Keyboard

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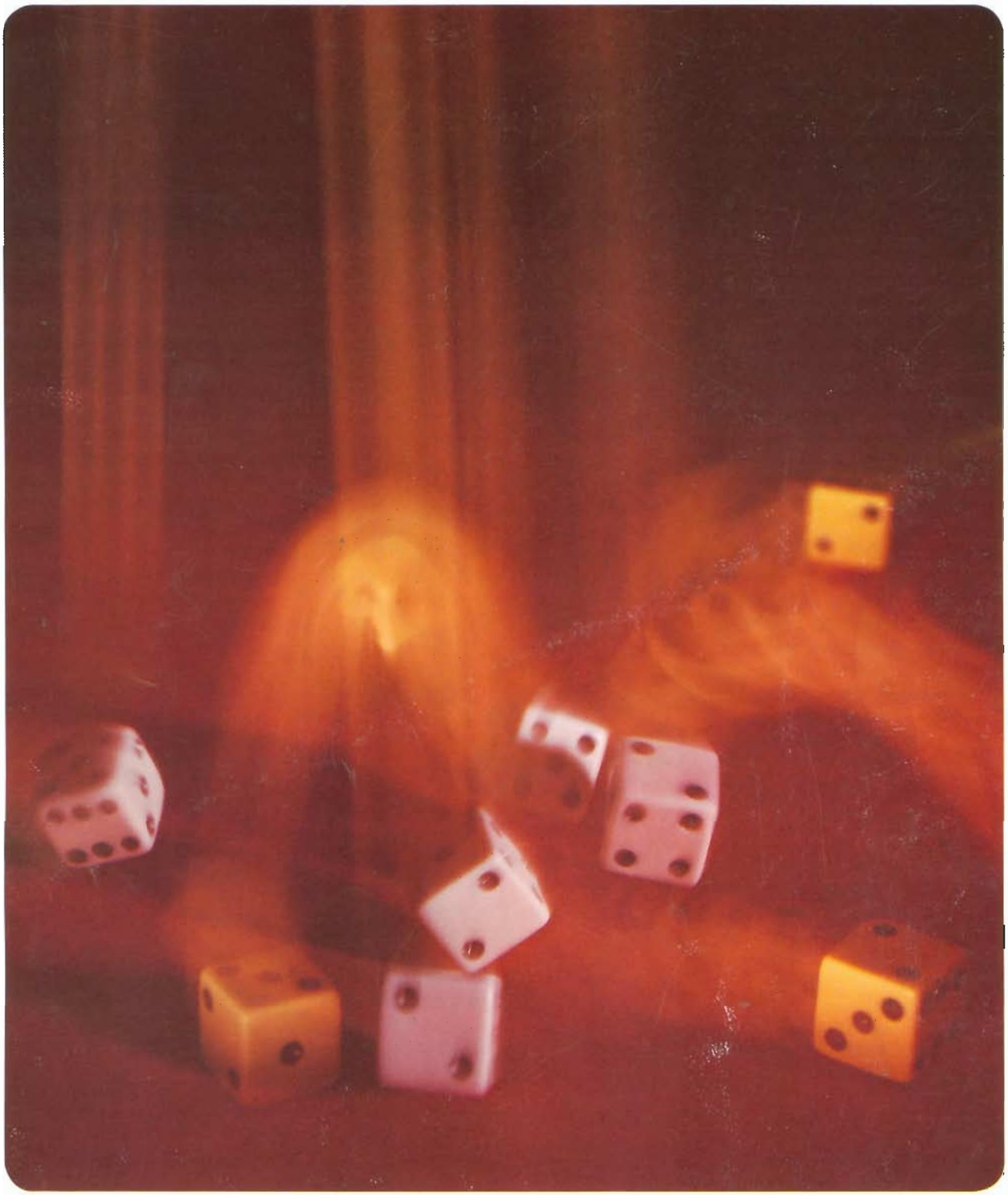

Keyboard

The Cover

Philosophers disagree whether the universe is deterministic or governed by chance. In any case, chance happenings and random events do play a large part in our lives and - perhaps unexpectedly - in computer programs as well. The dice on the cover symbolize the generating of random numbers, which is the topic of this issue's "Crossroads" article.

Features

Departments

Using the 9830A in the Clinical Laboratory

Economy and Efficiency are Benefits Gained

by H. Keller, P. Schleuss, R. Niederer

Grames and Pastor recently stated, "During the past 15 years the clinical laboratory has served as the nidus for medically based investigation of computer technology." Much of the extensive literature on this subject reports favorably on the use of computer systems, but personal observation indicates the contrary. In many cases the expense of acquiring, maintaining and operating a computer system is disproportionately high compared to the actual benefits gained. Also, the variety of reported concepts and configurations is confusing.

To help overcome these problems, we have tried to develop a hardware system that is less expensive, easy to operate and maintain, and 'hat offers both general-purpose and special support of laboratory duties. Such special support as calculation of RIA results is especially useful where the total system is not needed for all the lab requirements.

Our 9830A system is designed to accomplish the following aims:

- More accurate test analyses
- Shorter time between incoming specimens and test results
- Improved format and information content of test results
- Fewer lost requests and/or reports
- Fast retrieval of information
- Decreased overall lab operating expenses

It is not necessary to change the routine clerical work in the hospital, such as handling of patient data or in the processing of material on outpatients or from private practitioners.

I shall describe the actual working situation at our Institute at St. Gall, Switzerland, for clinical chemistry of serum or plasma. Similar forms of organization are in development for urine analysis, hematology and coagulation tests. I shall also report the experiences collected during approximately 30 months in which our system has been operating.

The Kantonsspital (hospital of the region) at St. Gall is a general medical center with 1100 beds. It is divided into four departments with 12 different clinics and four diagnostic institutes. Two-thirds of the test requests come from the hospital clinics and one-third from other hospitals and private practitioners.

200 to 300 samples are processed each day. On the average, 6.5 tests per patient specimen are ordered. The entire program of tests consists of more than 100 procedures. Of these, however, 20 tests cover 90% of all orders.

For routine chemistry of large series (high volume testing), we use an SMA 12/60 autoanalyzer for substrate analysis and the Eppendorf Enzyme-Automat for enzyme analysis. In addition, there are some one-channel autoanalyzers for iron and copper determination and several Eppendorf photometers for short series (low volume testing). For emergency requests, we use a DuPont automatic chemical analyzer (ACA) in connection with two manual flame photometers.

For special chemistry, we use a Perkin-Elmer spectrophotometer and a fluorometer, reflectionphotometers, and LKB equipment for electrophoretic work. The RIA lab is equipped with Nuclear-Chicago beta and gamma counters.

In the autumn of 1974 we started electronic data processing. The HP 9830 serves as our computer. It has a 32k byte memory and is expanded with some ROMs for an additional

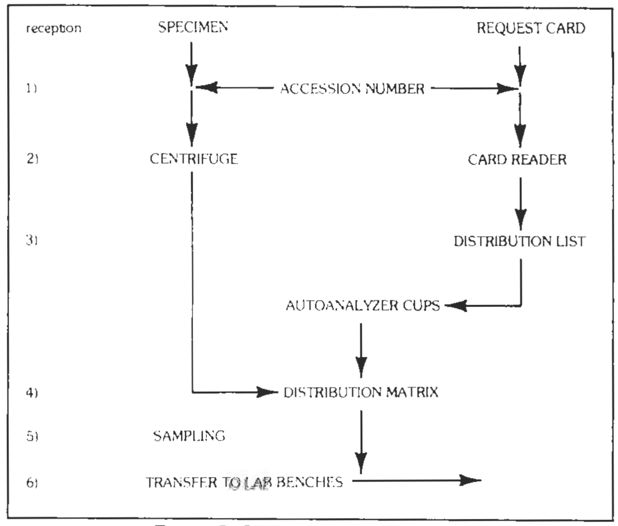

Figure 2. Steps in the test procedure.

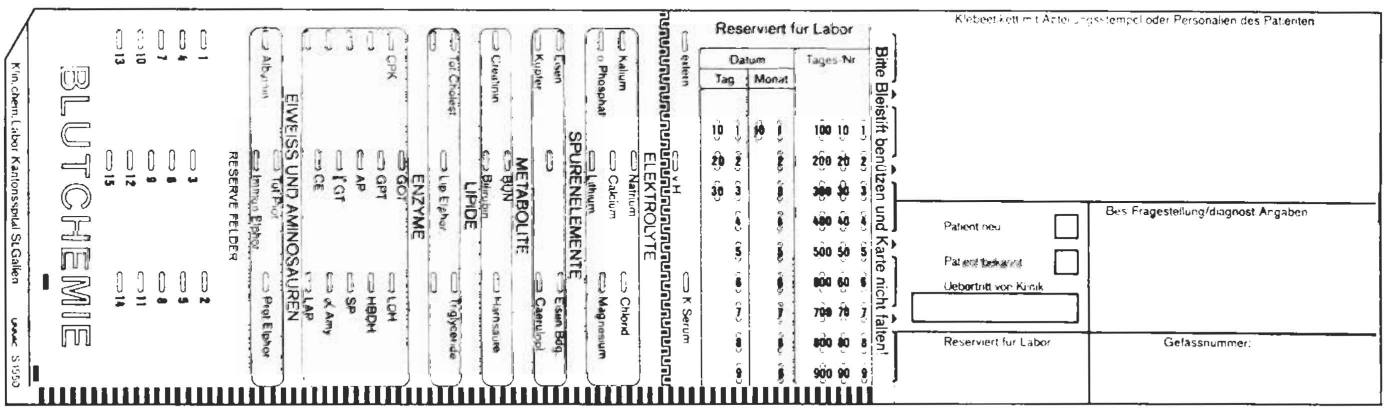

Figure 1. Test request card.

order repertoire. A 9880 mass memory with two 2.4M byte discs completes the hardware configuration.

The input consists of a 9869 card reader with select hopper, a 9883 punch tape reader and an HP 2640 display terminal. The output is a 9866 thermal printer and a Dataprint 3300 matrix printer with double tractor.

The inpatient's blood is drawn using monovettes, each labeled with a five-digit number. Medical tests are ordered on either a request card or an emergency request card. Each patient has received an adhesive label with his or her name, address, social security number, etc. This label is stuck on the request card (shown in Figure 1) and the nurse writes the number of the monovette in the cover field on the right side of the card. By doing this, we reduce the number of wrongly labeled blood containers to a minimum. (The nurse knows that a discrepancy between the tube number and the written card number leads to rejection of both tube and card.) Now the physician can order the tests by marking the card with a pencil.

The samples and cards are sent from the hospital wards to the lab between 8:00 and 9:00 a.m. At the lab, all specimens get their daily accession numbers, beginning each day with #1. This number is stuck on the tube with an adhesive label and marked on the card in a machine-readable form.

The samples are centrifuged in batches of 20 to 60 tubes. From now on, the samples can be identified only by their accession number. During centrifuging, the computer reads the test request cards and produces a distribution list of accession numbers and the tests requested for the distribution matrix.

This distribution matrix has a series of trays bearing 350 vertical columns marked with accession numbers. Each column has 15 positions marked with the letters A to O, which represent the analyzers and work stations. The centrifuged specimen tubes are placed in numerical order on the top of each matrix column. Small processing cuvettes (autoanalyzer cups) bearing the same numbers as the specimen tubes are placed in the appropriate positions along the column.

The tubes of plasma remain in place on the matrix. The plasma is distributed into the autoanalyzer cups with disposable pipettes. See Figure 2 for a chart of the overall procedure.

Data handling starts with the distribution list, accompanied by an ACA working list. The working lists for the SMA sequence, the enzyme sequence and the work stations are then printed. These lists are not necessary, but they are useful for control purposes.

The main advantage of our distribution system is that tests and analyses can begin before all specimens reach the lab. (It could happen, for instance, that specimens #1 to #50 are on the benches, #51 to #100 are being distributed, #101 to #150 are in the centrifuge, and the rest have not yet been received.) In the morning, half the personnel are working in the reception room with the matrix, and the other half are getting the analyzers ready, etc.

The production of distribution and working lists is based on the computer knowing which tests belong to which analyzer or work station. The operator, however, may change the lists. Should

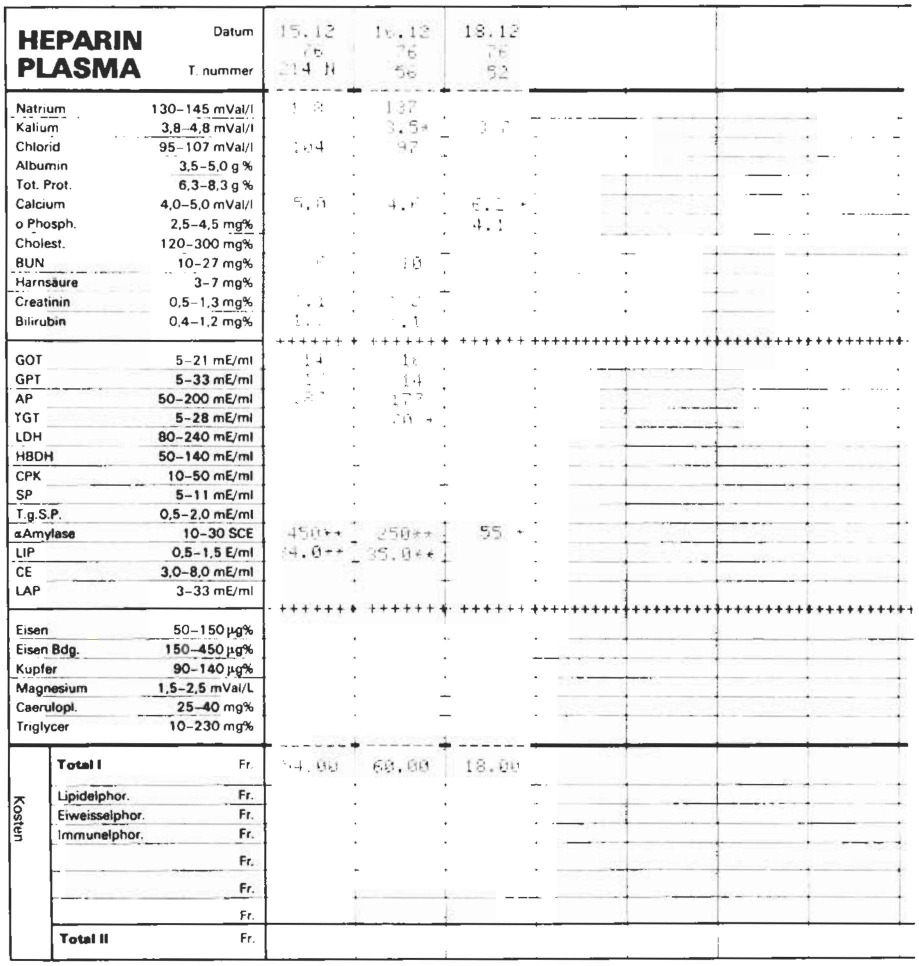

Figure 3. Master card with 9866 printout attached.

this occur, the system automatically adjusts to a new level or priority.

For instance, if the blood urea nitrogen (BUN) channel of the SMA autoanalyzer breaks down, the operator gives the following information to the 9830 system: "SMA-BUN-DOWN". The system will then assign any order for BUN tests to the ACA list or the manual list, in that order of priority.

Test results are documented in three ways:

1. The result card. This is a mark-sense card used for routine tests. Three types of cards are available, and it is very easy to learn the handling of data in this manner. The accession number and results are marked in pencil. Because of the limited range and order of magnitude of the results, it is very difficult to enter illogical numbers. Our experience shows that the number of mistakes on marked cards is much smaller than on conventional documentation.

2. The big analyzers such as the SMA, beta and gamma counters, etc., produce punched tapes. The 9830 system knows the sequence of standards, controls, blanks and accession numbers. This ensures the coordination of results and numbers. In the case of radio receptor assays, the system performs all necessary calculations.

3. Punched cards are used if longer alphanumeric tests are necessary (name of patient and physician, etc.). This is used, for instance, in electrophoretic procedures.

The operators enter corrections through a CRT. This is the only job for which a few specially trained people are needed.

Data is presended in the following three formats:

1. The cumulative report for internal patients. For blood chemistry and other lab tests, we have developed a master card with a field for the identification label at the top right, a column with test names and reference values and columns for dates and results.

The system prints the results in a format matching the columns on the master card, the printout is attached, and the master card is then photocopied and sent to the ward (Figure 3). The master cards are filed alphabetically to ensure that control is maintained and information is always available.

2. For external patients and private practitioners, the system prints a formal letter listing all analytical data and any additional comments.

3. For thyroid diagnostics, we calculate the diagnostic relevance according to Krieg et al with a very good response from the clinicians.

A similar kind of computer diagnostic is under development for lipid profiling, but in this field we must accumulate more experience.

The 9830 system also provides the following:

1. List of all tests being carried out, the results of which have not been received.

2. List of all results of certain tests.

3. List of all numbers for which a certain test was ordered.

4. Conventional quality control list.

5. Quality control list as Cusum test.

6. List of all external patients.

7. List of all external private practioners who have sent in orders that day.

8. List of completed daily workload.

9. List of completed workload for the year (accumulated on a magnetic tape).

All lists are printed by request only to prevent a paper jungle.

The 30-month experience with this computer-based organization model has been completely satisfactory, especially because the computer is not a *conditio sine qua non* for lab operations. A breakdown of the data system has never caused restrictions of the lab functions. Furthermore, our technical and administrative people have become familiar with the 9830 in a very short time and prefer to work with its assistance.

We began duplication of the 9830 system two years ago and have added a second 9830, disc memory, card reader, terminal and matrix printer.

Because of the modular program and the high level BASIC language, it is possible to introduce changes in organization, instrumentation, test sequences, etc. The 9830 data system can be adapted quickly and easily by virtually anyone.

Our system is a realistic tool for the support of lab operations. It saves us money and time to such a degree that it will have paid for itself in a few years. But more important are the gains in security, precision, and clarity of laboratory operations.

About the Authors

Herbert Keller, MD, PhD, studied medicine and chemistry at the University of Berlin, Munich and Erlangen. He was assistant and teacher at the Universities of Bonn, Aachen and Kiel. In 1963 he became Director of the Institute for Clinical Chemistry in Stuttgart and since 1970 has headed the Institute for Clinical Chemistry and Hematology of the Kanton St. Gall.

Peter N. Schleuss studied physics at Zurich University before he joined Sperry Univac Zurich. After a postgraduate EDP course he worked for the company's medical and hospital division for three years and was promoted to senior system analyst. A further step in his career was to become Technical Director of the Pathological Laboratory at Kanton St. Gall, where his main goal was to develop the laboratory's EDP system. Since 1977 he has been a government official of the Swiss Ministry of Defence. His hobbies are sailing, photography and model railroads.

Robert Niederer graduated from the Technical College in Buchs with a BSEE in Electronics with Specialization in Measurement and Control. He has been employed at Kanton St. Gall since May of 1976.

END

The distribution matrix is the nucleus of the laboratory's operations. The blood samples are centrifuged and distributed, according to accession numbers and the analyzer(s) assigned by the 9830 system, into the column positions. From there the specimens are taken for the tests that were ordered. It is apparent when all tests of a specimen are completed.

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New Products

7245A Plotter/Printer

by Bob Reade, Hewlett-Packard, San Diego Division

High quality graphics, fast printing and a continuous page format are combined in the Hewlett-Packard 7245A Plotter/Printer to bring unattended graphics, long-axis plotting and extensive plot annotation to your Hewlett-Packard Desktop Computer.

With a printing speed of 38 characters per second and plotting speeds greater than or equal to that of dedicated vector plotters, the 7245A is an excellent general-purpose output device to your HP-IB controller. Some areas of application are engineering design, production testing, data acquisition, process monitoring, analytical plots, long-term business forecasting and project management.

The microprocessor-based 7245A combines a 61m (200 foot) roll of paper and a bidirectional paper drive that acts as a chart advance for unattended plotting and long-axis plotting. The combination of a sprocket paper drive and patented microstep motor drive gives the 7245A Plotter/Printer excellent line quality and repeatability. The paper can be backed up for a length of 5 m and a point repeated within an accuracy of 0.25 mm.

A state-of-the-art thin film, thermal print head makes possible the combination of vector graphics and fast printing. It has 12 resistors to print 7 x 9 half-shifted matrix characters at 38 cps in four orthogonal directions. This font allows 88 columns to be printed across the page. A larger 14 x 9 matrix font is used to print titles at 19 cps in a 44-column format.

The same HPGL and Plotter ROM commands that drive the 9872A Plotter drive the 7245A.

For easy programming there are 46 built-in programmable instructions for such features as user unit scaling, graph rotation, point digitizing, character size, slant, direction, seven dash line fonts and 5 drawn and 8 matrix character sets, six of which are European.

Standard printer escape code sequences enable you to set, execute and clear tabs, form-feed forward or reverse, change character size, underline, select any of eight character sets and select the display functions mode for printing all 128 ASCII characters, including the control code characters.

(New Products continued on page 6 & 7)

9875A Cartridge Tape Unit

by Dave Morse, Hewlett-Packard, Calculator Products Division

The new 9875A Cartridge Tape Unit expands data and/or programming storage for these desktop computers: System 45, 9825A, 9831A, 9830A/B, 9815A and 9820/21A.

It uses the same data cartridge as the 9825A and other current HP Desktop Computers. The standard 9875A contains a single tape drive; a second tape drive is available as an option. Each tape can contain up to 225k bytes of data - a feature especially attractive to users who are tape-storage bound with their present mainframe. The 9875A has an HP-IB interface and can be connected to any computer having an interface also conforming to IEEE Std. 488-1975.

A 16-bit microprocessor controls the 9875A, providing an extensive command set consisting of two-letter mnemonics. For example, the character sequence MF5,4; sent to the 9875A will direct it to mark five files of 1024 bytes each. The tape can be partitioned into files and records, much like the structure of a disk memory. Since the tape can be accessed to the record level, there is exceptional flexibility in manipulating data.

Data Collection/Transportation

Several features of the 9875A are particularly useful for interfacing or data logging. One of these features is a talk-only or listen-only mode. In the listen-only mode and with a data cartridge inserted, the 9875A records any data presented on the HP-IB. The 9875A therefore can be used as a stand-alone data logger on an HP-IB system - it does not need a controller.

In the talk-only mode, the 9875A automatically reads the contents of file 1 on the tape and outputs it to the bus to drive a listen-only device, such as the HP 9871A Printer, again without the need for a controller.

A second useful feature is a time delay function. By setting the 9875A to delay a fixed time period between accepting or outputting values, the bus is paced. This eliminates the need for a real time clock in many cases.

Standardized Format

Another major feature is the new tape format, SIF (Standard Interchange Format). SIF will be available on many future HP products. Tapes produced by the 9875A can be read in the System 45 internal tape transport. Other 9875A performance specifications are similar to those of the internal tape drive for the 9825A or System 45.

Applications

Among the many applications for the 9875A are data logging without a bus controller, data interchange between dissimilar desktop computers, and providing increased on-line storage capacity. The 9875A can be used in virtually any system incorporating an HP-IB interface.

The following example illustrates the use of the 9875A as a data logger.

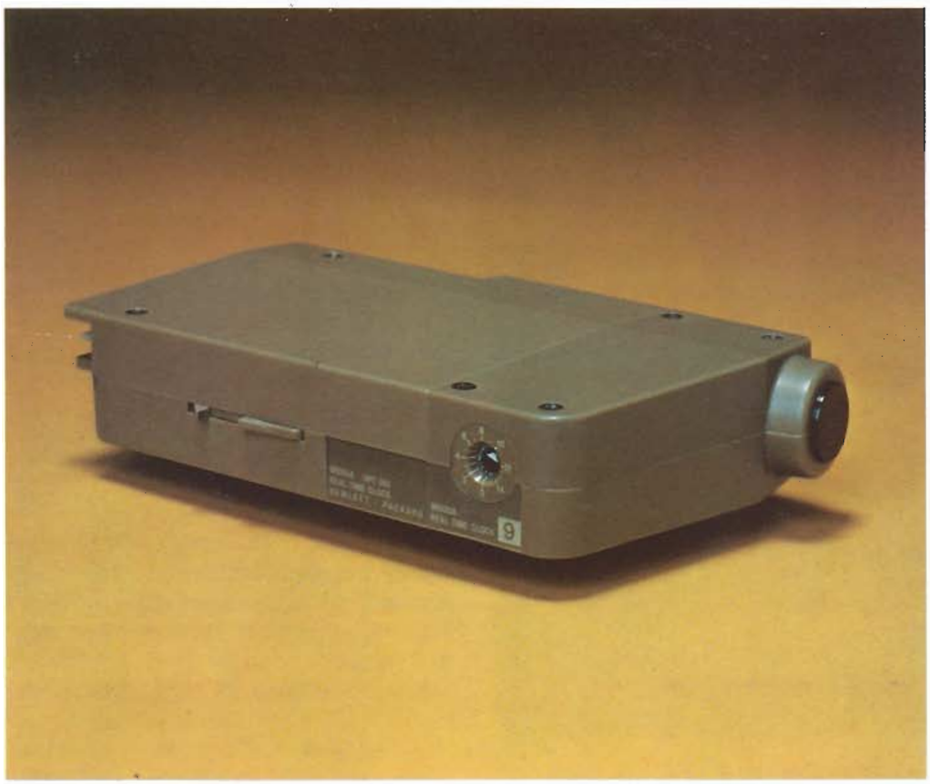
DVM → 9875A
↓
Test Fixture

The situation is production testing an electronic part using a DVM (digital voltmeter). The technician performs a go/no go test on the part, basing decisions on the voltage reading being within a given tolerance. The task is simple enough to be performed without a bus controller, since the DVM is controlled manually. In this case, the 9875A is used in the listen-only mode and accumulates readings as they are made. The tapes are saved and later analyzed by a desktop computer.

In the next example a 9875A is added to an existing HP-IB system controlled by a 9815A Desktop Computer.

```
        DVM    Scanner
         ↑        ↑
9815A ──────────────── 9875A
                  ↓
               Counter
```

Before the addition of the 9875A, the 9815A logged the test system data on its internal tape cartridge. The 9815A data cartridge holds 96k bytes of information. The user has programs on one track of the tape and uses the second track for data (48k byte capacity). With the addition of a dual-drive 9875A, on-line storage capacity is increased to 450k bytes. If still more storage is needed, additional 9875A's can be added.



98035A Real Time Clock

by Jackye Churchill, Hewlett-Packard, Calculator Products Division

What Is a Real Time Clock and How Do You Use It?

Real time clocks usually provide only a means of reading a calendar (month, day) and time of day (hour, minute, second). Another timing device, the timing generator, supplements the real time clock by providing other functions of subsecond timing, time interval measurements, system pacing, and system scheduling.

Many instrumentation systems need timing capability. For example, in a measurement system the time of day, interval timing and system pacing could be used to

- Schedule measurement sequences,
- Log data with calendar and time notation,
- Measure time between events,
- Execute program benchmarks,
- Plot events against a time axis,
- Insert known delays between measurements, and
- Initiate measurements on a periodic basis, precisely paced.

98035A Real Time Clock

An interface card recently introduced gives the 9825A, 9831A and System 45 all the capabilities of a real time clock and a timing generator. HP's 98035A Real Time Clock provides

- Real time information - calendar and time of day,
- Interrupts at a specified time, after a time delay and at periodic intervals,
- Counters incremented every millisecond to time events,
- An internal nickel cadmium battery that allows the 98035A to hold the real time for up to two months when it is not in use, and
- An optional external trigger cable to output pulses to external devices.

Setting real time is easy with the 98035A, and once the time has been set the accuracy of the clock remains at ±52 seconds per month. The real time can then be read in one of two formats - U.S. or European. European time format (Opt. 002) is day, month, hour, minute, second. U.S. format (Opt. 001) is month, day, hour, minute, second. Also, the 98035A is a 24-hour clock; 3:00 p.m. is represented as 15:00:00.

Timing Units

The HP 98035A contains four timing units that can be used in either interrupting or counting mode. In interrupting mode, you can configure any or all of the timing units to interrupt the 9825A or System 45 at a specified real time match, after a specified time delay, at a specified periodic interval, or at any combination of these. In counting mode, you can use any or all four units as counters to determine time intervals for the length of an event or the time elapsed between two events.

Counting Mode

In counting mode, the timing units are incremented every millisecond and can be used over a range of 1 ms to 115 days. Counter value can be read at any time and is accurate to 1 ms. You can also clear the counter to start timing an event or use the counter as an accumulator to determine the entire duration of several different events.

Interrupt Mode

Timing units can provide an interrupt to the 9825A or System 45 in one of three ways or in any combination of the three — real time match, delay or periodic. Interrupt is not available on the 9831A.

The real time match can be any day, hour, minute, second. The range of both the delay interrupt and the periodic interrupt is 1 ms to 1.16 days.

If a real time match and a delay are specified, only one interrupt will occur at the time of delay after the real time match. If a periodic interval is specified, interrupts occur at each of those intervals until halted.

If you would like more information, please contact your nearest Hewlett-Packard sales and service office or write to KEYBOARD, 3400 E. Harmony Road, Fort Collins, Colorado 80521, U.S.A.

END

Crossroads

by John Nairn, PhD
Hewlett-Packard
Calculator Products Division

"Almost all good computer programs contain at least one random-number generator."
Donald Knuth

Since the 9825, 9830, 9831, and 9845 Desktop Computers all have built-in functions for generating random numbers, I often get questions regarding these random numbers. They range from such general questions as, "What are random numbers?" and "What are they used for?" to more specific questions such as "What method is used to generate these random sequences?" and "How good are these built-in generators?"

In this article I will try to answer some of the questions concerning the nature and usefulness of random numbers. Methods of generating and testing sequences of random numbers will be discussed in a later "Crossroads" article.

First, we may as well get this discussion off on the right foot by flatly stating there is no such thing as a random number! Every number has certain properties that can be attributed to it. For example, the number four can be described by the terms "positive," "integer," "even," and "perfect square." But isolated by itself we cannot say that four is a random number any more than we could say that four is a large or a small number without knowing to what other set of numbers its size is being compared. Rather, the term "random" is applied to a sequence of numbers having two properties. The first property involves the concept of a distribution over a given range. For example, if we wanted to form a random sequence of the decimal digits (0, 1, 2, ..., 9) we would say that our sequence is formed from integers in the range zero to nine. In addition, if every digit has the same probability of occurring in our sequence as every other digit, then we say that random sequence has a uniform distribution.

The method used to generate sequences of random numbers can affect both the range and the distribution. If, for example, we repeatedly throw a six-sided die and write down the sequence of numbers that appear, this sequence would be over the range one to six and would have a uniform distribution, since (assuming the die is not loaded) each of the six faces is equally likely to appear on a given throw. If, on the other hand, we were to repeatedly throw a pair of dice and write down the sum of the numbers shown on the two dice for each throw, we would generate a random sequence of integers in the range two to 12. This sequence would not be uniformly distributed, since the probability of the middle values (centered about seven) is greater than that of the end values (two and 12).

The second property of random sequences is that each member of the sequence is independent of the other members. This simply means that knowing the first n-1 elements of the sequence does not affect the probability of the n^{th} element. For many people not familiar with random sequences, this property often is difficult to grasp. For example, if I wish to generate a random binary sequence made up of ones and zeros, I can do this by repeatedly tossing a coin and writing down a one for heads and a zero for tails. Many people believe that if I have just thrown a sequence of 10 heads in a row, I will be more likely to get a tail on the next throw. But if the coin is an unbiased one, the probability of a tail is exactly ½, independent of the long string of heads that preceded it. For this reason, humans make extremely bad random number generators. As an experiment, ask someone to write down a sequence of 20 or 30 random digits (0 through 9). Most people will try to "spread them out" by writing all of the digits once before repeating any, and they will usually avoid writing the same digit twice in a row, such as 22 or 33. However, in an actual random digit sequence, such digit pairs would occur about 10% of the time.

In using mechanical means for generating random numbers (coins, dice, cards, etc.) one should be careful that the principle of independence is not violated by the method of generation. For example, if we wanted to generate a sequence of five random digits in the range one to ten with a uniform distribution, we might decide to use a deck of playing cards with the face cards removed. The 40 cards would be well shuffled and five cards dealt. The resulting sequence of five random digits would not, however, be independent. If the first card dealt is a seven, then the remaining deck contains three sevens and four of each of the other digits. Thus on the second card dealt, the probability of dealing a seven is less than that for the other digits. We could make our sequence truly independent by writing down the first card dealt, replacing it in the pack, re-shuffling, and dealing the next card.

There are many ways of generating random sequences of numbers over a wide variety of ranges with various distributions. Most of these are very time consuming to actually perform. And as a result, this task is now commonly given to a computer. These so-called random number generators usually generate decimal fractions in the range zero to one with a uniform distribution. If other ranges or distributions are required, they can be gotten by manipulating the output of this standard generator. For example, if we wanted to simulate the throw of a die (i.e. generate random digits in the range one to six), we could use the expression

R = INT (6*RND + 1)

where the function RND returns a uniformly distributed random number in the range 0≤RND<1 and INT is the integer function.

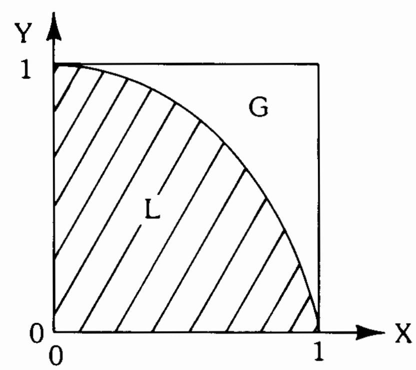
Before looking at how computers generate random number sequences, we will first consider why we would even want to have these sequences. One application is in simulation, or modeling real-world situations on a computer. For example, a traffic engineer might have several proposed timing sequences for a set of traffic lights at an intersection and would like to know which one is most efficient for moving cars through that intersection. The engineer could model this on a computer and simulate the random arrival of cars from the various directions and whether they wished to go straight or turn at the intersection.

Another application of random numbers is in the area of sampling. For example, the quality assurance group at a manufacturing plant wants to test products coming off a production line. But because of time and expense, only 10% of the products can be tested. One method might be to test every tenth item. However, if there were some correlation between bad products and their position on the line, this method might miss the bad items altogether. A much better method would be to generate random numbers in the range one to 20 and use these to pick the items to be tested. On the average, 10% of the products would still be sampled for testing, but without any correlation to the actual manufacturing process.

Many times complex mathematical functions and integrals can be extremely difficult to solve analytically. But approximations for their values can be obtained using the techniques of numerical analysis with random numbers. As a simplified example, we could use random numbers to approximate the value of PI = 3.14159.... To do this, we would generate pairs of random numbers, X and Y in the range of 0 to 1, and compute the value of

$$D = \sqrt{X^2 + Y^2}$$

For each pair generated, we would keep track of how many values for D were less than one (call this number L) and how many were greater than one (G). The shaded area in the figure would then be L/(L + G). And since this area is also equal to PI/4, we can approximate the value of PI by 4L/(L + G).



The more trials we perform, the better the final approximation to the value PI becomes. Because of its random nature, this method is often called Monte Carlo evaluation, after the famous gambling center.

And finally, random numbers are often found useful in computer programming for testing new algorithms. For example, random numbers could provide test data for a number-sorting routine to reduce the likelihood that the method used for sorting is somehow data dependent. If the programmer made some false assumptions in writing the sorting routine, he or she is likely to make these same false assumptions in generating the test data.

When computers are used to generate sequences of random numbers, the objection is often raised that these sequences cannot be truly random, since the next number in the sequence is predictable from the previous value and the generating algorithm. Indeed, this is true, and the sequences of numbers generated are sometimes called pseudo-random or quasi-random. In actual application, the fact that these pseudo-random sequences are repeatable is often an advantage. A program using random numbers would be extremely difficult to debug if a different set of random numbers were generated each time the program was run. And in most applications the only requirement for a random sequence is that it have no correlation with the thing being simulated, sampled, or tested. In practice, a sequence that is "apparently random" is usually acceptable. In a later article we will see that there are several tests that can be applied to measure how good or apparently random is the output of a computer random number generator. The generators provided by several HP desktop computers are intended as a convenient source of random numbers for simple applications. If a user has an application that requires a more sophisticated generator, he or she should probably provide his or her own routine, the characteristics of which are familiar.

In the next "Crossroads" article we will look at how the computer generates sequences of random numbers and at methods for determining uniformity, cycle length, and other characteristics of these generators. END

Potential Flow Around Arbitrary Airfoil Sections

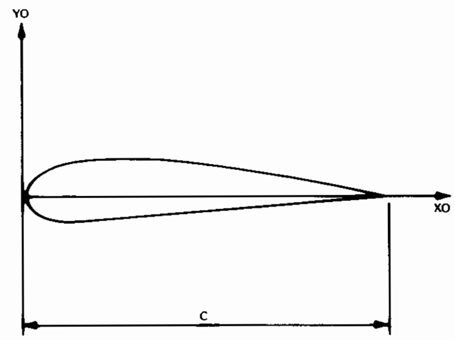


Figure 1. Airfoil coordinate system.

Airfoil Design and Analysis on the 9820A and 9862A

by Waldo I. Oehman

The potential flow around an arbitrary airfoil section may be calculated by using the theoretical method developed by Theodorsen nearly 50 years ago (see references 1 and 2). The theory of functions is used to transform the known flow around a circle into the flow around an airfoil section. The circulation of the flow is adjusted so that a stagnation point (that is, the local velocity is zero) occurs at the trailing edge of the airfoil section on the x-axis. The local velocity and, hence, the pressure coefficient at the airfoil surface can be calculated from the transformed flow around the circle.

The HP 9820A Calculator performs all of the calculations required to obtain optimum potential flow through the use of a program developed to aid in the design and analysis of low-speed airfoil sections. A second program, taken from the Model 20 Math Pac and slightly modified, is used as subroutines for integrations and plottings.

While a number of programs have been developed to perform this function on large, high-speed computers, these facilities may not always be available. Even if a large computer is available, a saving in turnaround time often may be realized by using the HP 9820A if the large computer must be shared with other users.

Theory

Theodorsen's basic ideas and equations pertinent to this article are as follows.

The airfoil section is transformed into a nearly circular section using the transformation function

$$\zeta = z' + \frac{a^2}{z'} \tag{1}$$

where $\zeta = x + iy$ represents the locus of points on the airfoil sections, and $z' = ae^{\psi + i\theta}$ represents the locus of points on the nearly circular section. The parameter a is a geometrical scale factor and ae^{ψ} is the radius of the nearly circular section at an angle θ. From Eq. 1, two equations for x and y in terms of ψ and θ are obtained. They are

$$x = 2a \cosh \psi \cos \theta$$

$$y = 2a \sinh \psi \sin \theta \tag{2}$$

Solution of Eq. 2 for ψ and θ gives the following equations:

$$\theta = \sin^{-1}\sqrt{\frac{p}{2} + \frac{1}{2}\sqrt{p^2 + \left(\frac{y}{a}\right)^2}} \tag{3}$$

where

$$p = 1 - \left(\frac{x}{2a}\right)^2 - \left(\frac{y}{2a}\right)^2$$

and

$$\psi = \log_e\left(\frac{x}{2a\cos\theta} + \frac{y}{2a\sin\theta}\right) \tag{4}$$

The second transformation function transforms a circle into a nearly circular section. The function is

$$z' = ze^{\Sigma(A_n + iB_n)\frac{1}{z^n}} \tag{5}$$

where the loci of points on the circle are given by $z = ae^{\psi_0 + i\phi}$. This transformation leads to equations that relate ψ_0 and ϕ to ψ and θ and are required to calculate the flow field. The equations are

$$\epsilon_c(\phi) = (\phi - \theta)_c =$$

$$\frac{-1}{2\pi}\int_0^{2\pi} \psi(\phi) \cot\frac{(\phi - \phi_c)}{2}\, d\phi \tag{6}$$

$$\psi_0 = \frac{1}{2\pi}\int_0^{2\pi} \psi(\phi)\, d\phi \tag{7}$$

The subscript c means that the quantity is constant during integration.

The flow field around the circle can now be transformed into the flow field around the airfoil section. The circulation of the flow is adjusted so that a stagnation point (zero local velocity) occurs on the x-axis at the trailing edge of the airfoil section. The resulting velocity ratio distribution on the airfoil surface is

$$\frac{v}{V} = \frac{[\sin(\alpha+\theta+\epsilon)+\sin(\alpha + \epsilon_T)](1+\frac{d\epsilon}{d\theta})e^{\psi_0}}{\sqrt{(\sinh^2\psi + \sin^2\theta)(1 + (\frac{d\psi}{d\theta})^2)}} \tag{8}$$

where v is the velocity at the airfoil surface, V is the free-stream velocity, α is the flow inclination to the x-axis of the airfoil, and ϵ_T is the value of ϵ for $\theta = \pi$. Further, the pressure coefficient on the airfoil surface is

$$\frac{P}{q} = 1 - \left(\frac{v}{V}\right)^2 \tag{9}$$

where P is the difference between the free-stream pressure and the local pressure, and q is the dynamic pressure,

$$\frac{1}{2}\rho V^2.$$

Formulas for the lift and pitching moment, in coefficient form, are

$$C_\ell = \frac{8\pi e^{\psi_0}}{c}\sin(\alpha + \epsilon_T) \tag{10}$$

and

$$C_{m_0} = \frac{4\pi b^2}{c^2}\sin 2(\alpha+\gamma)+C_\ell\frac{m}{c}\cos(\alpha+\delta)$$

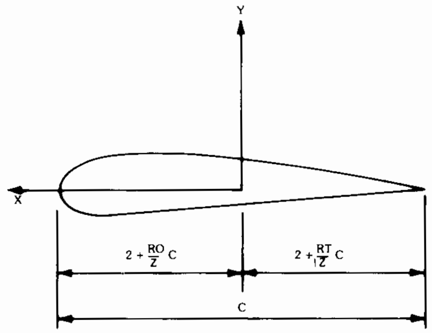


Figure 2. Transformed coordinate system.

where b^2, γ, m, and δ are obtained from

$$A_1 + iB_1 = me^{i\delta}$$

$$\left[1 + \frac{1}{2}(A_1^2 - B_1^2) + A_2\right] + i\left[A_1 B_1 + B_2\right] = b^2 e^{i2\gamma}$$

with

$$A_n = \frac{e^{n\psi_0}}{\pi}\int_0^{2\pi} \psi(\phi) \cos n\phi \, d\phi \qquad n = 1, 2$$

$$B_n = \frac{e^{n\psi_0}}{\pi}\int_0^{2\pi} \psi(\phi) \sin n\phi \, d\phi \qquad n = 1, 2$$

The pitching moment coefficient with the reference point at the airfoil quarterchord is

$$C_{m, c/4} = C_{m_0} - C_\ell x_0 \cos\alpha \quad x_0 = \frac{x_{L.E}}{c} - \frac{1}{4} \qquad (11)$$

Program Description

A program was designed to calculate the velocity ratio, $\frac{v}{V}$ (Eq. 8), and the pressure coefficient, $\frac{P}{q}$ (Eq. 9) at the surface of an arbitrary airfoil section. In addition, the section lift coefficient (Eq. 10) and the pitching moment coefficient (Eq. 11) are calculated for each angle of attack. The airfoil coordinates (XO, YO) (see Figure 1) are transformed to coordinates (X, Y) as in Figure 2. The function $\epsilon(\phi)$ is determined by calculating the function $\psi(\phi)$ to a second approximation. From the airfoil coordinates, the function ψ is obtained as a function of θ. However, Eq. 6 requires ψ as a function of ϕ. Therefore, the desired function is obtained by expansion in a Taylor series

$$\psi(\phi) = \psi(\theta) + \frac{d\psi}{d\theta}(\phi - \theta) + ---$$

or, to a second approximation

$$\psi(\phi) = \psi(\theta) + \epsilon \frac{d\psi}{d\theta}$$

Similarly, a change of argument for $\epsilon(\phi)$ to $\epsilon(\theta)$ is obtained by

$$\epsilon(\theta) = \epsilon(\phi)(1 - \frac{d\epsilon}{d\phi})$$

The program offers the user five options for plots on the HP 9862A Plotter. Two of the options provide plots of the velocity ratio and the pressure coefficient as functions of nondimensional distance along the airfoil chord. Two other options additionally provide plots of the functions $\psi(\theta)$, $\psi(\phi)$, $\epsilon(\theta)$, and $\epsilon(\phi)$ versus the respective argument. Usually these plots are used in an analysis of the airfoil characteristics. Of course, one option is available for which no plots are produced.

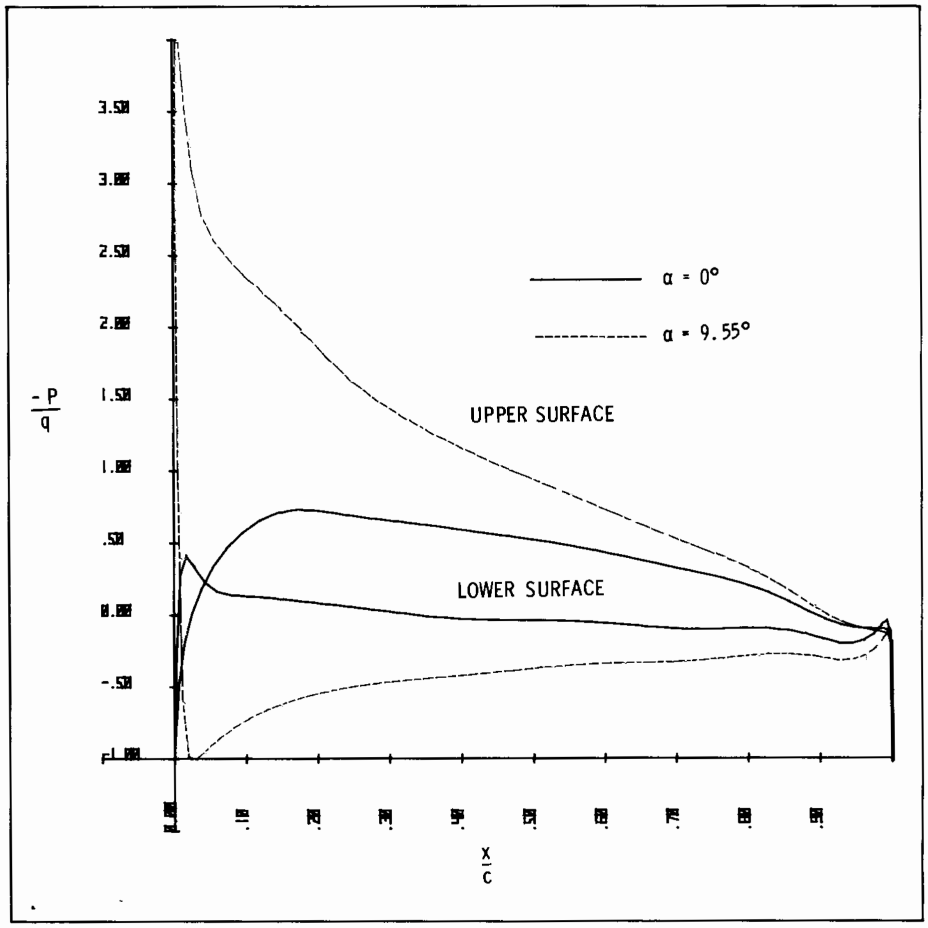


Figure 3. Theoretical pressure coefficient on a Clark Y airfoil section.

A short program has been included to record input values of the airfoil coordinates XO and YO.

The pressure distribution on a Clark Y airfoil section has been calculated to illustrate the use of the program. A plot of the pressure distribution for two angles of attack is presented in Figure 3.

Calculations using the Theodorsen method show a slight difference in the pressure on the upper and lower surfaces just ahead of the trailing edge, whereas in a non-viscous flow these pressures should be equal. Theodorsen chose the location of the rear stagnation point to be on the x-axis at $\theta = \pi$, rather than at the intersection of the extended chord line and the trailing edge radius. This difference was recognized by Theodorsen as a slight defect in the method and is believed to account for the difference in pressures just ahead of the trailing edge.

(continued)

Programming Tips

(continued from page 11)

In addition, small peaks in the pressure distribution plots at the trailing edge and waves forward of the peaks may be the result of using the cubic spline interpolation in a region where the functions are changing rapidly. The error is small, however, and occurs only near the trailing edge. Thus, the values of C_ℓ and C_m are not seriously affected.

User instructions and a program listing may be obtained upon request by writing to KEYBOARD, Hewlett-Packard, 3400 E. Harmony Road, Fort Collins, Colorado, 80521, U.S.A.

References

1. Theodorsen, Theodore: Theory of Wing Sections of Arbitrary Shape. NACA Report 411, 1931.
2. Theodorsen, T.; and Garrick, I.E.: General Potential Theory of Arbitrary Wing Sections. NACA Report 452, 1932.

About the Author

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END

Transferring Values (9830A)

Submitted by Daniel Treep, Folkert Postlaan 15, Abcoude, The Netherlands.

9830A users who want to transfer values from one vector or matrix to another may use the matrix assignment statement if they have the Matrix ROM installed in their calculator. MAT X = Y is the usual procedure. However, if the dimensions of the arrays are not compatible or if there is no Matrix ROM in the calculator, the transfer can be accomplished this way:

```
10 DIM X[10],Y[5,10]

100 R=4
110 FOR C=1 TO 10
120 Y[R,C]=X[C]
130 NEXT C
```

Those who have the String Variables ROM at their disposal can make transfers more efficiently:

```
10 DIM X[10],Y[5,10],A$[20]

100 R=4
110 TRANSFER X[1] TO A$
120 TRANSFER A$ TO Y[R,1]
```

Sometimes (not always) this procedure saves calculator memory, but at any rate the transfer of array values takes place much faster. The operation is also possible if the array elements do not represent ASCII characters; even negative values are allowed. The string must be at least twice as long as the number of elements that are to be transferred between the arrays, and the used part of the string must correspond exactly with this number. For instance:

```
10 DIM X[10],Y[5,10],A$[30]

100 R=4
110 TRANSFER X[1] TO A$
120 TRANSFER A$[1,20] TO Y[R,1]
```

or

```
100 R=4
110 TRANSFER X[1] TO A$[11]
120 TRANSFER A$[11] TO Y[R,1]
```

Parts of arrays can be transferred in a similar way:

```
5 DIM A[12],Q[6,13],Z$[18]

245 L=3
250 TRANSFER Q[L,5] TO Z$[9,16]
255 TRANSFER Z$[9,16] TO A[3]
```

The elements Q(3,5) through Q(3,8) are now transferred to A(3) through A(6).

The following restrictions must be kept in mind.

1. Only integer arrays can be handled in this way.
2. Matrix rows, not columns, can be transferred via strings. (Sometimes the Matrix "TRN" statement will be helpful.)
3. The maximum length of arrays that can be transferred at one time is 127, because the maximum even string length is 254.

Erasing 9825A Tape Cartridges

Submitted by Jackye Churchill, Hewlett-Packard, Calculator Products Division.

Error 43 can occur during an ERT (erase tape) operation to signify either a tape transport failure or an unexpected end-of-tape. Normally, this is due to an incomplete erasure caused by dirt on the tape or a loss of contact between the tape and the tape head during high speed movement. However, action must first be taken to determine if the error 43 was caused by tape transport failure. This can be done by rewinding the tape. If error 43 occurs again, it can be assumed the drive has failed. If error 43 is not caused by transport failure, the following steps can be taken to correct the problem.

The first step is to clean the tape head and capstan. Then rewind the tape and execute ERT. These two procedures can be repeated if necessary.

If the erasure remains incomplete, there still may be dirt on the tape. Several high speed end-to-end operations may be executed in an attempt to free the tape of dirt. The end-to-end operation is accomplished by executing these two operations:

```
rew
fdf 1000
```

If this procedure does not complete the erasure and eliminate error 43, the tape should be discarded.

Determining the Centroid of a Figure (9830A)

Submitted by Bob Floren, Red River Valley Potato Research Center, P.O. Box 113, East Grand Forks, Minnesota 56721, U.S.A.

This 9830A program finds the centroid of any figure traced with the HP 9864A Digitizer. The 9864A is commonly used to calculate areas and curve lengths, but the centroid capability may have been overlooked by many users.

The centroid coordinates, $\overline{X}$ and $\overline{Y}$, are closely approximated by the sums:

$$\overline{X} = \sum_{i=1}^{n} X_i \Delta A_i$$

$$\overline{Y} = \sum_{i=1}^{n} Y_i \Delta B_i$$

where

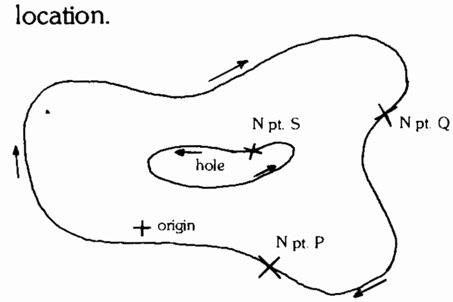
N = total number of points entered, at 4.5 pt./sec. rate,

ΔA_i = trapezoidal area increments having the Y axis as base,

ΔB_i = trapezoidal area increments having the X axis as base.

The centroid increments are calculated and summed in program lines 50 - 90. The SGN(Y) and (X-X1) terms in line 50 insure that the $\overline{X}$ increments are subtracted when X is increasing and Y<0, or when X is decreasing and Y>0. A similar rule holds for the $\overline{Y}$ increments. A clockwise tracing path around the area has been assumed.

When the area has been once circumscribed, the "0" key on the wand is pressed, which enters the (0,0) point. Lines 100 and 110 interpret this, stop data entry and cause the centroid coordinates to be printed in inches referenced to the origin. The routine of lines 500 - 520 can be used to pinpoint and mark the centroid location.



1. The origin is arbitrarily chosen, except that points S and Q must lie in the same quadrant.
2. Begin clockwise tracing at arbitrary point P on the boundary.
3. At arbitrary point Q, press "C" key on tracing wand to halt data entry. Slide wand to point S and press "C" to resume data entry and trace counterclockwise around the hole. When point S is reached, press "C". At point Q press "C" again and resume clockwise tracing.
4. When point P is reached, press "O" key on wand to stop data entry and print the centroid coordinates.

```
10 I=1
20 A=P1=P2=0
30 ENTER (9,*)X,Y
40 IF I=1 THEN 150
50 A1=SGN(Y)*(X-X1)*ABS(Y+Y1)/2
60 B1=SGN(X)*(Y1-Y)*ABS(X1+X)/2
70 A=A+A1
80 P1=((Y+Y1)/2)*B1+P1
90 P2=((X+X1)/2)*A1+P2
100 F=X↑2+Y↑2
110 IF F<0.01 THEN 190
120 Y1=Y
130 X1=X
140 GOTO 30
150 I=2
160 X1=X
170 Y1=Y
180 GOTO 30
190 P3=P1/A
200 P4=P2/A
210 PRINT "AREA ="A,"CENTROID:
    X ="P4"Y ="P3
220 PRINT
230 END
500 ENTER (9,*)X,Y
510 DISP X,Y
520 GOTO 500
```

Implementing a Binary Switch (9830A)

Submitted by Andrew Vettel, Jr., Science Dept., Steel Valley School District, 1705 Maple Street, Homestead, Pennsylvania 15120, U.S.A.

Many programmers use a variable as a flag in order to have two distinct states, usually 0 and 1. If you wish to have the state continuously alternate each time a certain line is reached in a program, the following assignment statement is useful for doing just that in a single line:

```
100 LET F = (F = 0)
```

When F's value is 0, then the logical expression F = 0 is true and has a value of one, which is then assigned to F. Conversely, if F's value is one, then the expression is false, or 0.

Further, any two values may be alternately chosen. For example, we may switch F's value between the value of A and the value of B:

```
100 LET F = A*(F = B) + B*(F = A)
```

Of course, if the value of either A or B were 0, one of the terms may be eliminated.

END

Update

9831A Two-Sample Nonparametrics Package, 09831-15010

Analyzes pairs of data for dependent and independent samples. Requires a 9831A with Opt. 001 and 9866B or 9871A Printer. The 9862A or 9871A Plotter and 9869A Card Reader are optional.

9825A Stepwise Regression Package, 09825-15040

Performs complete regression analysis using one of four methods for selecting variables; stepwise, forward, backward or manual. Transformations and residual analysis are included. Requires a 9825A with Opt. 001, General I/O-Extended I/O ROM, String-Advanced Programming ROM, 9866B or 9871A Printer. The 9869A Card Reader is optional.

9845 Computer Games Library Vol. 1, 09845-10010

A collection of currently available games to assist users in becoming familiar with the System 45.

Asynchronous Terminal Emulator, 09825-10040

This package allows the user to utilize the 9825A as a time share terminal. Software is used rather than ROM for maximum flexibility through program modification. Unmodified Terminal Emulators are quite general and should be useful with most time share systems. Requires a 9825A with Opt. 001 and 002, 9866B, Systems Programming ROM, General I/O-Extended I/O ROM and String-Advanced Programming ROM. The 9871A or 9881A Printer are optional.

Waveform Analysis, 09825-12520

Fast, efficient analysis of data via unified data input. Fourier Series coefficients for both equally and unequally spaced data.

Single Data Block Analysis includes FFT/IFT, Hanning function, power, autocorrelation (modulation/plotting).

Double Data Block Analysis includes FFT/IFT convolution, cross power, cross correlation, data manipulation, modulation and plotting.

98040A Incremental Plotter Interface

The 98040A Incremental Plotter Interface allows the System 45 to drive certain plotters manufactured by Calcomp, Houston Instruments and some other vendors. The interface allows the use of such high-level graphics commands as "PLOT", "SCALE", "MOVE", etc. to drive these plotters. It is now possible to write a graphics program to plot on the CRT and change one command to output the plot on an incremental plotter.

"Computer Interconnections: A Choice of Ways to Link HP 1000 Computer Systems to HP 9825A Desktop Computers," Application Note 201-6

Three system configurations are described; connections via HP-IB, via RS-232-C, and via the HP 3070A Terminal. Request Application Note 201-6 from your local HP sales and service office or write Hewlett-Packard, Calculator Products Division.

Keyboard
Hewlett-Packard, 3400 E. Harmony Road
Fort Collins, Colorado U.S.A. 80521

Keyboard

Publications Manager - Ed Bride
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For further information on HP products or applications, please contact your local Hewlett-Packard Sales and Service Office or write to Keyboard.