Hewlett-Packard

KEYBOARD

1977/1

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OVERVIEW

The dramatic photo used for this issue's cover was generously supplied by Floris Koenig, technician at Tensor, Inc. It was taken from the deck of the relief well drilling platform of the Middle East offshore well fire project. Floris also took the photos on location in Southeast Asia. We are indebted to him for allowing us to use them.

For a trial period of one year only, beginning with this issue and continuing through the issue 1977/4, we will be paying honorariums of $30 per printed page for feature application articles and $10 per printed programming tip. At the end of the year it will be decided whether or not to continue this practice. If you would like to see your own application published in KEYBOARD, please send a summary or outline of your article, not a completed article. Selection will be made on the basis of application, calculator or desktop computer used, and geographical location to give a good balance to the magazine and appropriate coverage to all our readers and their interests.

Fighting Oil Well Fires

by Nancy Sorensen

In October, 1975, shortly after the 9815A was introduced, Rick Dyer of the Hewlett-Packard sales office in San Antonio, Texas, received a call from Dr. Fred Morris of Tensor, Inc., a consulting firm in Austin, Texas. Dr. Morris owned an HP-65 and was interested in learning more about the added capabilities of the 9815A. And, since he was familiar with the common RPN language of both calculators, knew what he needed, and was impressed by Rick's description of the 9815A's abilities, he placed a verbal order and requested immediate delivery.

In fact, Dr. Morris was asking for even quicker response than is normally meant by "immediate delivery." Dr. Morris was on his way with other Tensor team members to the Middle East to help bring one of the world's largest oil well fires under control, and departure was imminent.

Rick called the Calculator Products Division in Loveland, Colorado, for assistance in trying to meet Dr. Morris' delivery request. His first call to the factory was late in the afternoon on a Friday, which started a series of communications back and forth between the factory and field. The next day, Saturday, Dr. Morris was met at the airport in New Orleans, Louisiana, by an HP sales person, who handed him a 9815A. Dr. Morris continued on to the Middle East, where the 9815A became the center of a great deal of attention.

Dr. Morris' letter of thanks expressed his appreciation of the quick response to his critical timing problem and mentioned that by the time he got to his destination, a 40-hour plane trip from the U.S., he had learned to program the 9815A and was ready to put it to use.

Because Tensor's application points out so many 9815A features that users are proud of—portability, versatility, ease of use, and reliability, you will be reading about this unique group at Tensor who use the 9815A to offer state-of-the-art instrumentation and expertise to help control oil well fires.

Fifty miles offshore, an oil well was burning. The flaming explosion had burned away the drilling platform, blown away the wellhead and conductor pipe, and carved a crater in the ocean floor some 200 feet (61 m) deep and several hundred feet wide. At times the burning gas spouted higher than 100 feet (30,5 m) directly out of the water. Heat from the fire could be felt on the relief well drilling platform, 2000 feet (610 m) away.

The gas contained hydrogen sulfide, which is extremely poisonous. If the fire had gone out but gas had continued to escape, there would have been immediate attempts to re-ignite it. Such an explosive, poisonous mixture floating through the air with no manner of control over it would have been far more dangerous than the fire.

Oil and/or gas well fires are uncommon occurrences, but when they do occur, there is often considerable equipment damage and personal danger. These fires are difficult at best to extinguish, and the battle is sometimes long and costly. The consulting engineers of Tensor, Inc., use their minds and equipment to help shorten the battle and, in the process, save the oil companies millions of dollars and the world millions of barrels of oil that would otherwise be lost for its energy needs.

How Oil Well Fires Start and Are Controlled

Today, oil wells are often drilled deeper than two miles (3,2 km), far beyond previous limits, in search for petroleum. The deeper the well, the more pronounced are the problems, the dangers, and the unprecedented situations.

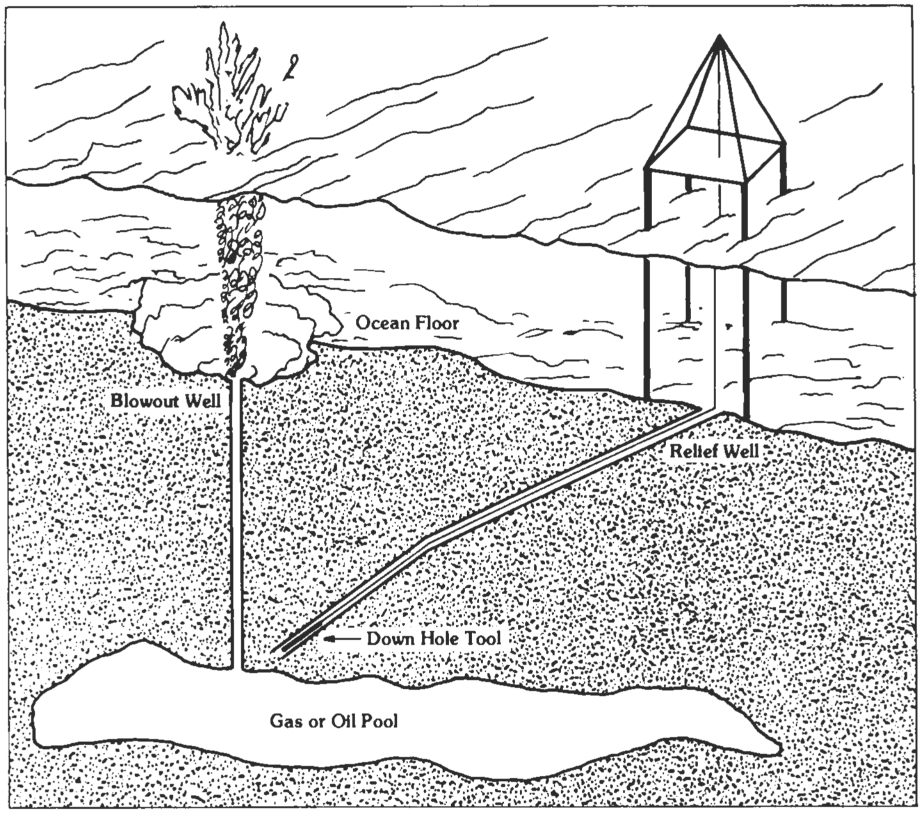
For instance, heavy fluids called "mud" are used in the drilling process to balance out pressures at the bottom of the well and to act as lubricant for the drilling. The pressure of the mud column at the bottom of the well must be kept equal to the pressure in the formation being drilled. The complications of maintaining this balance increase with well depth, and the loss of pressure balance could be serious. If the mud column pressure is less than the formation pressure, gas will enter the well and either force its way through the mud or back the mud up the well and allow the gas to escape. If the mud column pressure is greater than the formation pressure, the mud will be forced into the formation and the drill cuttings will collect at the bottom, causing the drill to get stuck or the drill bit to break. The more dangerous pressure imbalance is if the mud column pressure is too light and gas escapes. This occurrence is called a gas kick.

A gas kick is a preliminary warning to a blowout, which happens when the mud is blown out of the well. Blowout prevention devices are always installed as a part of the wellhead, and standard procedures have been established for their use. However, the time available to take corrective action is sometimes very short, and the blowout condition becomes imminent. If the mud column is lost, the gas pressure and the velocity of the escaping gas are so great that nothing can stop it. It was such a blowout at the offshore well in the Middle East that caused such extensive damage.

Gas and debris rushing up the blowout well can create enough friction against the well casing to raise the gas temperature above its ignition point, and when this hot gas hits the atmosphere, it spontaneously combusts. As mentioned earlier, the escaping gas is usually purposely ignited as a safety precaution.

Until recent years, oil wells were drilled vertically—the shaft went straight down. Now, for economic reasons, some land wells and nearly all offshore wells are drilled in several directions for a single platform. They "kick off" (change direction) one or more times. These are called directional wells.

The reason for drilling several wells from the same platform is to provide for more effective area coverage of the oil or gas field without the additional expense of moving the drilling rig for each well. Such a series of directional wells and the platforms would appear as a giant spider whose legs and feet dip into the producing formations. The consequence of having several such wells drilled and ready to produce when a blowout occurs severely complicates the problems of safely controlling all of the wells.



The most common method of fighting a blowout is to drill a second directional well, called a relief well, to come very close to the point at which the blowout well enters the oil or gas reservoir or close to the blowout well at a place where it has been drilled through a soft, permeable stratum. Then, after having established communication between the two wells with high pressure mud, water, or acid, a special quick-setting cement is sent under pressure through the relief well and through the communicating channel to the point of near juncture with the original well. The cement is forced either up into the blowout well and surrounding strata or into the producing strata in such volume as to seal it off from the blowing well. Both procedures cut off the fuel supply and extinguish the fire, much like corking the well off at the bottom.

Tensor's Contributions

Houston Oil and Minerals Corporation sponsored Tensor to develop an electromagnetic system called MAGRANGE II to measure the range and direction from a relief well to a blowout well. In this system, a downhole instrument is used to magnetically survey the blowout well from the relief well by detecting and measuring changes in magnetic field intensity. These magnetic fields are caused by ferromagnetic materials such as steel casing, drill pipe, or drills left in the blowout well.

The MAGRANGE II system consists of four pieces of equipment: the downhole instrument, the interface Surface Unit, the 9815A Calculator, and the 9862A Plotter. All equipment is used on site.

The downhole instrument is cylindrical in shape and contains electronic circuitry and magnetic sensors developed especially for this application. It is 6 feet (1,8 m) long and weighs 250 pounds (76 kg). The Surface Unit interfaces between the downhole instrument and the 9815A. Working through the Surface Unit, the 9815A collects the data, analyzes it, prints it, and records it for plotting.

The downhole instrument is sent down to the bottom of the relief well. As it is raised, the magnetic sensors take readings at a preselected interval of either six inches (15 cm), one foot (0,3 m), or two feet (0,6 m). Each reading is taken in less than 4 ms and held in the Surface Unit until the program instructs it to feed the information to the 9815A. The calculation and printout time of the 9815A determines the rate at which readings at each data station can be taken, and hence the speed at which the downhole instrument can be pulled up the relief well. The almost real-time printout permits the operator to monitor the data and the system operation; it also provides a permanent backup data record.

One part of the programmed calculations subtracts out the appropriate components of the earth's magnetic field, leaving only the magnetic effect of the anomaly to analyze for the range and direction to the target well.

After a run is completed, the 9815A scans the data, selects the proper coordinates for plotting, identifies the parameters, and instructs the 9862A to produce a finished graph including a stylized title block.

Tensor, to their knowledge, has the only system with computer capabilities on site. Readings from other surveying instruments must be sent to a computer or computer terminal back at the office. Depending on the well site, turnaround time could be many hours or days. Since the 9815A is on site, MAGRANGE II readings are available in a few moments.

The software is written to make the collection, analysis, and plotting of the data as automatic as possible. Some information, such as project number, date, and run number, is manually entered at the drilling site, but even this preliminary information is requested by the 9815A. This prompting type of programming eliminates the need for manuals or handbooks, which may be lost or left behind. The process is so automatic, all that is needed is to insert the programmed cartridge into the 9815A, push Auto Start, and turn the machine on.

A "glitch remover" subprogram has been added to the data collection, analysis, and plotting program package. Should there be inconsistent data caused by line transients, for instance, it is suppressed and is not shown in either the analysis or plot of the data collection run.

Modeling programs have been written for the 9815A to simulate the conditions of the particular job at hand. These provide predictions of what magnetic responses will be seen next in the data. Furthermore, the controlling parameters of these programs can be adjusted to match the data, thereby providing additional confidence in the accuracy of the results.

New program elements are continuously being added to the main program to upgrade the operation of the system. One of the most recent of these is a method of automatic operational recovery after a power failure. This is an important feature because all of the oil field operations use motor generators to supply electricity, and generators can miss a beat now and then.

The Middle East Fire

Three relief well-drilling platforms were strategically located around the flaming blowout. Each had specific targets to drill toward. After a relief well had been drilled to within the expected range of its target, the Tensor team of Dr. Morris, Bob Waters, and Floris Koenig would perform a MAGRANGE II survey for range and direction information so that corrections could be made as the drillers attemped to strike the target, only a few feet square, two miles (3,2 km) down.

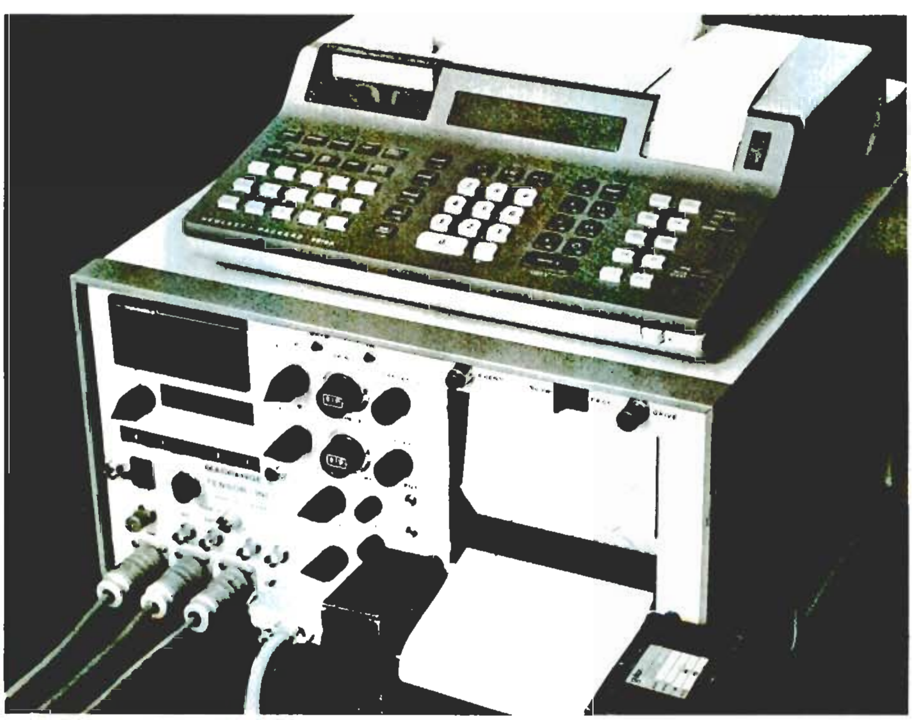
Between surveys, the team members ran demonstrations of the 9815A to several groups of interested people, who were impressed by its speed, power, and versatility. The excited comments resulting from watching the demonstration and trying the machine for themselves pleased Dr. Morris. He is an enthusiastic 9815A user and likes to share that enthusiasm.

Although MAGRANGE II had proven its reliability and accuracy in previous blowout situations, as the weeks went by and the relief wells were drilled and surveyed with MAGRANGE II, the suspense grew. These targets were not visible, verification by sight was not possible, and the situation naturally aroused some apprehension.

Finally, after several months of drilling, all was ready for the attempt to seal the blowout well. Water and mud were pumped through the main relief well into the blowout well. All eyes turned to the fire column, looking for proof of success. As the men watched, the fire abruptly stopped, except for a few small flames that soon died. The turbulence around the site quieted. In a few minutes it was as though there had never been a spectacular column of fire rising out of the ocean.

The platform destroyed in the fire had supported three wells in all. Sealing the remaining two wells and the relief wells that were drilled required a total of nine trips by Tensor personnel. The job was completed in October, 1976.

```
END
RUN
TENSOR PGM -36
CARTRIDGE 7

PROTOTYPE
RANGE AND
DIRECTIONAL
ANALYSIS

PICK TARGET
FREE AREA--
NEAREST TARGET

RUN
MD = ?

      1560.0
RUN
PICK TARGET
TO BE ANALYSED
RUN


AV D TGT FREE =
        -5876.2
ZERO CROSSING AT
  FILE #    119.0

DATA IS OK

PROCEEDING TO
RANGE CALC


TARGET HAS
DIPOLE
CHARACTERISTICS

RANGE = -52.2 FT
TARGET DIRECTION
IS      -77.8 DEG
FROM N/S LINE


FROM DEEPEST MD
IN TARGET AREA,
   MAGRANGE
IS APPROACHING
A   NORTH
MAGNETIC POLE


TARGET IS
    SOUTH
OF AN EAST/WEST
LINE THROUGH THE
    MAGRANGE
DOWNHOLE INSTMT
END OF PGM -36
```



Southeast Asia Project

Tensor also helped fight an oil well fire in Southeast Asia. This well was located on a coconut plantation near the ocean shore. Trees for 300 feet (91 m) around had burned as the well burst into fire.

By the time Tensor team arrived, the well had "bridged". That is, a section of the well shaft had collapsed, forming a temporary plug and putting out the fire. But the collapse also allowed ground water to enter the shaft. As gas pressure increased below the bridge, huge gas bubbles would rise up the shaft, throwing gigantic clots of mud high in the air. As in the case of the blowout in the Middle East, this well had also cratered; that is, the eruption of the well and the fire had blown away all the valves and upper casing and had formed a crater. The derrick was also destroyed, and the erupted mud filled the crater and overflowed. The photo sequence on this page shows the development of the situation. Again, drilling a directional relief well to plug the original well was the method used.

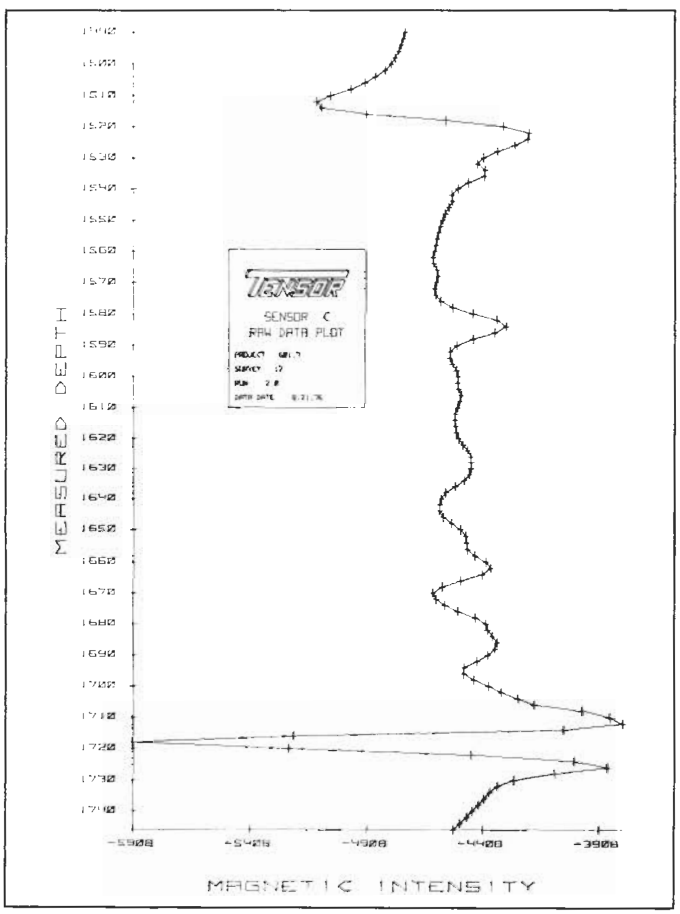
The 9862A data plots and graphs always draw a great deal of attention from the other people working at blowout well sites, and the men working on the Southeast Asia project were no exception. Even the untrained eye could see from the plot that the relief well was being drilled near the target. And, although the final evidence of success would be the prevention of escaping gas, these preliminary signs of successful progress were enthusiastically welcomed.

Since the well head of the blowout well was not clustered with others, the problems associated with sealing the well were simpler. This project required the drilling of one relief well, and total time and effort spent was much less than on the Middle East offshore fire. Accomplishing this project was routine, if such a challenging job can be so described.

System Reliability

For the equipment, air shipment from Austin to distant well locations may be 40 or more hours of vibration, temperature extremes, drastic humidity changes, and rough handling. Surface transport facilities may be rudimentary or even nonexistent in a practical sense at well locations. Offshore locations are reached by helicopter or by small craft running through all sorts of sea conditions and weather. Although the MAGRANGE II is shipped in specially constructed cartons to prevent damage, such rigorous conditions put the reliability of complex instrumentation to the test.

On the job, MAGRANGE II must be rugged enough to withstand the conditions of the job site—sea spray, mud, oil and grease, temperature extremes—and still operate reliably. An oil well drilling platform is no place to discover that one of the system components is down and in need of repair. The MAGRANGE II system has been remarkably reliable, including the 9815A and 9862A, which were not specifically designed for exposure to oil field environments as were the downhole instrument and interface unit. The downhole instrument has even been used as a battering ram to punch through clogs in yet-uncased sections of wells.



Tensor's 9815A and 9862A have been shipped around the world many times and were on the job in the Middle East and Southeast Asia. On one trip, the 9815A arrived inoperative after being shipped from the U.S. to Singapore. Dr. Morris called the HP Singapore sales and service office, and the 9815A was on the job the next day. He has high praise for HP products and personnel, but he feels the people at the Singapore office deserve special praise.

In case repair is required, the availability of worldwide service and immediate response is of paramount importance to Tensor. Fighting oil well fires takes them anywhere in the world on short notice. Delays are very costly—to Tensor because its reputation hinges on the dependability of its commitments — to the oil companies because Tensor personnel and all the other experts they work with are hired at a daily rate until the job is finished — and to all of us as consumers of oil and gas because these products are lost for our use.

About Tensor

Tensor is a research and development company. Its product is solutions to problems.

Dr. Fred Morris is President and Director of Research. Bob Waters and George Roberts are Vice Presidents and partners with Dr. Morris in the company. The fourth partner is Thora Carlisle, office secretary and company Secretary-Treasurer. She uses the 9815A for accounting and calculating antenna factors. Floris Koenig is a key technician who goes out in the field, and Les Stolle is the purchasing agent. The newest employee is Arthur Bryant, design engineer. The MAGRANGE technique was developed at Tensor.

In speaking about the versatility needed to work for a small research and development company, Les says, "We have found in the last two years that we all have hidden capabilities, and that's what makes our work so interesting."

Dr. Morris has high regard for the people he works with. "We have an unusual combination of people at Tensor, and that's what makes the company. Brainpower and resourcefulness are the true measure of Tensor's worth, not inventory."

Forum

Dear Editor:

A tired but still dependable worker, our 9100 requires fun and game programmes for entertainment after its imminent retirement. If you can contribute, please write.

Jay Peifoure
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Canada

Dear Editor:

In looking over the responses to Professor Maeder's question (Forum, Vol. 8, No. 1), I was surprised to see that no one made use of the Special Function Keys—a facility that certainly counts as one of the most powerful interactive tools available to 9800 Calculator users. If the application program is loaded into mainline memory from, say, cassette file 0, then one of the first statements executed might be

```
10 LOAD KEY 1
```

to load a previously stored set of parameter input sequences, one to a key. Then, at the appropriate point(s) in the main program, new values for any subset of the parameters are requested with

```
100 DISP "ENTER ANY NEW VALUES";
110 STOP
120 ..........
```

The prototype parameter input sequence is

```
10 DISP "ENTER (PARAMETER NAME)";
20 INPUT (VARIABLE NAME)
30 END
```

In this manner, parameter values may be changed in any order. When all changes have been made, execute the keyboard command CONTINUE to resume mainline execution at statement number 120 above.

A somewhat less useful way to achieve the same result is

```
100 DISP "ENTER NEW VALUES",
110 WAIT 3000
120 ..........
```

If no values are to be changed at this point, press any key but STOP to cancel the WAIT. If there is a change, press the STOP key, execute the new variable value(s) in keyboard mode, and then CONTINUE.

There is yet another solution to the problem of interactive parameter entry, which relies on the String Variables ROM. This approach is motivated by the NAMELIST input feature found in most FORTRAN processors. Anyone who has used this feature with time-shared FORTRAN will appreciate the value of the scheme presented here. It has been used successfully on our 9830A as a "front end" to a program that calculates ballistic trajectories of vehicles in interplanetary space. Solution of this problem typically involves iterative looks at various parameters and is well suited to interactive processing. A simplified example of the input scheme is shown below. Let P$ be a list of parameter names.

```
10   DIM P$ (30), B$ (5), A$ (80)
20   P$="PARM1PARM2PARM3
     FLAGERRORPRINT"
30   RESTORE 50
40   READ P1, P2, P3, F, E, P
50   DATA 12, 0, 8.977, 1, 1, 8
```

The parameter names may be any names of mnemonics that are meaningful to the user. Note that these names may have different character lengths in actual use, but the longest name used determines the space required for every name. Access to the various names in the list will be achieved by arithmetic on the subscripts modulo n, where n is the standard name length in characters. (An alternate method is to use a delimiting character between names of varying lengths. However, the potential savings in memory required for a relatively small number of names will be more than offset by the size of the accessing routine.)

In the lines above, the variables that correspond respectively to the parameter names are initialized to default values. When called for, each parameter value may be entered by the operator in the following general form:

PARAMETER=VALUE1, (VALUE2, VALUE3, ...)

These may be combined in any order that does not violate program logic. The result forms a string of parameters that may be entered over one or more input lines by the device of using a terminating delimiter, "$", for instance.

Example:

program prompt:	PARAMETER STRING ?
operator response:	PARM1=8.75, PARM2=63,
program prompt:	PARAMETER STRING?
operator response:	FLAG=0, PRINT −9, PARM1= 8.75, $

When "$" is encountered, operation continues. Note that "=" and "," are essential delimiters for the code shown below. These lines look a bit too cluttered to be optimal code; however, they get the job done.

```
100 DISP "PARAMETER STRING";
110 INPUT A$
120 IF LEN (A$)>1 THEN 160
130 IF A$="  " THEN 100
140 IF A$#"$" THEN 100
150 GOTO 1000
160 IF A$[1,1]#"  " THEN 190
170 A$=A$[2]
180 GOTO 120
190 IF A$ [1,1]="$" THEN 1000
200 B$[1,5]=A$ [1,FNF1-1]
210 FOR I=1 TO 6
220 IF B$=P$[ (I-1)*5+1, (I-1)*5+5]
    THEN 270
230 NEXT I
240 DISP "BAD INPUT: REENTER
    FROM"; B$
250 INPUT A$
260 GOTO 120
270 GOSUB I OF 300, 340, 350, 360,
    370, 380
280 A$=A$ [FNG1]
290 GOTO 120
300 REM *** PARM1***
310 GOTO FNH1 OF 240
320 P1-FNJ1
330 RETURN
340 REM*** PARM2 ***
```

A$ holds the current input parameter string, which is not saved. The string may contain embedded blanks. The program lines are responsible for breaking A$ down into individual parameter and value combinations and for controlling general edit features. A dedicated subroutine is prepared to look at each "parameter = value" combination and assign appropriate values to program variables. FNH in line 310 edits the value for non-numeric characters and returns a 1 if any are found. Three useful expressions may be abbreviated as:

```
900 DEF FNF[Zn] = POS[A$, "="]
910 DEF FNG [Z] = POS [A$, ","]+1
920 DEF FNJ[Z]=VAL[A$
    [FNF1+1]]
```

It is possible to enter several values with one parameter name. For example, initial, incremental, and final values of a loop on the independent variable, time, may be entered with

TIME=0, 10, 100,....

Variations such as this and editing features to check the input string may be as numerous and fancy as required; however, the amount of coding required to implement this scheme is not insignificant. Therefore, although this approach is a versatile answer to Professor Maeder's problem, it must be used selectively.

Michael L. Stancati
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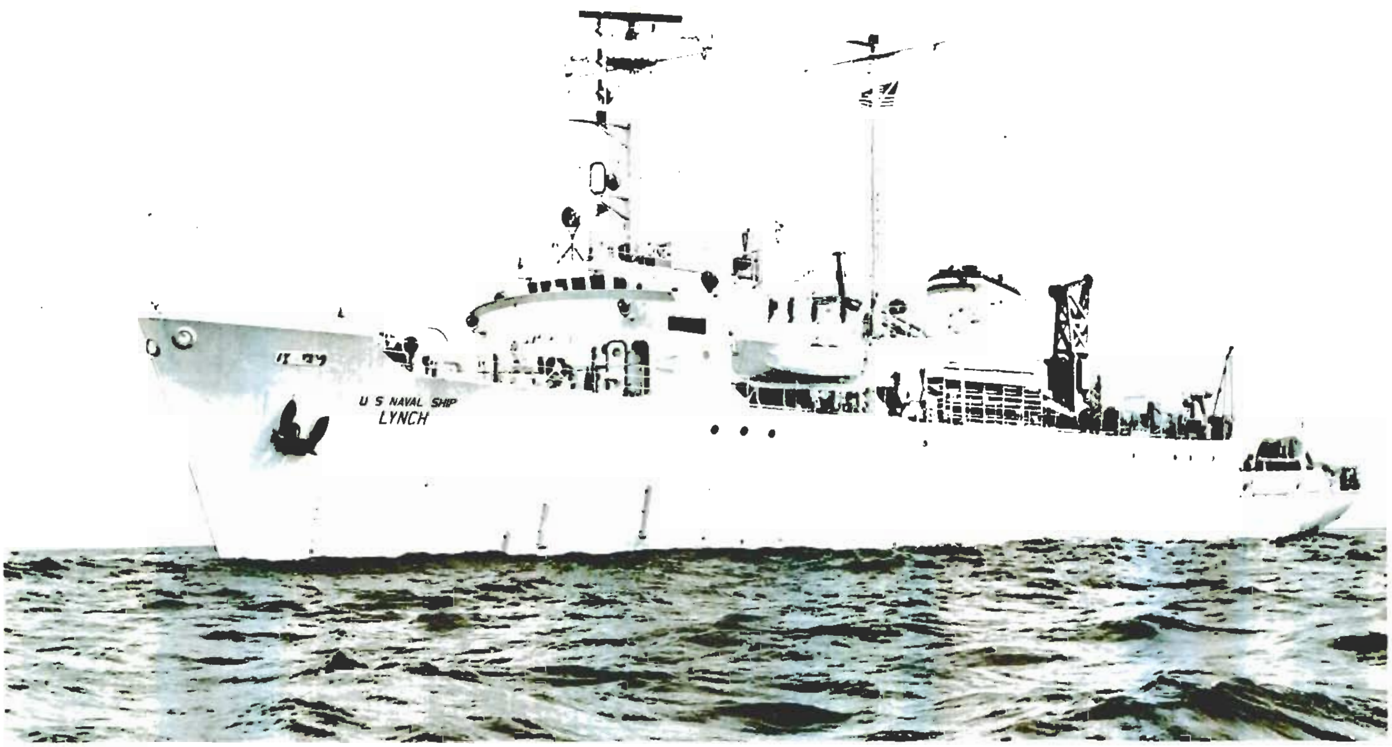
Salinity, Temperature and Depth Measurements with the 9830A



by B. Okawa and A. Newman

Studies of the marine environment at the Naval Research Laboratory address various aspects of oceanography and atmospheric physics with emphasis on their application to particular Naval problems such as marine biodeterioration, environmental pollution, hydrodynamics, and the prediction and monitoring of some important weather and climatic phenomena. The complexity and variability of the ocean frequently require that considerable effort be devoted to specification of the environmental conditions under which a particular problem is studied. Developments that simplify and shorten such auxiliary measurements permit more efficient use of ship time and scientific manpower. Additionally, the automation of shipboard processing of such data further increases research efficiency by providing quasi real-time-feedback to the measurement process.

In our particular case, the requirement was for a relatively slow-speed data acquisition/processing system to be interfaced with a Plessey 9040 STD, an instrument that measures salinity and temperature as functions of depth. This specific requirement led to five general system design criteria:

- Relatively slow speed data acquisition and processing on the order of 10 samples/second;
- Real-time or close-to-real-time data display and plotting to permit visual verification of the data and feedback to other measurement processes;
- Sufficiently general to permit expansion of the system to other measurement/processing applications;
- Operable by personnel with a minimum of training (process must be simple and routine in order to free personnel for more demanding tasks);
- Sufficiently compact to fit into the limited space available.

This latter requirement effectively excluded, for our purposes, the larger, more sophisticated minicomputers that NRL normally uses for shipboard work. After surveying the field, the Hewlett-Packard 9830A with Interface Bus appeared to be a natural solution to the problem. All components were off the shelf and readily interfaced with the Plessey system.

System Hardware

The STD cast is one of the fundamental measurements of oceanography. It permits the calculation of density, oscillation frequencies, the tracing of water masses, and the determination of current shear zones.

The Plessey 9040 STD/SV used by NRL is a submersible electronic package containing sensors for salinity, temperature, sound velocity, and pressure (depth). Temperature is detected with a platinum resistance thermometer, and pressure (depth) is determined using a bonded strain-gage transducer. Sound velocity is measured with a transducer that initiates an electronic pulse traveling along a fixed sound path length using the well-known "sing around" principle. Salinity is derived by first measuring the electrical conductivity of seawater and then, with measured temperature and pressure corrections electronically applied, the conductivity is converted to salinity.

Each sensor output is frequency modulated within a discrete band and then input to a mixer. The mixer output is then transmitted up a single conductor cable to the Plessey deck unit, where it is passed through discriminators to separate the individual FM signals. The four FM signals are thus continuously available at four BNC outputs on the deck unit.

In our application, the STD is typically lowered from the ship at approximately 40 metres/minute to a depth of 300 to 500 metres. If the desired resolution is 1 metre, the discrete sample rate must then be approximately 2 samples/second/channel or 8 Hz overall—a rate well within the capability of the 9830A system. As shown in Figure 1, the four data signals are routed from the Plessey deck unit to a single-pole, four-throw switch. From there they are consecutively routed to the counter, which measures the frequency and transmits the result to the 9830A.

The NRL system consists of the HP 59307A VHF Switch, 5345A Counter, the Plessey 9040 deck unit, 9830A and 9866A Printer, and the HP 9862A Plotter. The ASCII Bus Interface Card provides a means to transfer data bidirectionally between the 9830A and the ASCII General Purpose Bus Cable.

The 9830A serves as the system controller and can be addressed as a listener to receive data or as a talker to transmit data along the Bus data lines. It can also address other devices as a talker or listener, send commands, initialize the Bus, and remotely control other devices on the Bus.

The Interface Card plugs directly into one of the I/O slots located on the rear panel of the 9830A. The HP 59307A VHF Switch unit has two independent single-pole, four-throw switches (A & B), one of which in our scheme is remotely controlled through the Interface Bus system by the 9830A.

Under remote program control, the switches are operated by addressing the 59307A to listen on the Interface Bus and then sending the ASCII character A followed by the switch position number 1, 2, 3, or 4. This causes the common switch port to be connected to the selected switch position. The frequency for depth, for example, could then be sent to the counter. The 5345A is activated remotely by the 9830A to listen on the Interface Bus, initiate a measurement of frequency coming through the VHF switch unit, and send the measurement back to the 9830A. The common switch of the VHF unit is cycled through the remaining switch positions remotely by the 9830A through the Interface Bus to complete the measurement cycle.

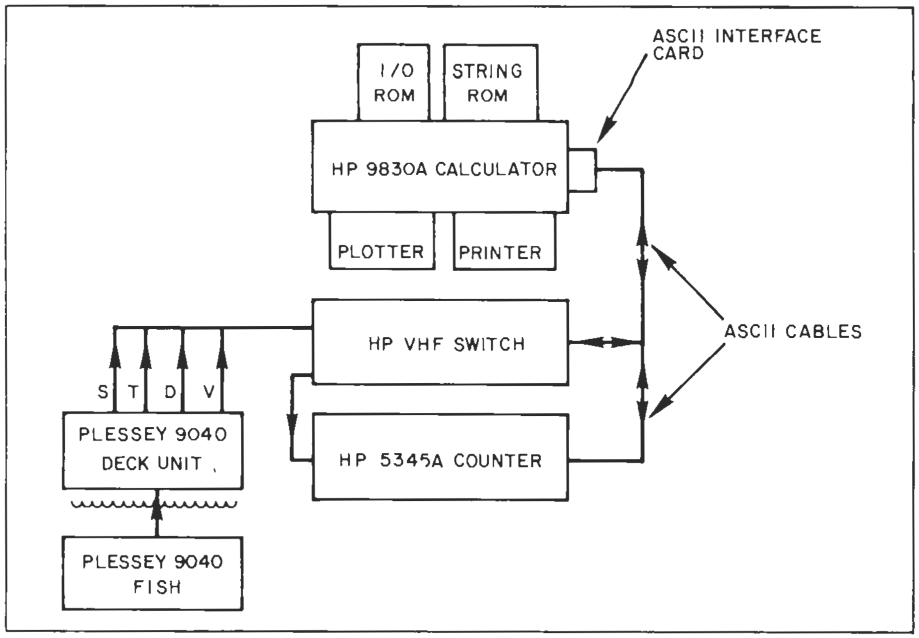


Figure 1 - Block Diagram of HP 9830A - Plessey System

System Software

The software consists of three packages: data acquisition, plotting, and secondary processing. Figure 2 is the flow chart for the acquisition package. The 9830A is the system controller and sends commands to the two ASCII addressable peripheral devices, the VHF switch unit, and the 5345A Counter. Data is acquired in two nested loops. The inner loop cycles through the four signals and stores frequency data in temporary locations. The outer loop then converts the depth data and compares it with the previous data point. If it exceeds that depth by the desired amount, the other parameters are converted and the data set is stored in memory. Otherwise, the inner loop is reentered and the data set is overwritten. After acquisition is completed, data is transferred from the 9830A memory to a tape cassete. It should be noted at this point that we are interested in depths of less than 500 metres with resolution of approximately 1 metre, and thus the 8k word memory is sufficient for our purposes. If larger data sets are required, magnetic tape units or ruggedized disk packs may be required.

The second of the software packages produces plots of the cast data for visual inspection and as information for other experiments. The third software package is still being developed. It presently provides corrections for the sampling lags due to sequential acquisition and for the various response times of the sensors. These corrections are important when taking measurements in a high temperature/salinity gradient region such as the oceanic thermocline.

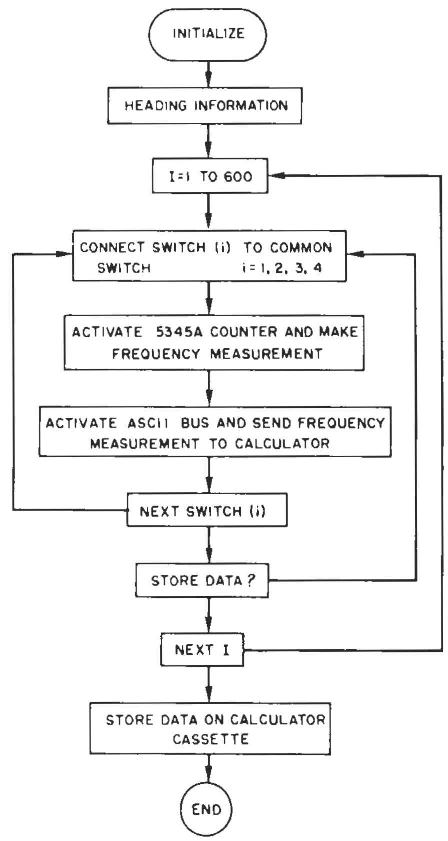


Figure 2 - Software Flowchart

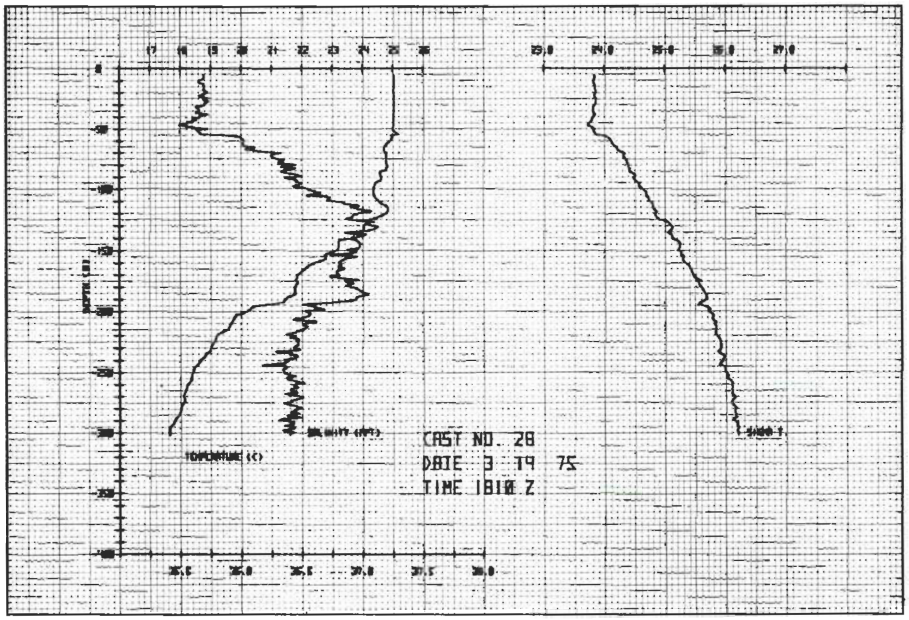


Figure 3 - Temperature, Salinity, and Sigma-T Data Plots for STD Cast Number 28

Field Test

The HP-Plessey system was field tested aboard the USNS Lynch in February and March, 1975, in an area near the Puerto Rican trench. Numerous casts were taken with multiple casts and varying drop rates, providing a large enough sample to permit preliminary evaluation of the system. A sample plot of cast No. 28 appears as Figure 3. Note the mixed layer in the temperature plot that extends to a depth of 50 metres. An extremely sharp halocline is shown in the salinity plot from 50 metres to 130 metres in depth. The Sigma-T or density curve is calculated by means of a complex formula involving the measured values of salinity and temperature as functions of depth. The Brunt-Vaisala frequency, which is the natural frequency of oscillation of a vertical column of fluid given a small displacement from its equilibrium position, may also be calculated from the Sigma-T curve using a simple formula. Both calculations are easily accomplished on the 9830A and were part of the data reduction during the time the experiment was conducted at sea.

No corrections for response time or sampling lag of the various parameters have been applied to these plots. System operation was relatively straightforward and the editing capabilities of the 9830A were invaluable to the software development aboard ship. Plots were made immediately after the cast and used as guidance for a cast of differential current metres and for other oceanographic measurements taken later in the day.

All five design criteria were shown to be satisfied during these operations. Once software development had been completed, the measurement became sufficiently routine to permit other personnel to man the equipment with very little training. The system appears to be quite reliable despite the severe vibration environment in which it was operated.

Other Applications

The versatility of the HP-Plessey system in oceanographic measurements demonstrates very well the unique capabilities of the HP Interface Bus. Its portability and ease of use make it well suited to data acquisition problems. The basic system can be easily configured to other applications. It is presently planned to make the system a diversified shipboard data acquisition/processing system by expanding its capabilities to include acquisition of expendable bathythermograph (XBT) data, reduction of radiosonde data to tables and plots, on-site reduction of meteorological and air-sea interface heat flux data, and correct navigational problems by use of a dead reckoning plotter (DRT) and using ship course and speed data.

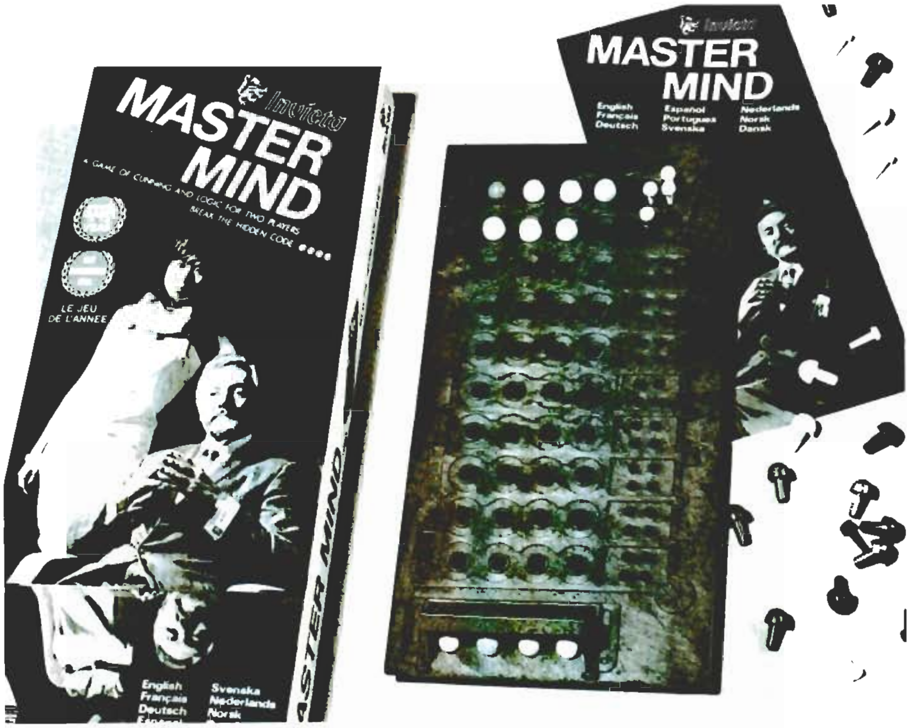
Ultimately, the increased utilization of such a system could justify two or more systems with the consequent increased reliability due to system redundancy. The system has shown itself to be an important addition to the oceanographic measurement process, and the prospects are excellent that an expanded use of HP-IB will be even more valuable in the near future.

Curriculum Vitae

Mr. Benn Okawa is an oceanographer in the Ocean Sciences Division of the Naval Research Laboratory, Washington, D.C. A native of Honolulu, Hawaii, he holds a Bachelor of Science in Physics from the University of Illinois, Urbana, Illinois, and is presently pursuing a Master's Degree in Fluid Mechanics from the Catholic University of America, Washington, D.C.

Mr. A.V. Newman is employed as a research physicist in the Special Projects Organization of the U.S. Naval Research Laboratory in Washington, D.C. He holds a Bachelor of Science degree in Physics from Pennsylvania State University, a Master's Degree from Catholic University, Washington, D.C., and is presently pursuing a PhD in Fluid Mechanics at Catholic University. His interests are concerned with wave propagation in random media with particular application to acoustics and radar problems. Most recently his efforts have been addressed to developing experimental programs to complement theoretical work in a microwave project.

Playing Mastermind on the 9810A



by Bertrand N. Bauer

The game called "Mastermind", an intriguing combination of luck, wits, and skill, is becoming very popular. Millions of sets have been sold all over the world. Mastermind normally requires two players, but the 9810A can substitute for one of the players, permitting solitaire games; or two or more people can play against the 9810A and compare scores to see which player wins.

The Rules of Mastermind

The rules of Mastermind are easy. One player is the codemaker and the other player is the codebreaker. The codemaker forms a code by placing colored code pegs in a special section of the playing board; the codebreaker cannot see the code. Then the codebreaker uses as many turns as needed, up to a specified maximum, to determine (or guess) exactly which colors are in the code and in what order. After each turn, the codebreaker is given some information on how well his or her current guess matches the code. Each code peg matching in both color and position is awarded a black information pin by the codemaker, but the codebreaker is not told which of the code pegs matches in color and position. Each code peg matching in color but not in position is awarded a white information pin by the codemaker, but again the codebreaker is not told which of the code pegs matches in color.

The essence of the game is the use of convergent, deductive logic—and some occasional inspired guessing—to break the code quickly. The logic is called "convergent" because the information from all of the plays should be pooled to narrow the possibilities for the code. The codebreaker's possible plays converge to the solution, and the game ends when the code is broken. The game is scored by the number of turns it takes to break the code. Then the two players reverse roles and play another game. The person with the lower score as codebreaker wins the round. If desired, scores can be cumulated over several rounds to determine the winner of a series.

There are certain restrictions that must be observed when awarding information pins. If a codebreaker's code peg deserves a black information pin, it must be awarded a black information pin. Then both that code peg and the codemaker's matching code peg are ineligible for further consideration of information pin awards for that turn. It is convenient to award all the black information pins first. Once that has been done, if a codebreaker's code peg deserves a white information pin, it must be awarded one, and both that code peg and the codemaker's matching code peg are ineligible for further consideration of information pin awards for that turn.

For example, suppose the codemaker's code is Black-Black-Yellow-Green and the codebreaker's play is Black-Yellow-Yellow-Black. The codebreaker's first Black deserves a black information pin, so it gets one. Also, the codebreaker's second Yellow deserves a black information pin, so it gets one. The only code peg still eligible for information pin award is the codemaker's second Black. One white information pin is awarded, making a total of two black information pins and one white information pin. The codemaker may place the information pins on the playing board in any order and in any pattern he wishes.

There is a penalty if it can be proved that the codemaker made any mistake in awarding information pins. The game is replayed and scored as taking three less turns than actually used in the replay.

The maximum number of turns is 10 in the original version of Mastermind. It is 12 in the expanded version, which is called Super Mastermind or Deluxe Mastermind.

The number of colors for code pegs varies. Mastermind has six colors, expandable to seven by allowing blanks. Super Mastermind has eight colors, expandable to nine by allowing blanks.

The number of positions also varies. Mastermind has four positions, and Super Mastermind has five positions.

9810 Mastermind

The 9810A can easily substitute for the codemaker, the playing board, code pegs, and information pins. Of course, the 9810A cannot handle alphabetic data, so the code is numeric.

There is no specific correspondence between numbers and code peg colors. You may, if you wish, consider the correspondence to be as follows: 1=White, 2=Yellow, 3=Red, 4=Green, 5=Blue, 6=Black, 7=blank, 8=Orange, and 9=Brown.

There are some differences between 9810 Mastermind and Mastermind using a playing board. First, the 9810A does not make mistakes when awarding information pins, so the three-turn penalty for such mistakes is not applicable in 9810 Mastermind. Second, the 9810A's color and position code is formed randomly, eliminating the codemaker's preferences and prejudices in forming the code. Third, 9810 Mastermind has no limit on the number of turns taken to break the code. Fourth, a null has to be earned in 9810 Mastermind. That is, every digit that the 9810A accepts as valid input from the player can occur in the code; if the player wishes to use a digit he or she knows is not in the code, regular turns must be used to find it.

Fifth, the number of positions in 9810 Mastermind can be anything from two through nine, rather than being four, as in regular Mastermind, or five, as in Super Mastermind. However, the character of the game changes rapidly as the number of positions departs from four or five. Players should usually restrict themselves to either four or five positions, unless, of course, they happen to like very few or very many positions. The probability tables accompanying the program listing show how the game changes with changes in the number of positions.

Sixth, the number of colors in 9810 Mastermind can be anything from two through nine, rather than being six or seven, as in regular Mastermind, or eight or nine, as in Super Mastermind. However, playing with fewer than six colors (digits) is likely to be unsatisfying, and players should usually restrict themselves to six, seven, eight, or nine digits per position. The probability tables mentioned also show the influence of changing the number of digits. Seventh, there is no relation in 9810 Mastermind between the number of positions and the number of digits per position. However, players should probably restrict themselves to the combinations used playing-board Mastermind. These are four positions with either six or seven colors (digits), and five positions with either eight or nine colors (digits).

If it seems to you that certain liberties are being taken with the standard rules of Mastermind, please be reassured. Quite a few variations are possible and players should feel free to adopt ones that please them. For an interesting discussion of many other aspects of Mastermind, see Leslie Ault's book, *The Official Mastermind Handbook.**

You should be able to break the 9810A's code in an average of about five turns after some experience, using four positions and six colors. Ault mentions a computer in England that has averaged 4.2 turns per solution in thousands of games it played as codebreaker. Surprisingly, there is only a small increase in the number of turns required for five positions and nine colors; an average of about seven turns might be reasonable. Even the 9810A's most difficult version - nine positions and nine digits - can be solved in roughly 12 turns by a determined, skillful player using paper-and-pencil analyses to figure out the best plays.

Serious Uses for 9810 Mastermind

Recreation is an important use for Mastermind, but there are other uses, too. If 9810 Mastermind is used for instruction, some of the points that can be made are:

1. Pseudo-random number generators—useful in many applications. The generator used in 9810 Mastermind is adequate for its purposes, but it is not really a very good generator. For serious applications, see Chapter 3 of Donald Knuth's book, *Seminumerical Algorithms.*** Also, I am writing a book on computerized random sampling that will include material on good pseudo-random number generators and is written at a level requiring much less mathematical training than Knuth's book. It is not yet scheduled for publication.

2. Programming problems—the interesting problem in 9810 Mastermind is counting the number of Blacks and Whites when awarding information. It is easy to award too many Whites. The problem is in arranging matters so that, once two digits have resulted in either a Black or a White, neither of the digits is used for another match on the same turn. Other programming exercises are discussed in the material accompanying the program listing. This material contains suggestions on changing the program in several different ways, i.e., programming the 9810A to make mistakes, so the player may challenge on this point, and modifying the randomly generated code. There is room for considerable creativity and ingenuity, especially in ways of using the random number generator, but matters must be handled carefully or the programming will not execute properly.

3. Game theory—there are interesting questions in tactics, such as the best opening move. Are there optimum sequences for the first several moves by the codebreaker? What is likely to happen when the 9810A is no longer the codebreaker's adversary, but another person is? Ault's book cited earlier includes material on these questions.

4. Deductive logic—it can be instructive to make formal statements of exactly what is known from the numbers of Blacks and Whites awarded. For example, if the player's opening move is 1122 and the 9810A awards two Blacks and no Whites, what is known? The answer is that the code must contain (a) at least two 1's, or (b) at least two 2's, or (c) exactly one 1 and one 2. There is also some information on positions. The information from future moves will eventually show which of these color-and-position alternatives is correct.

5. Extensions of the game—what happens when the number of characters per position rises to 26, or 100? What happens when the number of positions is increased?

6. Bayesian statistics—if modified random codes are used instead of always using strictly random codes, how should the relevant probabilities be assessed after each game is played? These assessments are not merely abstract exercises in probability calculations, since they guide the player in the choices of strategy and tactics.

In addition to recreational and instructional uses, Mastermind might be useful as a psychological test. It could be employed in candidate selection for hiring, promoting, and transferring people. Ault also mentions this possibility. If it is a good psychological test, playing poorly might be just as important for some positions as playing well is for others. Explanations of the moves might be as important as the moves themselves. Interest in the game (or lack of interest) might be as important as skill in playing it.

About the Author

Bert Bauer is the owner and chief consultant of Parameter Investigation, Evanston, Illinois. The firm does statistical consulting and specializes in probability sampling for managerial and legal decisions. "Probability sampling" is mathematically sound random sampling. It provides the ability to measure sampling error, and it eliminates any bias the investigator may have when selecting items into a sample.

His recent activities include testifying as an expert statistical witness in several cases involving probability sampling, designing national probability samples for consumer products, and measuring bank service areas and market potentials.

Mr. Bauer earned his BA and MBA degrees specializing in statistics and mathematics and has done further graduate study in business at the University of Chicago (Illinois). He was elected to membership in Phi Beta Kappa and Beta Gamma Sigma and held several scholarships. Mr. Bauer has taught statistics on several faculties including the University of Colorado and Northwestern University in Illinois.

A listing of "9810 Mastermind" and supplementary material by Mr. Bauer on operating instructions, probabilities, and changing the program may be obtained on request by writing to *KEYBOARD*, Hewlett-Packard, P. O. Box 301, Loveland, Colorado 80537, U.S.A.

**Leslie H. Ault, The Official Mastermind Handbook (New York: The New American Library, Inc., 1976, paperback).*

***Donald E. Knuth, Seminumerical Algorithms, Vol. 2 of The Art of Computer Programming (Read. Mass.: Addison-Wesley Publishing Company, 2nd printing, November, 1971).*

Author's note: Mastermind is a registered trademark of Invicta Plastics (U.S.A.) Ltd., New York City, which also has a copyright and a pending patent. Mr. Colin Wright of Invicta Plastics has kindly offered several suggestions that have improved this article.

New Products

The HP 9831A Desktop Computer

The 9831A is Hewlett-Packard's new, medium-priced, BASIC language desktop computer. Used alone or linked with peripherals, it brings a new dimension of computing power and speed to the fields of engineering, construction, medicine, and general computation. As examples, the 9831A can work through a five-variable stepwise regression in 1 1/4 minutes, reduce the data from a 100-tube RIA kit in five minutes, or analyze a six-story, 4-span construction frame in seven minutes.

Most of the 9830A/B software packages are compatible with the 9831A. A utility software package and a training tape accompany each 9831A to help you become familiar quickly and to give you some of the commonly used math and matrix programs and subroutines for 9885M/S and 9871A interface.

Memory size of the standard 9831A is 8k bytes, expandable to 32k bytes in 8k-byte increments. String Variables, Advanced Programming, and peripheral Input/Output commands are built into the 9831A as aids in advanced programming techniques. One of the features of the built-in string variables is the flexibility to handle string arrays as large as the total memory of the machine.

Two optional ROMs are available; the Matrix/Plotter ROM, which adds such matrix capabilities as inversion, transposition, and multiplication, and the Flexible Disk ROM. The 9831A has four slots for optional ROMs.

The 9831A's high-speed tape drive and high-density tape give you fast data storage and retrieval - many times the speed and four times the capacity of the 9830A. The tape cartridge stores 250k bytes of program and/or data on two tracks. Average access time to any place on the tape is six seconds.

As you record your data onto tape, it is automatically verified, which means that all information being stored onto the tape corresponds exactly with the original information in memory.

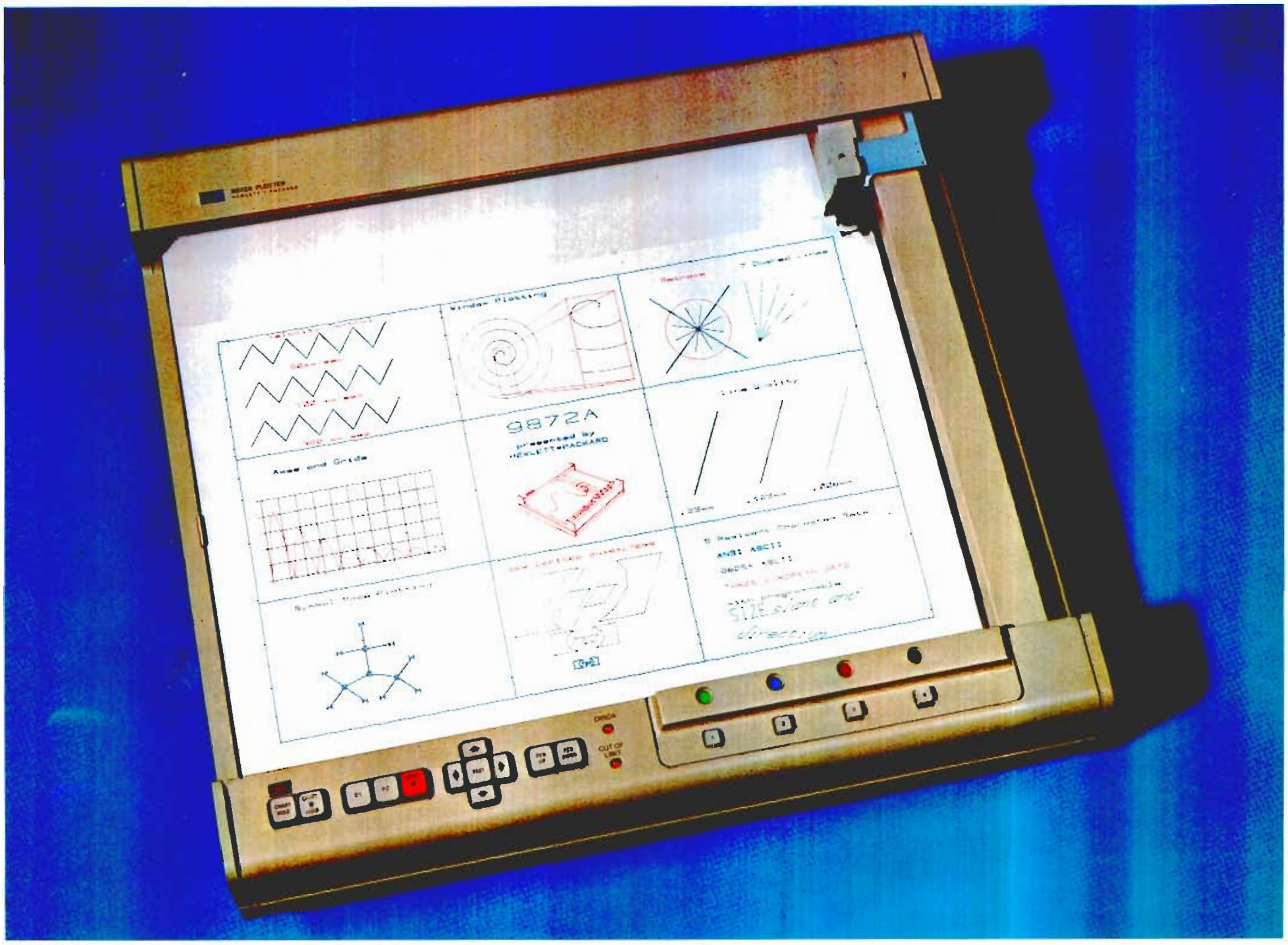
The 9831A's appearance is similar to the 9825A, but the keyboard functions remain essentially the same as that of the 9830A/B. The 9831A has 12 Special Function keys that shift to accommodate 24 operations. They serve as immediate execute keys, subroutine call keys, and typing aids. The keyboard also has upper- and lower-case alpha characters, Greek symbols, and European characters.

The LED display is 32 characters wide, has upper- and lower-case readout, and covers the full ASCII character set. As with the 9825A, a cursor in the display locates errors for quick identification.

Using interface cards designed for the 9831A you can connect the following peripherals:

9862A Plotter
9863A Tape Reader
9864A Digitizer
9866B Thermal Printer
9869A Card Reader
9871A Printer
9872A Plotter
9877A External Tape Memory
9878A I/O Expander
9881A Line Printer
9883A Tape Reader
9884A Tape Punch
9885M/S Flexible Disk Drive

The HP 9831A also serves as the heart of the new HP 9896A Computational System.



The HP 9872A Plotter

A new plotter for use with the HP 9825A and HP 9831A Desktop Computers has been added—the HP 9872A. For data in permanent, multicolor graphic form, the HP 9872A offers several advances. It holds four programmably selectable pens, which may be in any of four colors you choose. It is faster than previous HP plotters, has excellent line and character quality, and has built-in self-testing capabilities. The 9872A can execute and understand 38 different commands, and it window plots, point digitizes, and is HP-IB compatible.

The 9872A is designed to be especially useful in the areas of statistics, medicine, numerical control, surveying, and engineering design, but its usefulness is best measured by your own application and needs.

HP's newest plotter features seven dashed-line fonts for easy identification of closely spaced traces and symbol-mode plotting for further trace identification and for special effects. Improved line and character quality offers 0,04 mm (0.002 in.) repeatability for a given pen and a resolution of 0,025 mm (0.001 in.). The resulting high-quality graphics give you more detail for precise analysis of data, and final report quality plots, for presentations.

Pen speed is 50% faster than on our older HP plotters. In program mode, pen speed may be adjusted to any one of 36 rates from 10 mm/s to 360 mm/s in 10-mm increments. This precision velocity control helps you produce high-quality graphics not only on paper, but on such other media as mylar or acetate.

All four pens are stored and capped in the front-panel housing. Pens can be chosen either manually or under program control to save time completing multi-color plots. For longer use, the pens hold more ink, have a harder nib, and the pen movement is damped.

The 9872A has five character sets built in - standard ASCII, 9825A ASCII, and three European sets. They, plus any user-defined characters you may wish to use, can be further diversified by programmable size, slant, and direction.

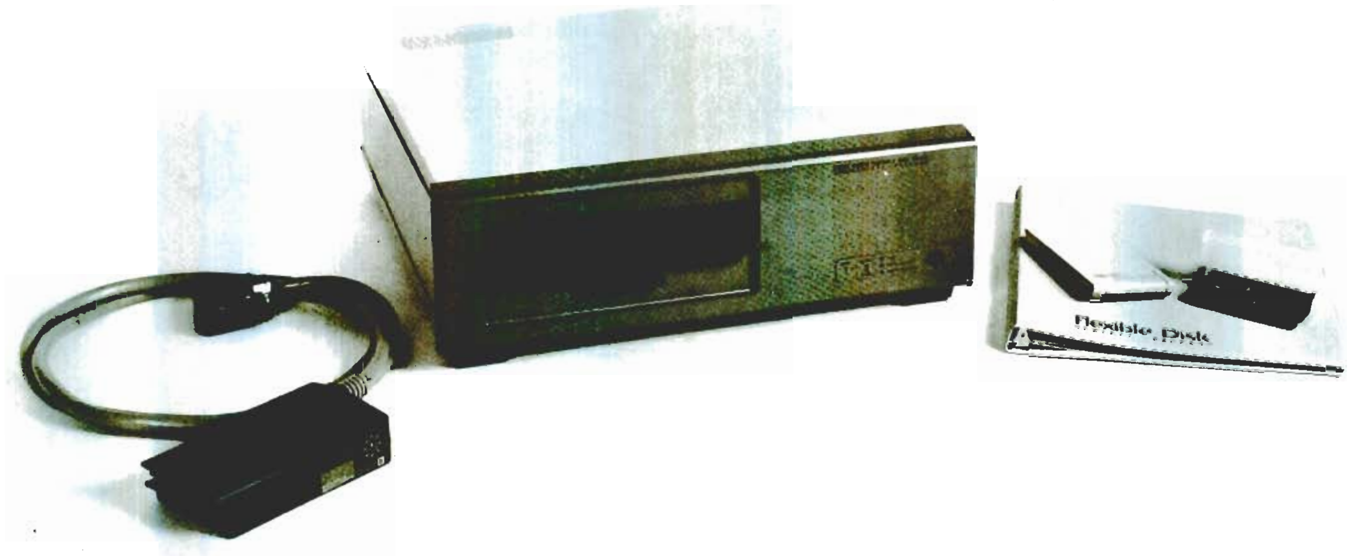
Window plotting, another significant new feature, provides the 9872A with the ability to handle off-scale data. The 9872A graphs to the point where off-scale data is encountered and continues graphing at the point where on-scale data is again encountered with no loss in accuracy. Point digitizing is used to determine coordinates and transmit them to the controller. Combining point digitizing and window plotting allows you to magnify sections of your original graph at any proportion you choose for more detailed analysis.

The 9872A's built-in confidence test helps you locate malfunctions. If your 9872A is part of a system, for instance, you can quickly and easily determine if the malfunction is in the plotter, possibly saving a service call.

The 38 instructions programmed into the 9872A are in a readily identifiable, two-letter mnemonic language. The instructions include often-used commands to free space in mainframe memory and to make programming even easier.

HP-IB (conforms to IEEE Spec. 488-1975) gives the 9872A the flexibility to interface now and in the future to all HP-IB compatible instruments.

Additional ROMs for language expansion and easier programming are available, and software for statistical graphics, business statistics, and quality control statistics will be available. Please watch "Update" for future software announcements.



9885M/S Flexible Disk Drive

The HP 9885M/S offers economical, convenient, off-line storage for programs and data. Both the 9885M (master) and 9885S (slave) have a capacity of approximately 500,000 bytes per disk and use double-density recording. It can be used with the 9825A and 9831A Desktop Computers and is part of the 9896A Computational System.

Along with a built-in power supply, the master contains the controller for managing slave unit operation. Up to eight 9885S units can be connected to each master—a total of 32 disks with 14,991,360 bytes of user-available memory.

Fast transfer rates are achieved through the direct memory access (DMA) feature. Transfer rates of information between disk and desktop computer total 62,500 bytes per second. Access time to any place on the disk averages 260 ms.

The disk's double-density read/write feature accelerates access rate and increases total storage capacity. A high-level command system controls the 9885M/S and organizes the data into named files on the desk. A directory keeps track of file names, location, and file type and size.

The write/verify procedures ensure that disk-recorded information is identical to its source information. Additional features include the ability to sort and print directory or catalog information, recover data after a check sum error, and copy files, portions of files, or complete disks onto other disks. Data can be organized either serially or randomly for optimum data access.

Ideal for data acquisition, for program and data storage, for search, sort, merge and update of records or back-up duplication of records, the Hewlett-Packard 9885M/S Flexible Disk Drive makes a significant contribution to system memory capacity.

Crossroads

by John Nairn, PhD
Hewlett-Packard
Calculator Products Division

I was at a party once when someone asked me what I do for recreation. I replied that I like to work mathematical puzzles. Her reaction immediately told me that I should have mentioned my photography or folk guitar pursuits, and I was not too surprised when she spotted someone else to say hello to.

Nevertheless, mathematical puzzles do intrigue me, and judging from the response I got from an earlier "Crossroads" article, there are many of you readers who share my fondness.

Here are a few of my favorite brain teasers for all of you fellow puzzle buffs. The solutions will be given in a later article along with the names of those readers who contribute solutions.

1. A friend of mine who doesn't trust banks or the worth of the U.S. dollar keeps his money in gold coins. He has 10 bags, each containing 10 gold coins, and each coin weighs 16 grams. Recently he had reason to suspect that one of the bags might be counterfeit and contain gold-plated coins weighting 17 grams each. He asked me to devise a method by which he could determine which bag contained the counterfeit coins in the fewest number of weighings. Since I was busily engaged in discovering secrets of the universe at the time, I was not able to help him. Can you give him his answer?

2. Many interesting brain teasers involve discovering the generating rule for a sequence of numbers and thereby determining the next number in the sequence. For example, given the series

1 1 2 3 5 8 13

we would recognize that each number in the sequence is the sum of the previous two numbers and thus determine the next number in the sequence to be 21. Some sequences have a generating rule that is devilishly tricky to find, as in the following cases. Can you find the generating rule and the next number in each sequence?

Sequence A: 0 1 1 1 1 2 1 1 1 2 1 2 1 2 2
1 1 2 1 2 2 2 1 2 1 2 1 2 1 ?

Sequence B: 10 11 12 13 14 15 16 17
20 22 24 31 100 121 ?

3. Usually I don't get very infatuated with problems involving plane geometry proofs. But when one purports to prove that all angles equal a right angle, obviously my curiosity is aroused! Refer to Figure 1 and begin by constructing the square ABCD. From the point D, mark off a line DE whose length is equal to DC and at any arbitrary angle CDE. Connect the points B and E with a straight line. Construct FG as the perpendicular bisector of BC and HI as the perpendicular bisector of BE. The FG is extended so that the two perpendicular bisectors meet at the point I. Finally, construct the lines AI and DI. This completes the construction.

a. AB = CD; sides of a square.
b. CD = DE; by construction.
c. AB = DE; from steps a and b.
d. BI = EI; any point on the perpendicular bisector of a line is equidistant from the end points of that line.
e. AI = DI; same reason as in step d.
f. Triangles ABI and DEI are congruent, 3 sides equal.
g. Angles BAI = EDI; corresponding angles of congruent triangles.
h. Angles GAI = GDI; base angles of an isoceles triangle.
i. Angles BAG = EDG; equals subtracted from equals.

However, angle BAG is a right angle and angle EDG is a right angle plus our original arbitrary angle CDE. Therefore, any arbitrary angle is equal to a right angle (which further implies that all angles are equal). By now I am sure that you are as incredulous as I was when I first saw this proof. But remember that a counter proof is not acceptable. You must find the fallacy in this proof. Readers may vote on any of the nine steps in the proof (or any combination of them) as the candidate for "most fallacious", but you should be prepared to say what's wrong with it. Good hunting!

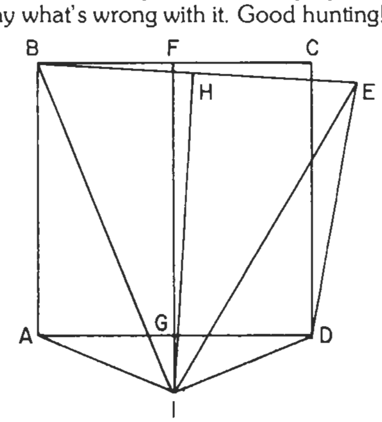


Figure 1

4. Well, so much for abstract geometry and on to more practical matters. I read in the paper recently that the ruler of an Eastern kingdom (it shall remain unnamed to protect it from justifiable harrassment by the feminist movement) wanted to assure the continuation of a long-established custom of the men in the kingdom having harems. In order to do this, he wanted to increase the ratio of women to men in his country without resorting to the Western custom of war. He therefore enacted a law that all families must continue to have children until they have a male child, and then they must have no more children. Thus, families would consist of a boy, or a girl and a boy, or two girls and a boy, or three girls and a boy, and so on. The king has a computer on order so that he can calculate what the final ratio will be after several generations. Can you figure it out for him while he is waiting delivery of his computer?

5. An interesting class of problems concerns the so-called "truthers" and "liars". Most problem fans have heard the one about the man who comes to a fork in the road on his way to the city. At the fork, he finds two men, one of whom always tells the truth and the other of whom always lies. The problem is for the man to devise one question to be put to either the truther or the liar (he doesn't know who is which) whereby he can determine the correct road to take.

An interesting twist is put on this problem if we introduce a third man at the fork in the road who is a "random". No matter what question he is asked (it must be a choice between two alternatives since he is lazy and doesn't like to formulate long answers), he makes the choice of his answer randomly. For example, if you asked him, "Are you the truther?", he might answer yes or no with equal probability. I come to the fork in the road and find a truther, a liar, and a random sitting there. I don't know who is which, but they know each other. How many questions do I have to ask to determine which road to take, and what are the questions?

6. My favorite kinds of problems are those for which it does not appear that sufficient information has been given. One of these problems is given in Figure 2. I take a sphere and drill a hole through the center; that is, the center of the cylindrical hole goes through the center of the sphere. Figure 2 shows a two-dimensional cross section of the hole and sphere, but the actual problem is in three dimensions. The length of the hole is two inches. The question is, what is the volume of the remaining material?

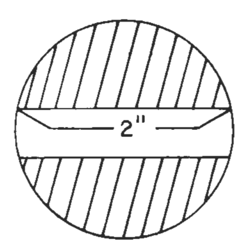


Figure 2

I warn you that if you take up a pencil and paper and begin writing equations and performing integrations, you will take all the fun out of the problem. There is enough information already given for you to calculate the answer in your head.

Programming Tips

Subroutines and Junctions (9825A)

Submitted by Howard Rathbun of Calculator Products Division Marketing.

Callable subroutines and junctions should be placed at the beginning of a program for faster execution. Junction and subroutine calls always search for the subprogram label starting at line 0. The time saved is not a great amount per line (about 30 ms), but for large, long-running programs the savings in time can add up.

Random Number Generation (9830A)

Submitted by Stanley Deming, Assistant Professor in the Department of Chemistry, University of Houston, Houston, Texas.

I enjoyed the tip on random number generation on the 9830A by Philip Dawdy in Vol. 8, No. 1. Our laboratory makes use of randomized experimental designs and has a need for generating different variable-size sets of random numbers.

The program below generates a randomized set of a given number of values. The only major change in the original method of generating random numbers is to test for RES=Ø. If it is true, the program prompts the operator to supply a different seed.

```
10 DIM S[100]
20 IF RES#0 THEN 90
30 PRINT "PLEASE TYPE IN A NUMBER <1000"
40 PRINT "PRESS 'EXECUTE'"
50 PRINT "PRESS 'RUN'"
60 PRINT "PRESS 'EXECUTE'"
70 PRINT
80 GOTO 350
90 DISP TAB32;RND(-0.123456789-ABS(RES)*0.0008)
100 DISP "HOW MANY NUMBERS TO RANDOMIZE";
110 INPUT S3
120 IF S3=0 THEN 330
130 PRINT
140 PRINT "NUMBERS TO BE RANDOMIZED = ";S3
150 PRINT
160 REDIM S[S3]
170 FOR S=1 TO S3
180 S[S]=S
190 NEXT S
200 FOR S=S3 TO 1 STEP -1
210 S1=INT(S*RND(0)+1)
220 S2=S[S]
230 S[S]=S[S1]
240 S[S1]=S2
250 NEXT S
260 FOR S=1 TO S3
270 WRITE (15,280)S[S];
280 FORMAT 10F5.0
290 IF S/10#INT(S/10) AND S#S3 THEN 310
300 PRINT
310 NEXT S
320 PRINT
330 DISP TAB32;RND(0)
340 DISP "END"
350 END
```

Answering the Challenge of One-Line X/Y Integration (9820A)

Submitted by Carlton E. Thurston, Martin Marietta Cement, Thomaston, Maine.

The programming tip entitled "One-Line X/Y Integration" in Vol. 8, No. 2 was quite interesting, and I am unable to resist Mr. Siwertz's challenge. Here is my entry:

```
Ø:
ENT X,Y; FLG Ø(.5
(X-A) (Y+B)+C)→C;
PRT X→A, Y→B; SPC
;SFG Ø; GTO Ø; IF
FLG 13; PRT C ⊦
```

The basic structure of the program has not been altered, but two operating improvements have been made:

1. Register C is automatically initialized to zero, and
2. Input data is printed out for reference.

Also note that the FLG 13 term is not required in the mathematical expression, since the (X-A) term is always zero when the program is run without a data entry. By omitting the absolute value operation on (X-A), it is possible to make corrections to data after it is entered. This is accomplished by simply reversing the order of data entry until a good entry is re-entered. Then proceed normally.

The only drawback is that the last set of X and Y data is printed twice. The following program corrects this but requires the use of RØ and R1. Can someone find a simple way to correct this problem and still only use the alpha registers?

```
0:
ENT X, Y; FLGØ(.5
(X-RØ) (Y+B)+R1)
R1; X→RØ;PRT R→
FLG 13; SFG Ø;
GTO Ø; IF FLG 13=
0; PRT Y→B; SPC ⊦
```

Obtaining Non-Keyboard Characters (9830A)

Submitted by Mr. Robert J. Rahmann, computer programmer at Goonyella Mine, Queensland, Austrialia.

Non-keyboard characters can be placed on Special Function keys of the 9830A very simply if you have an external plotter ROM. Even without the ROM square brackets can be entered. First ensure the ROM is in the central slot of the five ROM slots, then proceed as follows:

- Fetch a Special Function key -- FETCH F_0
- Type in a legal array statement -- 1A (1,1)=1
- Press END OF LINE and ↓ (display viewing key)
- Edit the display 1A (1,1)=1 to *(or *) and press END OF LINE.

For the rest of the characters, begin as above or use the brackets placed on the keys to enter, while in key mode,

(95,1)−1

The characters outside the brackets are unimportant. The first number inside the brackets is the ASCII code for the symbol required; 95 is the code for an underscore.

Press EXECUTE
Press RECALL

The display should read

(95,1)⊦1

Edit to place

*⊦

on the key.

The non-keyboard characters, including line feeds, etc., can now be included in WRITE, PRINT, and FORMAT statements. Code 162 produces a quote on the display and the 9866A printer, but it does not terminate the quote field of a print statement or string variable assignment. In some programmes, use can be made of the fact that the operator cannot normally enter these characters. They can be used, for instance, to separate substrings of keyboard characters within a string.

Filling a String with Spaces (9825A)

Submitted by Howard Rathbun of Calculator Products Division Marketing.

It is often necessary to fill a string or portion of a string with a number of spaces. This method, which uses a for-next loop, is one way to do this:

```
0: dim A$(100)
1: for I-1 to 100
2: "  "→A$ (I,I)
3: next I
```

The method shown below not only uses less code, but is about 80 times faster. Note, however, that this second method can be used only for filling the entire string with spaces.

```
0: dim A$(100)
1: "  "→A$ (1,100)
```

Labeling Special Function Keys (9825A)

Submitted by Sam Sands of Calculator Products Division Marketing.

To avoid guessing what your Special Function keys do, label your key files and the individual keys. Then you need only do a list k to see at a glance what each key is for. You can:

1. Put a label in front of an executable statement,
2. Use a label instead of a statement number in a CONT command, or
3. Put in a dsp statement. The key then tells you what it is doing as soon as you press it. You don't have to wait for a program to be loaded from the tape cartridge, for example, before you know whether you hit the right key.

If you should accidentally press the wrong key, press RECALL to see what key you pressed.

```
f0: *"Program
    Modification
    Keys":

f1: *"Modify
  Variable":3→X

f2: *cont"Entry
  Point"

f3: *"Program
      Selection
      Keys":

f7: * dsp "Engin
  eering";trk 1;l
  dp 8

f10: *dsp "Stati
  stics";trk 0;ld
  p 5

f18: *dsp "Graph
  ics";trk 0;ldp
  3
```

A "Keyboard Interrupt" for the 9830A

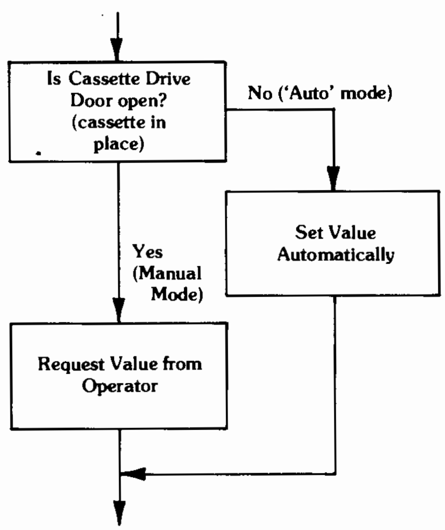
Submitted by the 9830A/B Users' Group in Melbourne, Australia.

Wouldn't it be nice to hit a key on the 9830A and cause a flag to be set? That is, to be able to change the course of a program while it is running from the keyboard? It can be done on the 9820A, 9821A, and 9825A, but there is no key to achieve this on the 9830A. Or is there?

If you have an 11272A Extended I/O ROM, try the following:

- Type in the program (see below).
- Put any cassette into the transport and close the door.
- Run the program. "999" will flash repeatedly.
- Open the cassette door.
- Enter a value manually in response to the display.
- Until the door is closed again, the program remains in manual mode.

```
10 V=999
20 If Stat 1Ø# 8 then 5Ø
30 Disp "Enter Value";
40 Input V
50 Disp V
60 Wait 1ØØØ
70 Goto 1Ø
```



A Method of Inputting Variables (9830A)

Submitted by Mr. A. de Faro Barros of GESPO, Porto, Portugal.

Sometimes one needs to enter an array, many of whose elements are zeros. Instead of the time-consuming

```
1010   For J = 1 to 50
1020   For K = 1 to 9
1030   Disp "Number";
1040   Input M(K,J)
1050   If M(K,J) = 0 then 1070
1060   Next K
1070   Next J
. . . . . . . . . .
```

use

```
1010   For J = 1 to 50
1020   Disp "Dependencies of" J;
1030   Input N(1), N(2), N(3), N(4),
       N(5), N(6), N(7), N(8), N(9)
1040   For K = 1 to 9
1050   If N(K) = 0 then 1080
1060   M(K,J) = N(K)
1070   Next K
1080   Next J
. . . . . . . . . .
```

Continual digitation of 9 numbers can be partially avoided by entering

,0,0,0,0,0,0,0,0

onto a Special Function Key (f_9, for example). As an illustration,

- The display shows: "Dependencies of 5?"
- You enter: 3, 4, 15, 33, 45
- Press: f_9

Row 5 of the array now contains

3, 4, 15, 33, 45, 0, 0, 0, 0,.

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