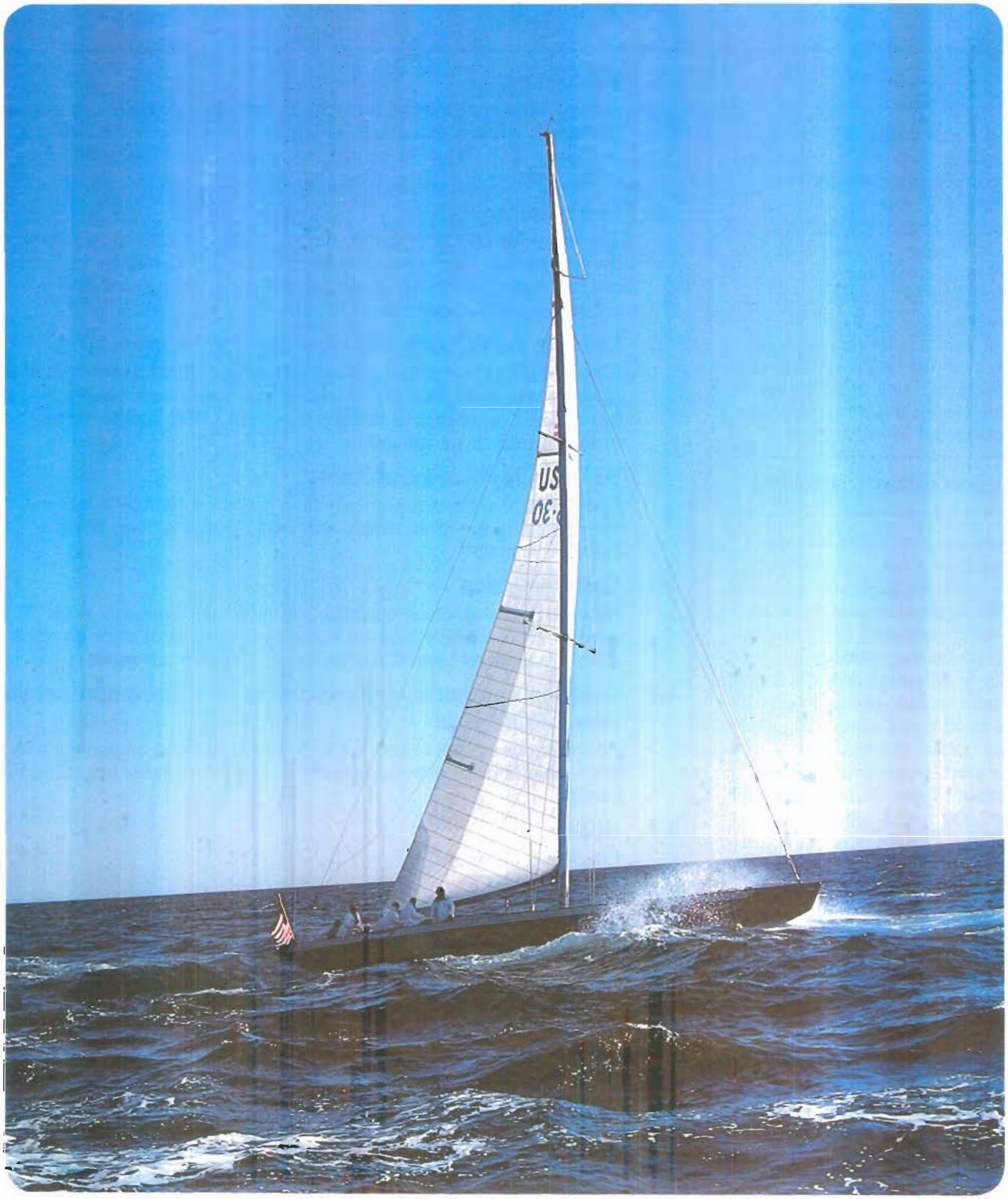
# Keyboard

Nov-Dec/80 A Publication of Hewlett-Packard Desktop Computer Division



Keyboard
November-December 1980

## Cover

At sea and under sail, the sleek sailing yacht "Freedom" pushes the waves aside and catches the sun on her mainsail. The crew of the yacht included a compact 9825 Desktop Computer, which helped make navigation about as accurate as it can be. Our cover article begins on the facing page.

"Full steam", which begins on page 4, describes another shipboard application, this one from Norway. We have begun the article with an abstract printed in Norwegian.

## Subscription renewal

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# Reckoning



*by John Monahan*
*Keyboard feature writer*

*For more than a century the America's Cup has been the foremost prize in international yacht racing. The series began in 1851 in England, when the schooner yacht "America" defeated the Royal Yacht Squadron to earn the Hundred-Guinea Cup.*

*The trophy became the America's Cup in 1857 when it was deeded to the New York Yacht Club to be an international challenge cup. One hundred years later twelve-meter yachts were introduced into the races. The term "twelve" denotes the design formula that determines the yacht's racing class.*

*Including Freedom's 1980 triumph, American entries have defended the cup successfully 24 consecutive times. Yachts from Canada, Scotland, Australia and England have attempted to take the cup to their home shores.*

*"Freedom" defeated "Australia" four races to one, with no more than four minutes separating victor and loser in any race.*

Main sails and spinnakers aloft and full, "Freedom" (left), and "Clipper" vie for the wind during campaigns to determine the American defender of the cup. Both yachts were aided by computers.

## Electronic mate

You may be a romantic who prefers to steer his ship by a star, but if you have more than two million dollars invested in a racing yacht and are defending the America's Cup, you might want to trade your sextant for an onboard desktop computer.

Skipper Dennis Conner and navigator Halsey Herreshoff of "Freedom", America's Cup victor over "Australia", depended on sensors and radio signals to determine their twelve's speed and position, plus a desktop computer that recommended the most advantageous course to steer.

Their electronic mate, not counted among the skipper and ten-man crew, was the HP 9825. Acquiring data from the sensors, the desktop computer calculated the shortest distance to the next of six turning marks or the finish line. These race course designators were often obscured by high seas, the pitch of the yacht and the position of her sails.

Moreover, because it kept track of wind speed, current and course, the 9825 allowed the sailors to decide the most advantageous time

*The desktop computer, contained in a plastic bag to keep out the sea, was situated belowdecks and within reach of navigator Herreshoff.*

The 9825, wrapped in its plastic bag, is stowed safely in the compartment interior.

for manuevers such as tacking.

The 9825 is one reason why the America's Cup still resides at the New York Yacht Club, and why that coterie selected "Freedom" to defend its 129-year-old prize.

## Campaigns

During six-week pre-race trials, or "campaigns" in yachting parlance, Conner and crew outclassed "Clipper", a boat with a computer system larger than the 9825, and "Courageous", cup defender in 1974 and 1977, which reportedly also employed data processing instruments.

The 1980 race was Conner's first attempt at winning the cup. The skipper from San Diego, California, has been described by an interviewer as "quiet, confident, and a winner." Preparation, Conner was quoted as saying, is the key to finishing first.

A belief like that would quite logically lead him to selecting Halsey Herreshoff as his navigator.

The Bristol, Rhode Island, sailor and ship designer seems to have spent his life preparing for, and defending, the America's Cup. Herreshoff was there in 1958 when twelves were introduced into the competition.

Since then he has served in six campaigns, and counting "Freedom", has guided three yachts to cup victories.

## Dead reckoning

Herreshoff called the 9825 his "constant adviser," from which he sought advice as often as 100 times per hour during the average 24-mile race. The computer showed information via Rochester Instruments Company liquid crystal displays located on the port and starboard sides of the yacht.

In effect, the 9825 performed dead reckoning, telling Herreshoff:

- Apparent wind speed and direction (in relation to the yacht's bearing).
- True wind speed and direction (in relation to the axis of the earth).
- The computer's advised course.

## Seamanship

But the America's Cup was not decided by engineers, any more than a thoroughbred horse race is decided by geneticists.

Seamanship and luck ultimately determined the outcome, despite "Freedom's" 9825 and "Australia's" innovation, a flexible mast. At times Conner ignored computations from the computer, perhaps demonstrating that instinct can transcend logic.

Still, the computer seems destined to be a part of future America's Cup races.

As Herreshoff said, one day "all serious contenders will use computers, because they allow us to do more work in a given time with more precision."

The feature on the 9825 that Herreshoff made most use of was the Special Function Keys. Each of the eight keys was programmed to provide particular information. (Using SHIFT, the number of key functions was doubled).

When, for instance, the navigator wanted to know the distance to the next turning mark, he pressed the designated key, and the answer flashed on the display screens. The keyboard was not used, and in fact was covered by a sheet of cardboard that listed what information each Special Function Key provided.

The program was planned by Pete Lawson of New Haven, Connecticut, who along with Herreshoff, is one of the most heralded maritime navigators in the country. Navigator — not computer programmer. Lawson's background in computers is not extensive. "I'm a sailor first," he said.

At the America's Cup defense of 1977, won by "Courageous", Lawson wrote some programs when he saw that "the computers they were putting on the twelves had about a 60 % reliability."

Navigator Halsey Herreshoff mans his post, with one hand in the 9825 compartment.

When "Freedom's" backers approached him this year for computer help, Lawson adapted the programs he'd developed over the years to fit the yacht's needs.

"This time," Lawson said, "I decided to use off-the-shelf hardware" rather than spend his time "soldering wires."

Lawson said he looked at computers made by several manufacturers, and then decided on the 9825. He said the support he would receive was a deciding factor.

## In the bag

"The biggest complaint I had about the 9825," he said, "was that the damn thing wasn't waterproof."

The desktop computer, contained in a plastic bag to keep out the sea, was situated belowdecks and within reach of navigator Herreshoff. The data displays, on the port and starboard sides, were liquid crystal because that type of display was easier to read in the water's glare.

Every two to four seconds, the sensors fed data over the HP 98032A 16-bit Parallel Interface, to the 9825. Data included boat speed, apparent wind speed, apparent wind angle and compass heading.

## LORAN

This was just part of the process, however, because for the computer to determine a course, it had to know where it was.

The twelve's position was ascertained using LOng Range Aid to Navigation (LORAN), which is a worldwide network of radio stations. By coordinating any two signals broadcast by the stations, it was possible to pinpoint the yacht's position "to a precision of 100 feet," according to Herreshoff.

This position data was manually entered into the computer by the navigator. Having this information, and taking into account data from the sensors, the 9825 computed the distance to the next mark or finish line, along with the bearing that took "Freedom" home first — four times out of five.

It is likely that in the future a desktop computer and the LORAN signals will be interfaced, thus circumventing the need for the navigator to enter position data himself.

And it is just as likely that other forms of high technology will be incorporated into this tri-yearly contest for the cup. (Just as, in 1760, a new device called the sextant revolutionized maritime navigation.) That is merely the form, of course. Teeth white as milk, the sea waves will rage as always, and good men will still come to them. Romance, like treasure, is kept there permanently.

Skipper Dennis Conner keeps his eyes on the sea before a day of racing begins.


With her crew hard at work, "Freedom" sports main sail and jib as she works her way at sea.

# Full steam

by John Monahan
Keyboard feature writer

*A/S Maritek i Bergen, Norge forbedrer brennstoff-økonomien ombord i skip ved hjelp av borddatamaskin. Så snart årsaken til overforbruk er klarlagt, foreslår A/S Maritek de nødvendige tiltak for forbedring av brennstoff-effektiviteten.*

In Norse mythology the ship *Skidbladnir* could hold all the gods and their households, yet so craftily was it built, it could fit into a coat pocket.

In light of today's energy squeeze, modern ships, too, depend on skillful construction to operate efficiently. Belowdecks is found perhaps the most important point where energy can be saved: the steam power plant.

The marine engineering and naval architecture firm A/S Maritek of Bergen, Norway, offers services and equipment for improving performance and conserving fuel of the steam-powered ships plying the world's seas. An important part of Maritek's fuel conservation system is the Hewlett-Packard 9815A Desktop Computer.

## Measuring fuel waste

Maritek, which has performed tests and analyses on more than fifty ships, specializes in identifying the causes of improper fuel economy, then providing a ship's owners and engineers a method to measure with continuity a ship's performance. The system is called Predikt 10 Steam. It consists of six elements:

- Testing of present instruments which report a power plant's operation and condition.

*Predikt 10 Steam allows engineers to separate design deviations from operating deviations, yielding a more accurate picture of a steam plant's efficiency.*

- Calibration of these instruments and recommendations for repairing existing instruments or adding new ones.
- Testing of the power plant and recording its performance using these instruments.
- Anaysis of actual component performance and heat-plant performance.
- Determination of the standard (or ideal) heat balance conditions.
- Use of the 9815 to calculate performance parameters, store performance data, and make trend analyses.

These elements compose an overall effort by Maritek to develop a monitoring plan (elements one, two and three), which enables the firm to compare plant conditions (element four), to a set of standard conditions (element five), and ultimately make suggestions for more efficient ship operation (element six).

Once the plan is completed, Maritek instructs the ship's engineers about how to use Predikt 10 Steam to gage the ship's performance.

## Designing unique systems

Predikt 10 Steam, says the consulting firm, allows engineers to separate design deviations from operating deviations, yielding a more accurate picture of a steam plant's efficiency. Each Predikt 10 Steam system is uniquely designed for a single ship.

However, Maritek's experience has shown that ships are subject to common problems when it comes to inefficient fuel use.

Errors in instruments can cause an excessive effusion of steam to the condenser and an imblanced steam flow within the power plant.

Operating engineer miscalculation may be caused by a failure to

Instrumentation aboard ship may need to be modified to better monitor the power plant.

understand the design intent of the heat balance and how deviations affect the steam plant's cycle and fuel consumption.

Undetected faults in original design, evidenced on a ship where the boiler economizer unit was causing inefficient combustion and increased losses in the boiler, are common trouble spots.

Other factors also may be encountered, such as inadequate maintenance and a consistent failure to monitor fuel-efficient improvements ordered by a ship's fleet operating manager.

## Finding causes

With these problems in mind, Maritek's engineers first study the ship's design, inspect its instruments in port, then recommend changes or repairs. The company also installs its own devices for monitoring areas important to fuel economy.

Next, the engineers go to sea with the ship, where they take readings to determine its standard heat balance. Numerous pieces of information are gathered concerning the main boilers, feed pumps, turbogenerators, main condenser, condensate and auxilliary systems and fuel oil.

After the ship returns, Maritek analyzes the data, makes standard heat balance diagrams, prepares various reports, and writes the software that the 9815 will use for calculations.

## Analyzing data

Performance parameters, determined by Maritek in concert with the ship's owner, are calculated by the 9815 to relate such information as the efficiency of the boiler, turbines or steam plant overall.

The 9815 provides a printout of heat balance conditions for a given set of input data. Any item of actual heat balance output can then be compared to the standard heat balance. This is useful, Maritek says, when studying the performance of individual machinery.

The desktop computer also aids in making trend analyses. Most of the 20 ships now using Predikt 10 Steam typically input data to the 9815's memory file (cartridge tape) every two weeks. Each tape holds more than a year's worth of information. This provides a library from which the Maritek-written software can generate a character plot of shipboard energy use trends.

Because the 9815 makes thermodynamic calculations, Maritek says, the ship's operating engineer has more time for diagnosing problems and making adjustments to maintain the steam plant's efficiency.

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# How high is the ground?

*by Steve Leibson*

It is a paradox that of all the signal wires used in interfacing, the most complex is the one that seems the most simple.

Ground wires are usually ignored in the design of computers and interfacing circuitry. No signals are intentionally impressed on them.

Often, the number of ground wires in an interface cable is determined by how many conductors are left over after signal wires have been allocated. This type of interface design can lead to signal degradation, loss of data and even destruction of equipment.

Why do designers include ground wires in the first place? Electricity flows in loops. Current must always return to its point of origin according to the laws of physics.

If we want to send a logic signal to a peripheral device we will be sending it in the form of a current. This current must have a return path of low impedance so that the full signal strength is observed by the peripheral device. Any impedance in the pathways will diminish the signal observed by the peripheral.

One reason to provide a ground is to supply a low-impedance signal return path. This type of ground is called a logic ground because it is associated with the logic signals.

## Plug problems

A second type of ground serves to ensure that the devices at either end are at or near the same potential. One of the "laws" of interfacing states that there are never enough sockets on a wall power outlet to supply a complete computer system. At least one device will be plugged into another wall outlet several feet away.

Most computer devices now are sold with three-pronged power plugs and use the third wire of the power outlet as an earth ground. This "earth ground" is used as a safety ground to keep the voltage of exposed metal parts within strict safety limits.

Unfortunately, due to haphazard wiring practices, there may be several volts of potential difference between the third wire of one electrical outlet and the third wire of an electrical outlet only a few feet away in the same room.

This potential difference is usually not large enough to pose a hazard to humans but can be death to a computer system. Signal levels for most interfacing systems today are five volts. A potential difference of only two or three volts can destroy

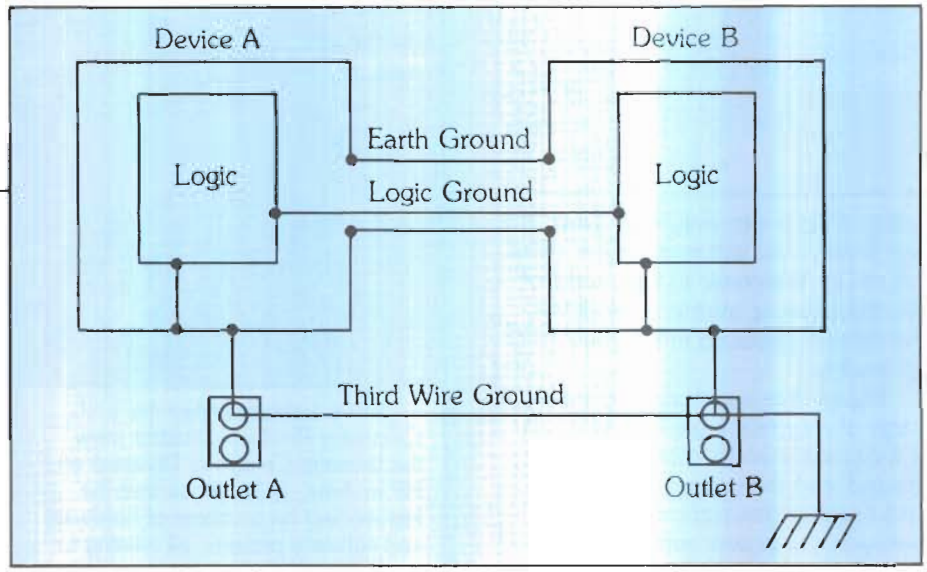


Figure 1

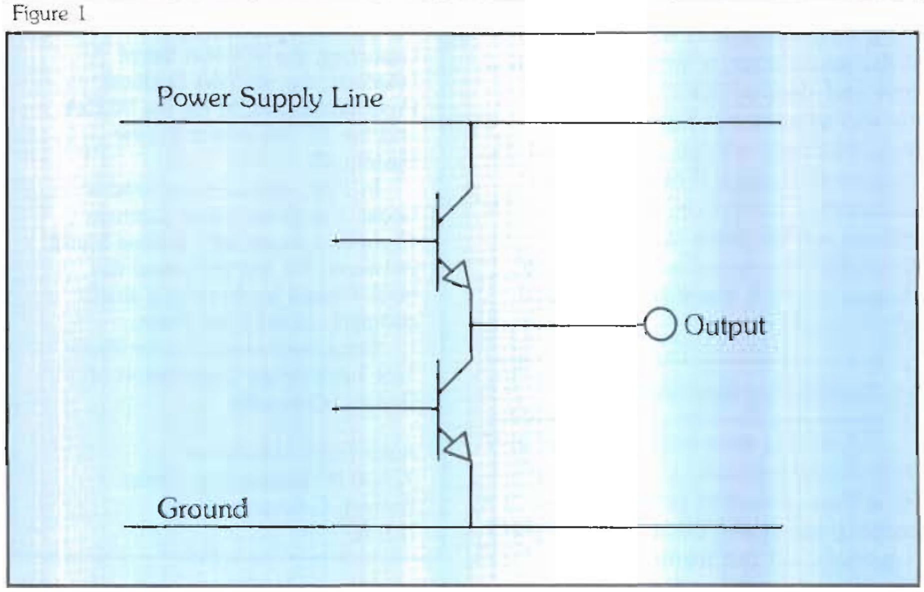


Figure 2

all trace of a signal. A potential difference of twenty or thirty volts can destroy circuitry.

A safety or earth ground between devices can minimize this potential difference. One again, we seek the lowest impedance possible so that the potential difference is as small as possible.

## Ground tools

Now that we have good logic and safety grounds between our computer and our peripherals, we can relax, right? Probably not. Chances are we have created a ground loop.

Figure 1 shows a system with just such a problem. The computer and the peripheral are tied together with three grounds. There is a logic ground for the signal return, a safety ground for potential minimization and the third wire grounds in the power cords.

The safety and third wire grounds are connected together intentionally. That loop cannot be avoided. The logic grounds in both devices are connected to third wire ground which is common in computer design. Loops are formed between logic and safety, logic and third wire and third wire and safety grounds.

Two sources of problems exist for this system. First, current may be flowing in the third wire conductor due to a faulty or leaky device someplace else in the power system. This will cause a voltage difference at the two power outlets A and B. That is why we installed the safety ground, to add a low impedance path and minimize this difference.

## The third path

The current sees the dual paths of third wire and safety grounds and the voltage difference will indeed be small. Unfortunately, the current will also see a third path to flow through, the logic ground.

Logic grounds are not typically designed to carry power fault currents. They have higher impedance. Thus a large current flowing through signal ground may prevent communications.

Since we put the grounds in to allow the logic signals to be received reliably, how do we prevent ground loops from destroying that reliability? The best method is to plug all devices in a computer system into one electrical outlet.

This assumes that there is enough current capacity on that circuit to supply the computer and all of its peripherals with power. If there are not enough sockets on the outlet, use a power strip. The third wire ground in a power strip is short, well defined and will be of low impedance.

## EMI

Now that we have eliminated the effects of ground loops and our system is performing flawlessly, we can relax. Unfortunately, we notice that whenever the computer system is on, there is a lot of static on our

Steve Leibson joined the Calculator Products Division (now the Desktop Computer Division) of HP in June, 1975. Since then he has worked on a variety of hardware and software projects, all relating to interfacing of desktop computers. His products include the 9878A I/O Expander, the 98036A Serial Interface, the 98224A Systems Programming ROM for the 9825A and the I/O backplane for the System 45.

In 1980 steve co-authored a book: *The Great Small Business Computer Ripoff* with a close friend, Bill Scott. He has published the book himself by forming a small company called Data Press.

Steve now works for the Auto Trol Technology Corporation of Denver, Colorado.

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radio. Worse, our neighbor down the hall notices the same effect on his or her radio. Welcome to the world of electromagnetic interference (EMI): the second problem in interfacing grounding.

Figure 2 is a picture of the output stage of a typical logic circuit. There is a transistor connected between ground and the output signal line and another transistor connected between the power supply and the output signal line.

If both transistors are turned on at the same time, a large current will flow and destroy the circuit. If only the top transistor is turned on, the output voltage will be close to that of the power supply. If only the lower transistor is turned on, the output voltage will be close to ground potential. The signal is switched by changing which transistor is on and which is off.

## Computing antenna

When this switching takes place, both transistors will be partially on for a brief period of time. One is partially on, going off and the other is partially off but turning on.

At this instant, a large current is allowed to flow from the power supply to ground through both transistors. This current spike will make the ground jump a bit through the small but finite impedance of the ground line.

There are literally thousands of these output circuits in a computer, switching constantly. All are adding their share of noise to the logic ground. This noise is carried out to the interface cable and over to the peripheral on the logic ground wires we ingeniously ran between the devices in our computer system.

The voltage spikes in the ground are too small to affect the interface logic signals but the interface cable acts as an antenna and transmits this noise for all to receive. The thousands of output circuits team up to form a low voltage but high current signal. The actual logic signals are much lower current and don't cause as much trouble.

## Solutions

There are two solutions to this problem. The first involves the use of low impedance ground planes in the computer and peripherals to minimize the ground noise. The second to to shield the interface cabling to prevent the noise from escaping. Both of these techniques are used in Hewlett-Packard desktop computers.

Finally, interface designers are attacking the ground loop and EMI problems using a new interfacing technology: fiber optics. Glass optical fibers carry modulated light signals between devices. There are no grounds, thus no loops. There are also no "antennas" to pick up and transmit noise.

Currently, fiber optic interfacing costs more than the conventional interfaces we have covered in this series. Some applications requiring long distance or good noise immunity are already using this interfacing technology. Many more applications will use fiber optics in the future. K

# 9111A Graphics Input Tablet

*by Brenda Hume*
*Hewlett-Packard Company*
*Desktop Computer Division*

The new 9111A Graphics Input Tablet is designed for use in interactive graphics, graphics entry and menu selection applications.

### Interactive graphics

The 9111 acts as the CRT's cursor mover. As the user draws on the tablet, the picture appears on the CRT. Drawing is as effortless as pressing down on the stylus pen.

In single mode, a program can interpret an entered point as the end of a line, center or circumference of a circle, corner of a rectangle or location of a drawing. Continuous mode makes it easy to sketch freehand and trace existing drawings, diagrams, charts or photographs.

Once the drawing is in a data base, it can be modified, rescaled and plotted. With these capabilities, designs, diagrams and layouts can be changed on the spot. Schematics, computer-aided design, printed circuit and integrated circuit layouts and office and industrial floor plans are among the applications where the flexibility of the tablet can be put to good use.

### Picking from a menu

Users can create a customized keyboard or control panel through the 9111's menuing capability. Sixteen softkeys can represent any designated data or commands.

With a program to interpret, the user can enter words such as "enter" or "delete" or an entire phrase such as "quantity of units back ordered" with a press of the stylus pen to the appropriate softkey.

For additional softkeys, a menu can be designed on paper or HP menu blanks, then placed on the tablet. The entire tablet can be converted into a menu keyboard for additional entries.

### Features

The graphics tablet has a durable, ceramic platen that will not easily scratch or pit. A pen-shaped stylus and inclined working surface provide operator comfort for long periods.

The pen can be fitted with either ink or non-ink ballpoint pen refills available though HP's worldwide supply centers. The data-transfer rate is programmable from 1 to 60 points per second, assuring smooth cursor movement.

A programmable beeper gives audio feedback when operations are complete. And two built-in self tests allow isolation of problems should they arise. The tablet accommodates letter-size documents.

The 9111 is fully compatible with the HP-85 , 9800 series desktop computers and the HP 1000 technical computers through HP-IB and HPGL (Hewlett-Packard Graphics Language).The System 45B and 45C Graphics ROMs also provide easy access to the 9111A.

### Software

Utility software is available for use with the tablet when linked to a System 45B Desktop Computer. The software, ordered as product number 88100A, includes:

- Drawing Utility — to draw a picture, add text, create a data base and plot. Useful in creating graphics presentations.
- Graphics Editor — to choose, place, delete, move, rotate and rescale elements. Useful in creating schematics, flowcharts, PERT charts and layouts.
- Menu Utility — to create a program driver for interpreting a menu. All coding for the tablet is provided. Users need to add only application subprograms. K

# Color graphics

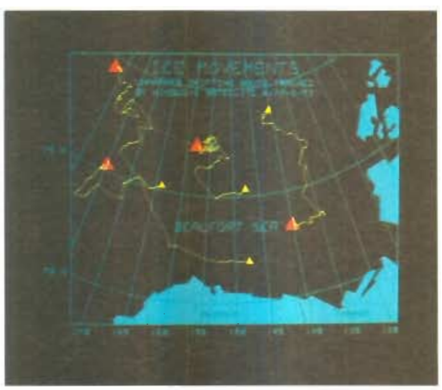
by Albert B. Sperry
Hewlett-Packard Company
Desktop Computer Division

The complexity of scientific and technical problems is growing rapidly in the wake of technology's speeding progress. Using computers to help reduce this complexity requires a method of human data assimilation that can keep pace with these number crunchers.

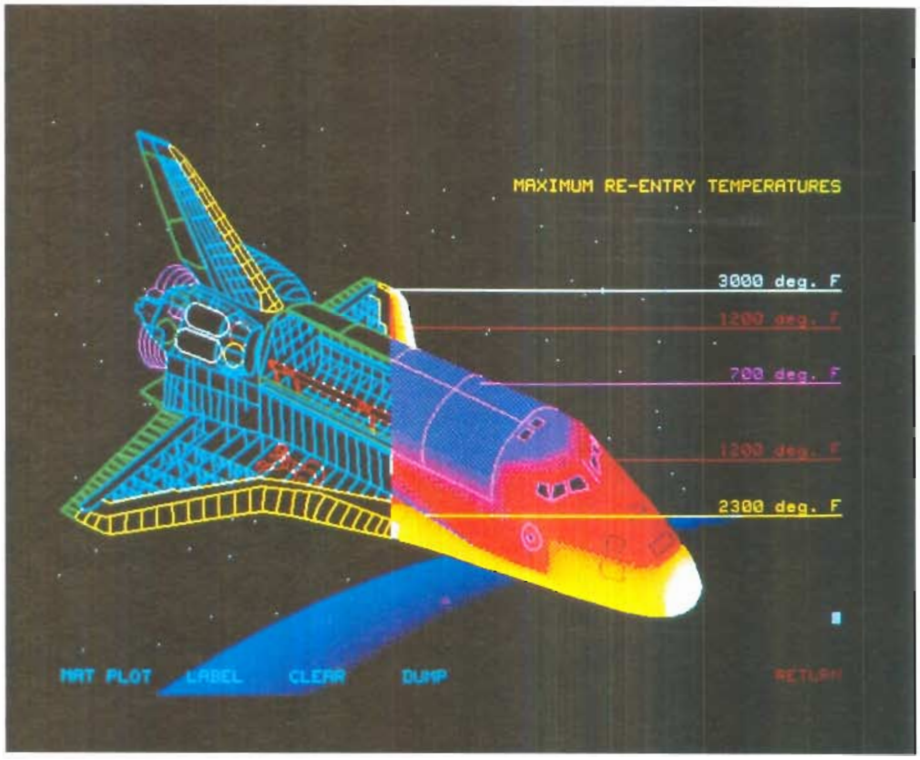
One tool that can enhance both speed and accuracy in interpreting data is computer graphics. The user, who may find numeric output data tables utterly confusing, can quickly interpret results in graphic form.

Graphic output speeds mental interpretation, analysis and decision-making. It also can pinpoint discontinuities resulting from data input errors.

Using graphics as a natural extension of the computer's human interface can produce benefits in data interpretation, productivity and complex problem solving.


System 45C image shows ice movements off the shores of Alaska and Canada.

Enhanced data interpretation is the most commonly recognized benefit of graphics, when numerical data is converted to a graphical format. Bar charts, pie charts and trend lines seen in annual reports, and frequency response plots used in electronic design are a few types of graphics that enhance the viewer's understanding.



Reentry temperatures, designated by colors, mark the exterior of this image of the space shuttle generated on the System 45C. Interior frame colors here denote sections rather than stresses.

Increased productivity can result from using computer graphics with automation in development areas such as computer-aided design and computer-aided manufacturing. As examples, city map drawings, electrical circuits or IC masks can be designed and developed with computer graphics.

This tool can help simulate and solve complex problems. Examples include simulation studies and 3-D wire-frame analysis of objects. The object under study is graphically portrayed for the user's problem-solving interaction.

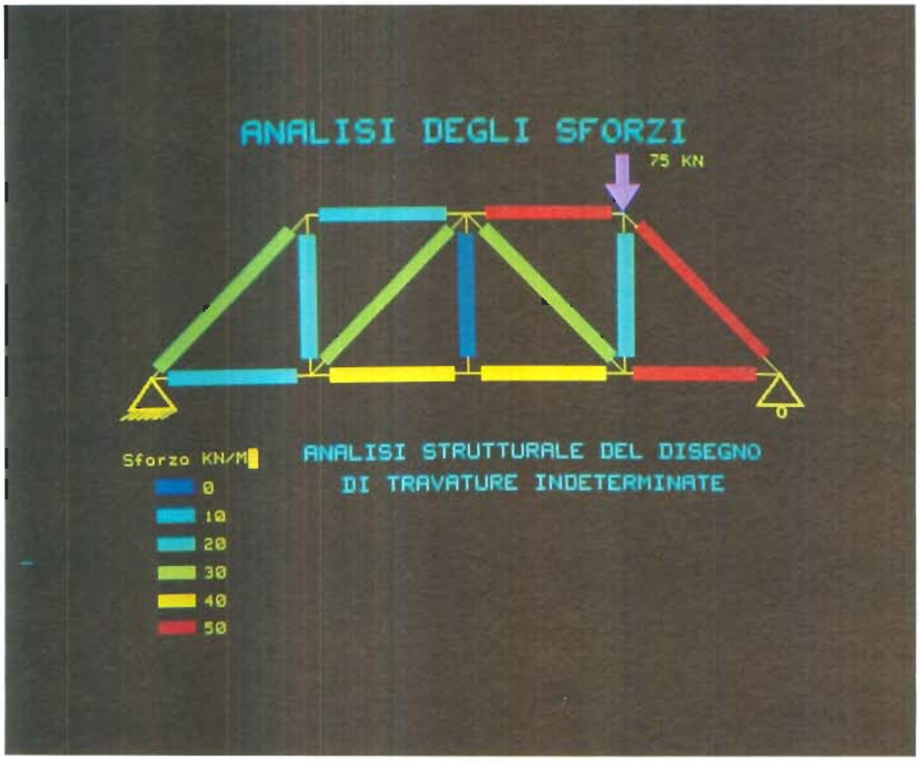
## Color graphics

When the color of the recently-introduced System 45C is added to computer graphics, it enhances the benefits described above and adds the natural attraction of color to draw the user's attention. Color aids data interpretation abilities, both in recognizing and processing data faster and in processing data that is more complex.

## Monitoring

A significant benefit of color graphics is its ability to draw the user's attention to an important situation. In the North Atlantic, ice movements can destroy oil rigs or ships.

An ice monitoring program might use an airborne data gathering system, with conversion of photographic data to digital using a digitizer. Color graphics can be used to clearly chart the movements of a number of different ice masses. When an ice mass acquires a motion vector that might endanger an oil rig




Stresses on a bridge design are shown in colors that denote the degree of stress in this image generated on the System 45C. Labels in this image are presented in Italian.

or ship, the vector can be shown in flashing red, signaling the need for emergency measures.

### Simulation studies

In complex problem solving, color can add realism to a simulation, provide differentiation or be used as a third output parameter. In wire-frame analysis, color helps depict the inside as well as the outside of a structure. Other information can relate to gradations in temperture, stress, or other parameters not readily identifiable in monochromatic displays.

Simulations of the space shuttle during re-entry can help in studies of exterior and interior temperatures with varying spacecraft skin temperatures. Using a cutaway diagram of the craft, interior stresses can quickly be grasped by displaying a limited spectrum of colors designating a temperature range. A different spectrum can define temperatures on the craft's skin. This use of color allows rapid assimilation of complex data patterns, speeding the simulation studies.

### Engineering design

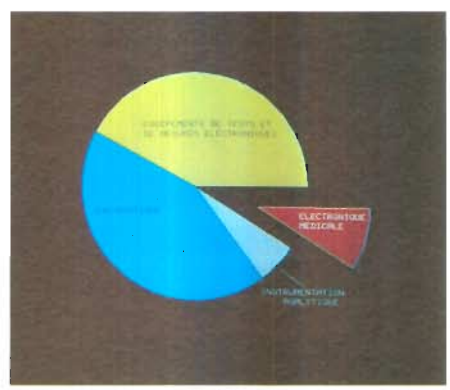
Color graphics can turn a desktop computer into an interactive engineering design station. Each member of a structure can be shown, with different colors representing a range of stresses encountered using the design. The engineer can study the stresses and determine what portions of the structure need to be redesigned to optimize efficiency and strength.

The light pen that comes with the System 45C assists the engineer in laying out the required geometry for the structure, saving time. It allows changes to be made with a minimum of effort, encouraging experimentation. The bottom right portion of the screen could be set aside to display current design parameters.

### Presentation graphics

Producing management presentation graphics is rapid and practical using the light pen in conjunction with color graphics firmware. Resulting displays can be used in management conferences via either four-color plots on transparencies using the HP 9872A plotter, or 35mm slides photographed directly from the CRT.

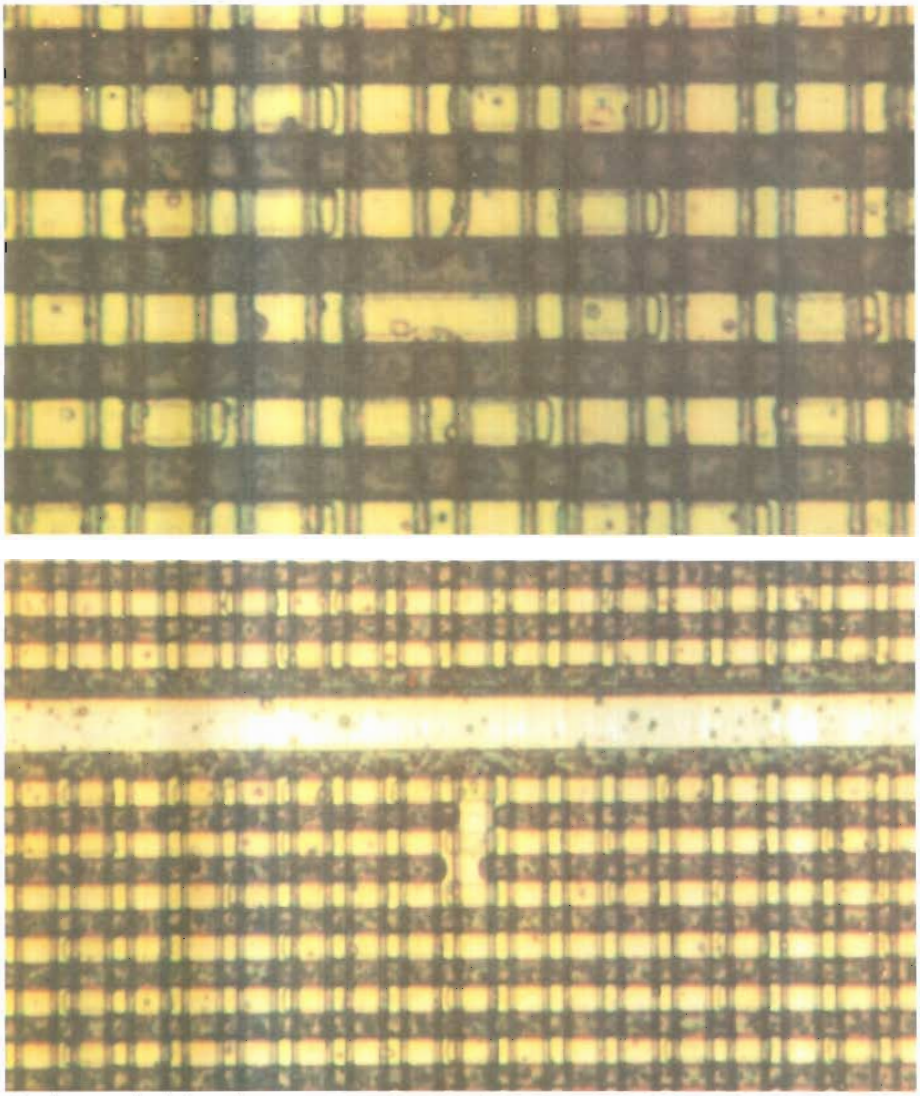
The possibilities for using color graphics to advantage with a desktop computer may be endless. But the reason why it can augment the already considerable capabilities of the desktop computer is that it offers another dimension in human interfacing.



Pie charts have more impact in color, as does this 45C image. Labels here are in French.

In order to make computers useful to the largest possible percentage of people, computers must be designed to make communication with humans as easy and efficient as possible. K

# Computer network raises ROM yield



As photographed through a microscope, this chip demonstrates defects detected by the ROM-checking system. A diffusion short is shown in the upper photo, a metal short in the lower picture.

*by John Monahan*
*Keyboard feature writer*

Hewlett-Packard's Desktop Computer Division (DCD) increased its per wafer yield of the integrated circuits it manufactures by over 100% in the last year, thanks in large part to a system that uses the division's own desktop computers.

The ICs are 64K ROMs (memory devices with unalterable information), which are essential components of many of the division's products. Increasing their availability has been a boon to manufacturing efficiency, according to process engineer Mitch Weaver.

"Costs of parts have decreased and delivery times for DCD products have been reduced," Weaver says. A further result, he adds, has been an increase in the amount of time engineers can spend designing new types of ICs.

## Three computers

DCD, Fort Collins Colorado, employs its own HP 9825 and System 35 Desktop Computers, along with an HP 3000 mainframe computer. The 64K ROM they help produce is part of the System 35.

DCD's testing for defective ICs is two-part, says Weaver, who watches the yields as closely as a farmer watches his fields.

In part one, a Xynetics Model 1034X Prober, controlled by the 9825 through the HP 98032A 16-bit Parallel Interface and other electronic instruments, examines a 100-millimeter (diameter) silicon wafer containing 300 ICs. When it finds a defective ROM, it marks it with a dot of ink. The other instruments include five HP 6200 Programmable Power Supply units, the HP 6940 Multiprogrammer, the HP 59500 Multiprogrammer Interface and the HP 3490 Multimeter.

Traditionally, most defect-analysis systems use one or more test chips to monitor the production process. Engineers then attempt to estimate the IC yields they would obtain from other chips, based on yields from the test chips.

## Prober

Weaver describes this as allowing the process to control the product, which is less desirable than the product itself indicating to the engineer what's causing defects.

Thus, part two of the process takes advantage of the nature of the 64K ROM, which Weaver says can actually "address" its own failures by the correct and incorrect data it produces.

Each ROM consists of 65 536 bits, organized in a 4K by 16 format. This means there are 4 096 possible addresses, any of which supplies a 16-bit data word, manifested as an X-Y location. A group of failed X-Y locations produces a pattern unique to the defect causing the failure.

Using the computers, one can determine the cause of the defects by studying these patterns.

And so when the prober finds a defective IC, it does more than simply ink it and move on to the next one. Instead, it stays at the scene and sends the data it is acquiring, including the location of the defect, to the 9825. The volume of this information is huge: The correct functioning of each of the 4 096 addresses must be checked, for an average of 8.5 megabytes per day.

To analyze properly the defect patterns requires a computer the size of the 3000. But because the big mainframe is time-shared, and because of the immensity of the data, the System 35 comes into use. Its software is written in Assembly language for greater speed.

Connected to the 9825 through the HP 98032A Interface, the System 35 accepts data from the smaller computer and compresses it (that is, it converts 16-bit words into ASCII characters).

Next, through an RS 232C interface, it "contacts" the 3000 to determine if the big computer is ready to receive information. If not, the System 35 stores the data on an HP 9885 Flexible Disc Drive.

If the 3000 is in the receiving mode, the System 35 sends the information it acquired from the 9825. The information is stored in a data base, and the patterns of defects are analyzed for each wafer.

HP employee Koko Jacobs unloads a 100 mm wafer from the prober. The defective ROMs have been inked and the failure locations sent to the HP 9825.

## Defect patterns

How are the patterns recognized? DCD's research shows there are at least 12 classes of defects for any 64K DCD-made ROM. The 3000 creates a 65 536-bit array which recognizes defect paterns as falling into one of the 12 classes.

This recognition, Weaver says, could be performed by HP's System 45 Desktop Computer, but for the sake of speed he chose the 3000 to do the job.

The pattern recognition data may be plotted by an HP 7221 Plotter, interfaced to an HP 2648 Graphics Terminal, or output by the HP 2608 Printer on a daily, weekly or monthly basis, depending on current needs.

## Loss mechanisms

The high yields that have resulted from this system stem from several factors. Weaver can receive information about what's causing defective ICs just about any time he wants it. This, he says, enables him to "track yield loss mechanisms which may be due to equipment or chemical problems.

"This closes the loop on the process, not allowing short-term problems to get out of hand," Weaver says.

More importantly, the system has allowed Weaver and his team to identify yield loss mechanisms that are inherent to the IC manufacturing process.

"Fixing these primary yield loss mechanisms has not only resulted in an increased ROM yield," Weaver says, "but has had dramatic effects on the rest of our products that use ICs, such as our 16-bit processors." He adds:

"We've been able to leverage our engineers' time in those areas we know are decreasing our yields, rather than worry about details. We're able to let the 64K ROM tell us where the process is hurting our yields, rather than let the process dictate to us."

Software for the three computers was written for the application by HP employees. At present, none of the software is available for use outside Hewlett-Packard.

The HP 9825 interfaced to the System 35 interfaced to the HP 3000 — as DCD found out, to solve some circuit manufacturing problems, there's no place like home. ■

# Update

## Errors and omissions

- In the March/April 1980 issue of *Keyboard*, page 5, Figure 2 was inadvertently printed upside down.
- An Update item in the September/October 1980 issue of *Keyboard* indicated correctly that the new 9895 Flexible Disc Memory can be used with System 35 and System 45 Desktop Computers, as well as with HP Series 1000 Minicomputers. We wish to point out that the 9895A also can be used with the HP-85A and the 9825T.

## VuGraph program

The VuGraph program described in the July/August 1979 issue of *Keyboard* enables owners of 9825 Desktop Computers to use the 9872A Four-Color Plotter to quickly develop a variety of plots and overhead transparencies. When we first published the article, readers were unable to obtain the program from the Software Center at Argonne National Laboratory. The Center now has made that program available at a cost of $130 per copy, to cover costs of producing the program.

Richard J. Knox, who wrote the original program, has since left Lawrence Livermore Laboratory and has established his own software firm. He is distributing the program at a cost of $50 per copy.

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## Digiplot unavailable

In the September/October issue of *Keyboard*, we published an article, "A fast draw in Colorado," on the Digiplot software used at HP. That software will not be available through the Calculator User's Club as indicated in the article. *Keyboard* regrets any inconvenience to its readers.

## System 35 software

General Statistics and Analysis of Variance software packs are now available to any System 35 user. AC Circuit Analysis and Waveform Analysis software also is available for the 35. Circuit Analysis software requires the use of a plotter. Waveform Analysis is written in Assembly language. These packs, as well as all other System 35 software packs, are available from HP sales offices.


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