90^\circ - \theta) = \rho\cos\theta = x, \quad (4)$$

where the initial coordinates are:

$$x = \rho\cos\theta, \quad (5)$$

$$y = \rho\sin\theta. \quad (6)$$

As shown in Figure 5, the rotation is achieved in two steps; first the sign is changed to all x and/or y of the processed geometry, then all these data are shifted upward one register. Data are stored beginning with memory register 216. The coordinate stored in the top memory register is saved in the lowest register involved. The first step represents a mirror image.

After completion of the drawing, the stored data must be multiplied by the ratio $\frac{d'}{d}$, where d′ is the scale factor for the rubylith. Since the listed coordinates must be in mm and the initial data are in μm, d′ always must be less than 1. Thus for a magnification of 500 on the cut and strip machine, d′ is 0.5 and the desired ratio is

$$\frac{d'}{d} = \frac{0.5}{5} = 0.1, \quad (7)$$

supposing a magnification of 250 for the plot (d = 5).

The layout of a MOS/MSI static shift register designed with the aid of the LAYOUT-3 program is shown in Figure 6, and Figure 7 contains a list of coordinates of the diffusion mask at the scale 500. The plot of the layout of a bipolar IC is shown in Figure 8.

EXPANDABILITY

The LAYOUT-3 program presented above has been developed on a HP 9100 System, but full efficiency of its possiblities can be achieved on a HP 9800 System. The HP 9830A Calculator and the 9880B Mass Memory System, which enables a large number of coordinates to be stored and pro-

DIFFUSION MASK

120.00	177.00	130.00	174.50
126.25	149.00	123.75	174.50
105.00	177.00	114.00	170.50
118.50	161.50	116.00	168.00
106.00	154.00	108.50	144.00
115.00	135.00		
152.50	177.00	162.50	174.50
158.75	149.00	156.25	174.50
137.50	177.00	146.50	170.50
151.00	161.50	148.50	168.00
138.50	154.00	141.00	144.00
147.50	135.00		
185.00	177.00	195.00	174.50
191.25	149.00	188.75	174.50
170.00	177.00	179.00	170.50
183.50	161.50	181.00	168.00
171.00	154.00	173.50	144.00
180.00	135.00		
217.50	177.00	227.50	174.50
223.75	149.00	221.25	174.50
202.50	177.00	211.50	170.50
216.00	161.50	213.50	168.00
203.50	154.00	206.00	144.00
212.50	135.00		
250.00	177.00	260.00	174.50
256.25	149.00	253.75	174.50
235.00	177.00	244.00	170.50
248.50	161.50	246.00	168.00
236.00	154.00	238.50	144.00
245.00	135.00		

Fig. 7 Sample list of coordinates.

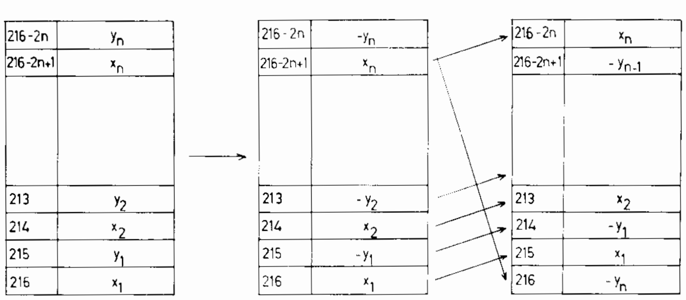


Fig. 5 Data updating for a geometry rotated through 90°.

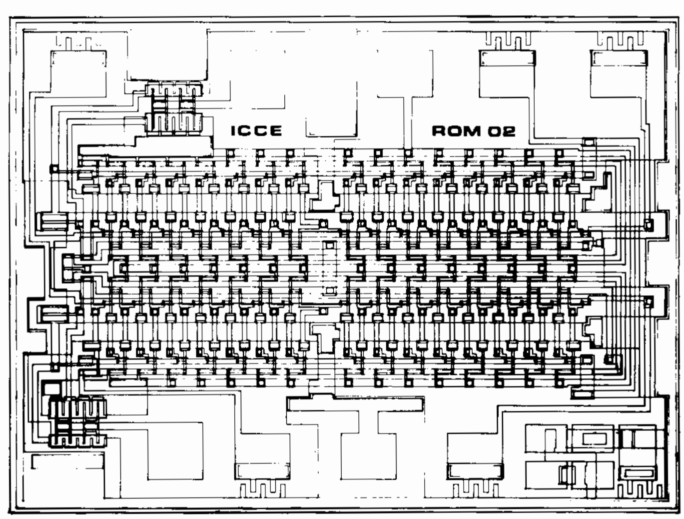


Fig. 6 MOS/MSI IC layout designed with HP desk-top calculators.

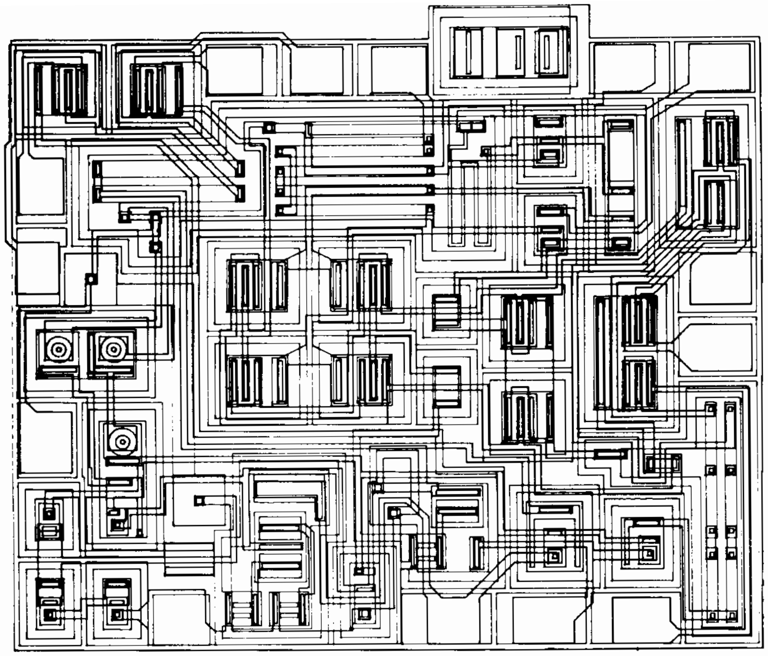


Fig. 8 Bipolar IC layout designed and plotted with LAYOUT-3.

cessed, are the ideal hardware for this program. The system must further contain a Card Reader (9860A), Typewriter or Printer (9861A or 9866A), and a 9864A Digitizer, which is very useful for laying out the metalization mask starting from the contact mask. Further, a dimensional checking program can be added, and a punched paper tape can be output on a 2895B Tape Punch to control an automatic drafting machine.

On a HP 9800 System, LAYOUT-3 represents a very powerful program for the design, plotting, verification, digitizing, and artwork generation of integrated circuits.

CURRICULUM VITAE

Andrei Vladimirescu was born in Bucharest, Romania, on May 20, 1948. He received his Phys. Eng. degree in electrical engineering from the Polytechnic Institute of Bucharest in Bucharest, Romania, in 1971. He has worked with the R&D Center for Electronic Components ICCE since 1971, where he worked on the development of device models and algorithms for the Computer-Aided Integrated Circuit Analysis and Design. He is presently engaged in MOS/LSI design and technology and is preparing to work toward a Doctor of Engineering degree in the field of semiconductor devices.

Dorel C. Prisecaru was born in Botesti, Romania, on July 14, 1946. He received his Phys. Eng. degree in electrical engineering from the Polytechnic Institute of Bucharest in 1969. Since 1969 he has been with the R&D Center for Electronic Components ICCE, where he is engaged in the research and development of silicon semiconductor devices. In 1973 he was named head of the MOS/LSI group of the R&D Center. His specific research interests are related to the Computer-Aided Design and Testing of semiconductor devices.

HP-81 REAL ESTATE AND INVESTMENT ANALYSIS HANDBOOK

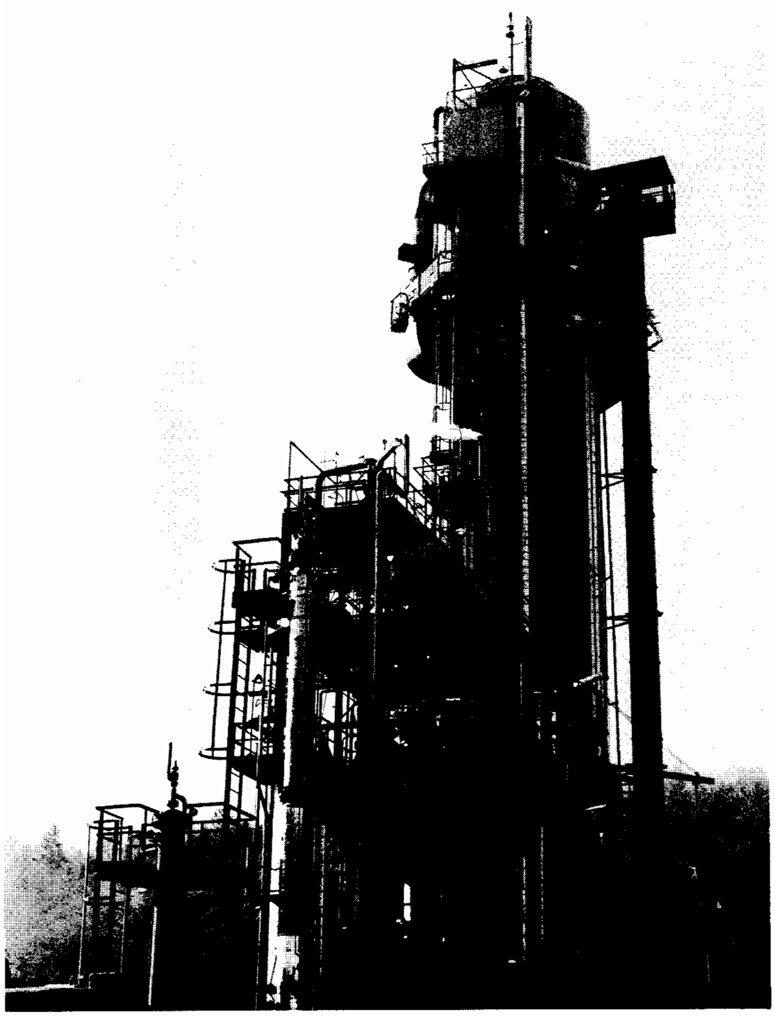
The *HP-81 Real Estate and Investment Analysis Handbook*, by Dr. William Kinnard and Dr. Byrl Boyce of the University of Connecticut, is now available. The 243-page handbook spells out the step-by-step procedures for doing internal rate of return, depreciation schedules, discounted cash flow, present value calculations, cash flow projections, statistics, and more.

The HP-81, a desk-top, printing, preprogrammed financial calculator, is more powerful than the hand-held HP-80. It is used by managers in finance, engineering, construction, real estate, and manufacturing. It is an excellent financial decision-maker's aid.

To order the *HP-81 Real Estate and Investment Analysis Handbook*, Part Number 00081-90020, price $15 in the U.S.A., contact your local Hewlett-Packard sales office; for further information, ask for the HP-81 Real Estate and Investment Analysis Handbook Application Summary, 5952-8993.

OPTIMIZING THE OPERATION OF A CHEMICAL PROCESSING COMPLEX

by Ken W. Lessey



The world food shortage has put a burden on fertilizer manufacturers to tighten their belts and produce the very best mix of fertilizer products. Reichhold Chemicals shares this burden at its complex of fertilizer plants at St. Helens, Oregon. The plants manufacture steam, ammonia, urea, and a nitrogen solution. The products in the plants can be marketed through several different channels, and there are alternate sources of raw materials.

PRODUCTION FACILITIES

The interrelationships of the steam, ammonia, urea, and nitrogen solution plants are shown in Figure 1. The product from the first plant is used as a raw material in all the others. The product from the second plant is used in the third and fourth plants, and the product from the third is used as a raw material in the fourth plant. Also, energy produced in three plants is consumed in three plants. The total energy consumed must equal the total energy produced. This results in a unification of all four plants. For example, when the operating conditions in the nitrogen solution plant are changed, the operation of the steam, ammonia, and urea plants also changes automatically.

MARKETING AND INVENTORIES

The fertilizer market is seasonal. This fact, coupled with the sales contracts in existence and limited storage on inventories for products, places some interesting minimum and maximum limitations on production for each product that must be met. The availability of raw materials is also seasonal. Natural gas is more available in the summer than in the winter. Fuel oil and propane are seasonal, but they can be stored. There are very large differences in cost in alternate raw materials and sources of energy.

INTUITIVE SOLUTION

Traditionally, the plant has been operated at a point that intuitively seems to be the best one. Some rough calculations were used to make small improvements in profit pictures. With approximately 60 variables to consider at one time, it is difficult to come

In the foreground is the urea plant. The structure at the back is the urea prilling tower.

up with the very best solution. We now use linear programming and the HP 9830A Calculator to optimize the operation of the plant. The potential impact on profits wasn't really appreciated when we began. As it has turned out, the difference between the optimum point and the intuitive point of operations has had a very significant impact on profits.

LINEAR PROGRAMMING SOLUTION

Linear programming is quite well known, and the primary purpose is to find the one optimum point of operation. For us, this is really a secondary aspect. The primary value of the system comes under what is called sensitivity analysis. Here we can look at a great number of alternatives and quickly determine the consequences of each one. The program also points out opportunities to improve profits and to realize other advantages in operations that are not evident without the program. Another result of the program that we had not really anticipated was the deep understanding of the economics of operations that comes from analyzing the alternatives of plant operation. It is so easy to evaluate different situations that you can get many years of experience in one day by using the calculator with linear programming. Many times we found that the intuitively obvious balance in plant operations was just the opposite of the actual optimum balance.

OPERATION OF THE SYSTEM

The program is a modified version of the Stanford HP Program GLPSA1. It is used to simultaneously solve 32 equations and 60 variables covering energy consumption, steam production and demand, ammonia, urea, and nitrogen solution production and demand, raw material supply, and inventory levels.

The first step is finding an optimum solution to a given set of conditions which takes about two hours on the calculator. The second and primary step is evaluating alternatives to the optimum solutions. Examples are buying alternate sources of raw materials at higher prices, expanding capacities of different sections of a plant, putting in new facilities to change the operating characteristics of the plant (such as insulation to reduce energy losses), determining the value of facilities to increase production and the value of facilities that would allow use of new raw materials. Many alternatives can be considered that would not be possible with a manual system.

Evaluation of an alternative takes 2 to 10 minutes of calculator time for an accurate answer. Manual methods take 8 hours for an approximate answer. Some results have been changes in budgeted production and a decision to de-bottleneck and expand the capacity of one plant. It pointed out the value and opportunity in switching to a very expensive fuel during some periods of the year, which had not been considered feasible before.

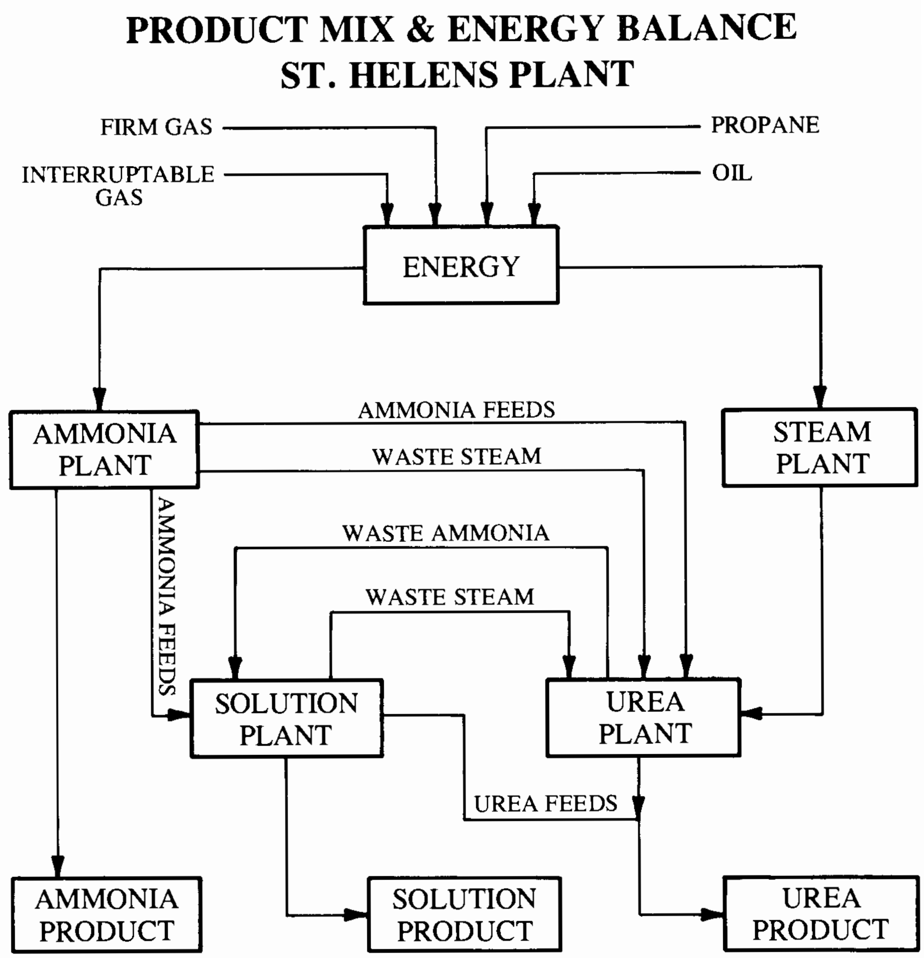


Figure 1. Schematic of plant operations.

CURRICULUM VITAE

Ken W. Lessey attended high school in Rigby, Idaho, and received a BS in Mechanical Engineering from the University of Idaho in 1966. He worked for Shell Chemical from 1966 until 1972, when he returned to school to earn his MBA from Portland State University. After graduation, Mr. Lessey joined Reichhold Chemicals, Inc. as Manager of Maintenance and Engineering.

DON'T FRET

Ask the Machine*

*Reprinted from the souvenir program for the National Folk Festival, August 1-4, 1974, Wolf Trap Farm Park, by permission of the National Folk Festival Association, Inc. The article was written by Jonathan Eberhart.

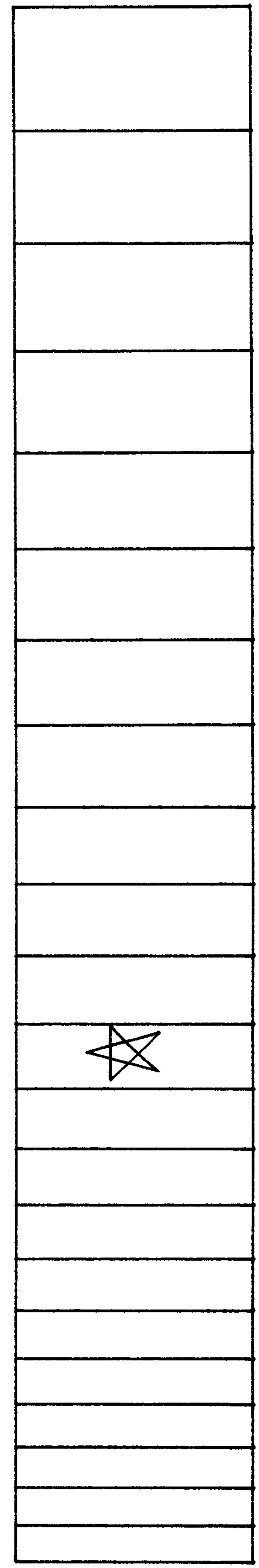
Some may protest the inclusion of the following rather technological subject in the program to an otherwise traditional festival, but we've included it in the spirit of fun (it's even a little practical). It's the brainchild of Mike Rivers, a long-time picker, occasional instrument maker and accomplished electronic engineer.

A surprising number of musicians and instrument builders are also involved in some way with computers, usually through science, engineering or other mathematically-related professions. This article is for them. It is simply a computer program that draws properly spaced frets for the fingerboards of instruments such as guitars, banjos and mandolins.

There's not much point in using it to pattern a replacement fingerboard for an existing instrument, since it would be much easier merely to trace the old one. It would be more helpful in laying out the frets for, for example, a newly-built instrument of an unusual size or a hybrid instrument for which no pattern is available. The program was designed, in fact, simply as a diversion (computer types are like that), an attempt to do something musical with a computer (computer music is a whole 'nother game, requiring additional equipment). But it has its uses.

The program, in a computer language called BASIC, is based on the fact that in the case of a fretted instrument, the distance from the bridge (through which the strings contact the "face" of the instrument) to any given fret is equal to the distance from the bridge to the next farthest fret divided by the 12th root of 2. This precise relationship results in the equal-temperament, or "well-tempered," tuning system that is now common to much of western music, in part through the influence of Johann Sebastian Bach's series of compositions called "The Well-Tempered Klavier." (There are several other systems, one of which is sometimes used by dulcimer makers.)

The program was originally run on a Hewlett-Packard 9830 Programmable Calculator, equipped with a HP flatbed plotter (which makes the drawing), but anyone with reasonable experience ought to be able to adapt it to his or her own equipment. In essence, the operator begins by telling the calculator the desired string length and the number of frets. Otherwise, the poor calculator would spend all its time drawing frets at tinier and tinier intervals and would never be able to stop and finish the sides of the pattern. Next there is a subroutine (a sort of



side-program) designed to make sure that the resulting pattern will fit the size of the paper on the plotter (in this case 15 inches). Larger fingerboards can still be drawn — the plotter can simply print the first octave (12 frets) on one sheet and the second octave (which is exactly half the length of the first) on another.

As an added touch, the program prints a star at the twelfth fret to indicate the octave. Then it goes on drawing the rest of the frets, comes back around to draw the edges and finally labels the drawing with the string length and the number of frets.

Despite its semi-frivolous intent, the program found a use almost as soon as it was completed. Alberto Vazquez, a Virginia banjo maker and picker, wanted to make a five-string banjo neck for a petite, seven-inch shell, or body, from a hybrid called a banjo-ukelele (the original neck was too short, lacked one string and had too few frets). The problem was to end up with 22 frets spaced for a string length that would allow placing the bridge in a position that would produce a good tone (the tone of a banjo depends largely on the distance of the bridge from the edge of the banjo's head, or skin).

The first step was to make an educated guess at the string length and tell it to the calculator, which then obligingly drew out a fingerboard for it. The drawing was then laid in a position next to a seven-inch circle drawn to represent the shell, so that another educated guess could be made about whether the bridge was in a good spot (the bridge is placed at exactly twice the length of the first octave for a given fingerboard). Because the bridge position came out a little too close to the edge of the shell, a slight increase was made in the string length, and presto, Al had his fret pattern. (The illustration is a pattern for a Gibson A-model mandolin, reduced by the calculator from its actual 14-inch length to fit on this page.)

```
10 DISP "SCALE LENGTH";
20 INPUT L
30 DISP "HOW MANY FRETS";
40 INPUT F
50 IF F>30 THEN 70
60 GOTO 90
70 DISP "THAT'S ABSURD!  HOW MANY FRETS";
80 GOTO 40
90 F0=F
100 L0=L
110 GOSUB 320
120 F=F+1
130 SCALE (L0-15),L0,-3,3
140 PLOT L,0,1
150 IPLOT 0,1,2
160 L1=L
170 L=L/(2↑(1/12))
180 D1=L1-L
190 F=F-1
200 IF F=F0-11 THEN 460
210 IF F=0 THEN 230
220 GOTO 140
230 L=L*(2↑(1/12))
240 IPLOT (L0-L),0
250 IPLOT 0,-1
260 IPLOT -(L0-L),0
270 PEN
280 PLOT L,-0.75
290 LABEL (*,1.9,2,-PI/2,8/10.5)"SCALE LENGTH:"L0"IN."
300 LABEL (*)F0"FRETS"
310 END
320 L=L/1.05946
330 F=F-1
340 D=L0-L
350 IF F=0 THEN 370
360 GOTO 320
370 IF D>15 THEN 410
380 F=F0
390 L=L0
400 RETURN
410 DISP "TOO MANY FRETS FOR THIS SCALE"
420 WAIT 2000
430 L=L0
440 GOTO 30
450 END
460 IPLOT -((D1/2)-0.15),-0.6,1
470 IPLOT -0.125,0.3,2
480 IPLOT -0.125,-0.3
490 IPLOT 0.3,0.2
500 IPLOT -0.35,0
510 IPLOT 0.3,-0.2
520 PEN
530 GOTO 210
1000 LABEL (*)"FHJFJFHJHJ"
1010 LABEL (*)X"EFEFJ"
```

EPILOGUE

When I made up this program, I did it merely as a programming exercise while playing with my new 9830, which is now happily at work for the Naval Oceanographic Office. Some of my friends who do more building of instruments than I have picked up on it and to this date one guitar and two mandolins have been built based on the program. In actual application, it was found that the Hewlett-Packard 9862A Plotter with its soft tipped pen did not draw lines fine enough to use as an accurate pattern, so the program was modified and run on a machine with a CalComp drum plotter with a very fine pencil on mylar. This made a dimensionally stable and useful pattern. This program generates a fret pattern of equal temperament useful for conventional instruments (such as the guitar) which can play in all keys. For an instrument such as the fretted dulcimer which plays in only one key without retuning and is traditionally fretted "by ear," just intonation, based on pure Pythagorean intervals, is appropriate. This will give a sweeter tone in one key but will be out of tune in others. A just-intonation program has been written but has not yet been applied.

CURRICULUM VITAE

Mike Rivers is a project engineer with the U.S. Naval Oceanographic Office in Washington, D.C., where he is using the 9830A (legitimately) to record and process underwater environmental data. He has co-authored a paper for the recent Plessey Environmental Systems User's Conference on that subject. He has a BS degree in Electronics from George Washington University and enjoys playing and collecting traditional American folk music.

Photo credit: Jane Beethoven

programming tips

CALCULATIONS ON THE 9830A DURING PROGRAM EXECUTION

Joe Armstrong of Hewlett-Packard submitted this programming tip.

During the execution of a program, it is often necessary to make calculations to answer certain program-prompted questions. You can use the HP 9830A to perform these calculations by pressing either the up or down display keys (↑,↓) when the 9830 is waiting for an input. This will put the 9830 in the calculator mode. You can now perform any normal keyboard function.

Examples:

1. To check the status of A. Key in A and press EXECUTE.
2. To calculate A*B/C. Key in A*B/C and press EXECUTE.
3. To change the status of D(1,5). Key in D(1,5) = T*5 and press EXECUTE.

You can return to the input step where you exited the program by pressing CONT and EXECUTE. The only disadvantage is that the original display message will be replaced by a ?. Simply remember what the message was and enter the response as usual.

NOTE: Use the 9830 as a calculator only. Do not attempt to edit, add, or delete any program lines during this procedure. To do so would cause the 9830 to lose its pointer to the step in memory where you exited the program.

SIGNALING THE END OF A PROGRAM (9830A)

David M. Kuchta and Rona J. Newmark of Case Western Reserve University, Cleveland, Ohio, submit this helpful programming tip.

In the course of our programming on a Hewlett-Packard 9830A, we have developed the following method of signaling the end of a program, or a particular segment of program, such as a lengthy routine followed by an input by the operator. By inserting

```
10 A=9↑9↑9↑9↑9↑9↑9↑9↑9↑9↑9↑9↑9↑9↑9
```

at the end of a segment, the calculator will emit its characteristic beeping sound for ten seconds. Since this results in a recoverable error (error message 100 — numeric overflow), program execution can be continued at the next line. Each time the expression is raised to another power of 9, the machine will beep for another second.

Printed in U.S.A.
September 10, 1975

TAPE DUPLICATION ON THE 9820A

Our thanks to William H. Clayton, College of Marine Sciences, Texas A&M University, for the following programming tip.

Here is a tape duplication program for the HP 9820A that does not copy empty files, is not wiped out by a binary file, and copies the files exactly. Also, it incorporates adequate explanatory material concerning the use of the program and the copying of binary files.

I have used this program several times and found it efficient and trouble free. It may be that other people have run into the problem of copying tapes and could use this program.

```
0:
GTO 13⊢
1:
FXD 0;ENT "FIRST
 FILE NO.=?",A→C
⊢
2:
DSP "LOAD MASTER
";STP ⊢
3:
FDF A;IDF A,B,X,
Y;BKS ;IF X=0;A+
1→A;GTO +0⊢
4:
GTO 6;IF X=28;
PRT "FILE IS TYP
E 28";GTO 5⊢
5:
PRT "A=",A,"C=",
C,"Y=",Y;STP ⊢
6:
PRT "COPY FILE",
A;IF X=28;GTO 13
;LDF A,8⊢
7:
LDF A⊢
8:
DSP "LOAD COPY";
STP ⊢
9:
IF C=0;REW ;MRK
1,Y⊢
10:
FDF C;MRK 1,Y;
IF X≠2;GTO 13;
RCF C;GTO 12⊢
11:
RCF C,R(B-1)⊢
12:
C+1→C;A+1→A;GTO
2⊢
13:
PRT "TAPE DUPLIC
ATING","PROGRAM
FOR 9820"⊢
14:
PRT "---DOES NOT
 COPY","EMPTY FI
LES.  IF"⊢
15:
PRT "INITIAL FIL
E NO.","ON COPY
TAPE IS"⊢
16:
PRT "NOT ZERO (N
OT ON","CLEAR LE
ADER),","ENTER T
HIS INIT-"⊢
17:
PRT "IAL FILE NO
. IN","REGISTER
C (WHEN"⊢
18:
PRT "THE COPY TA
PE IS","LOADED).
";SPC 2⊢
19:
PRT "THE PROGRAM
 WILL","PRINT OU
T A,C,&Y"⊢
20:
PRT "VALUES AND
THEN","HALT WHEN
 A TYPE"⊢
21:
PRT "28 FILE IS
MET.";SPC 2;PRT
"BEFORE LOADING
A"⊢
22:
PRT "TYPE 28, RE
CORD","THIS DUPL
ICATING"⊢
23:
PRT "PROGRAM BEC
AUSE","ALL OF TH
E USER","RWM WIL
L BE DE-"⊢
24:
PRT "STROYED BY
SUCH","LOADING."
;SPC 2⊢
25:
PRT "TO COPY THE
 TYPE","28, PRES
S LDF A ("⊢
26:
PRT "EXC)--THEN
LOAD","COPY TAPE
--PRESS","FDF C
(EXC)-MRK"⊢
27:
PRT "1,Y(EXC)-IS
P 1,C","(EXC)-IS
P 2(EXC)","--FIL
E IS COPIED";
SPC 2⊢
28:
PRT "RELOAD DUPL
ICAT-","ING PROG
RAM AND","GTO 1
TO RESUME-"⊢
29:
PRT "BE SURE TO
ENTER","CORRECT
NEW VAL-","UES F
OR A AND C.";
SPC 8⊢
30:
GTO 1⊢
31:
END ⊢
R287
```