

# HEWLETT-PACKARD

The HP-71 In:  
Production Process Monitoring  
and Low-Cost Test

Good! 764

IF THEN ELSE FOR TO NEXT DEF  
CALL GOSUB RETURN GOTO INPUT PRINT U  
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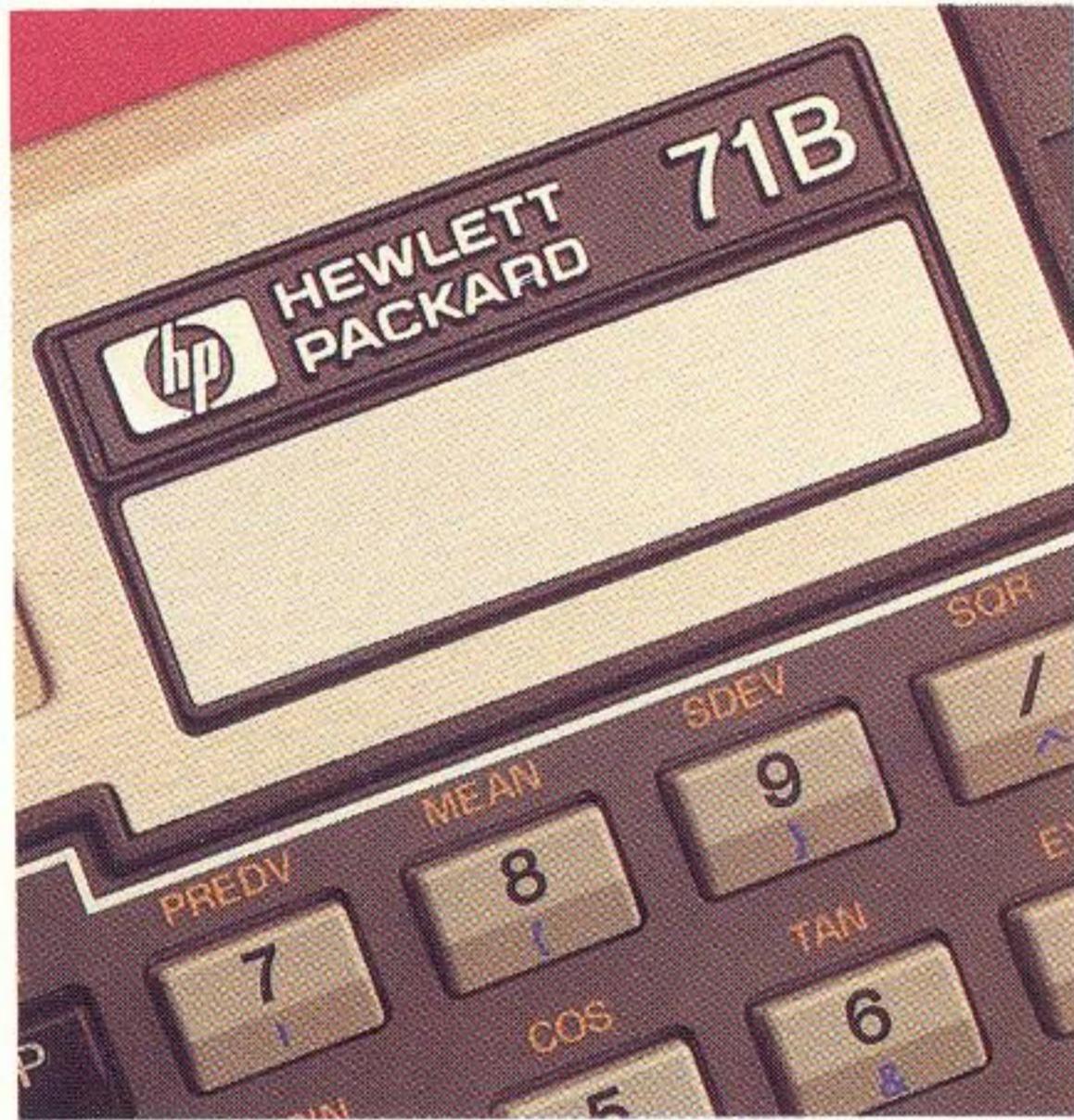
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**D**o you need to measure the efficiency of your production line? Gather data on your production process and how it works? Find out why you have too many production defects? Monitor the time it takes to perform various operations in your manufacturing process?

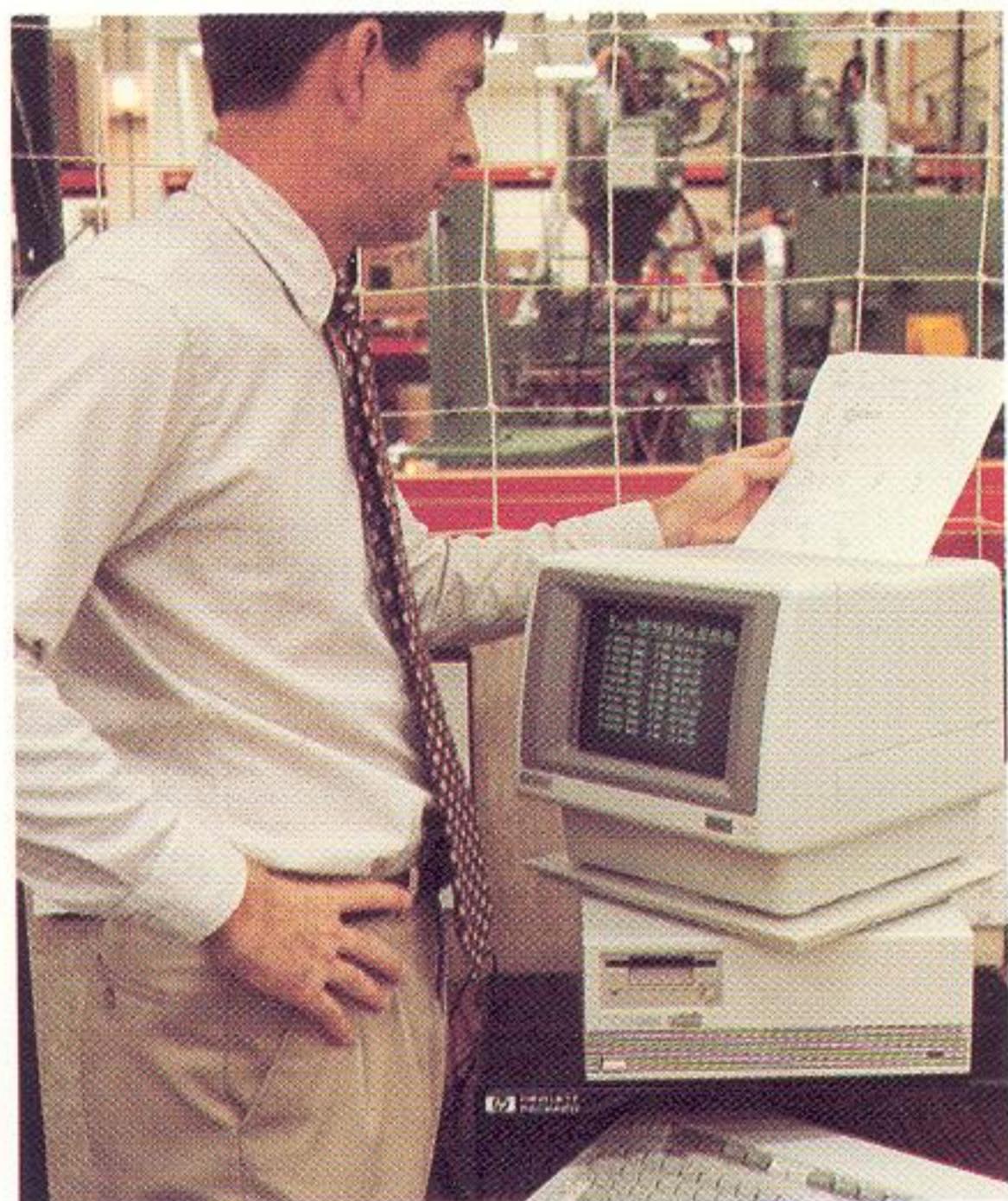
Whether you want to know if your production process is within bounds, accurate, consistent, failing, or out of control, you can get the facts – with the HP-71 Handheld Computer as part of a Hewlett-Packard Interface Loop (HP-IL) system.

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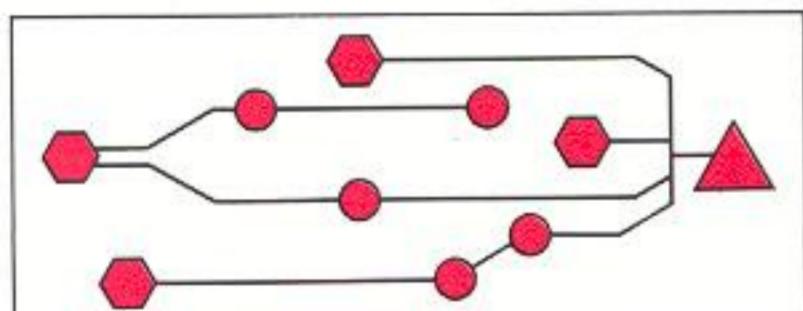
# Streamline Your Production Operation With the HP-71 Handheld Computer



The highly flexible HP-71 Handheld Computer is used both as a worker input terminal and as a computer to perform statistical analysis.



Network HP-71 systems to a supervisory computer for information on overall line performance.



The HP-71 is most effective when used in well-lighted, moderately clean environments such as those found in electronics, aerospace, utilities, medical, packaging, and rubber and plastics industries.

When you combine your manufacturing processes into an integrated system controlled locally by the HP-71, you can:

- Improve cost control
- Improve productivity
- Improve process efficiency
- Reduce production variances
- Produce consistently high-quality products

To realize these benefits, use HP-71s as controllers at local nodes. For even greater benefits, network the entire system under the control of a larger, supervisory computer.

## The HP-71 in Manufacturing

The HP-71 is cost effective, fits the speed and power requirements of many manufacturing environments, and distributes intelligence by putting computing power where it's needed. And because it's so small (7.5 x 3.8 x 1.0 in; 19 x 9.7 x 2.5 cm), it fits on the bench or production line.

Low-cost HP-IL peripherals are readily available and also occupy a minimal amount of space.

HP-IL is the key that allows fast, easy expansion and contraction of HP-71 subsystems within larger data acquisition or test and process monitoring systems. That means you can conveniently modify systems to meet your production needs.

HP-IL interface converters open the door to a wide range of HP-IB instruments as well as RS-232C and GPIO equipment. And numerous HP-IL devices are available from third party vendors.

If something goes wrong with one element in the system, it can be replaced quickly and easily without affecting the operation of

the rest of the system. After the faulty system element is repaired or replaced, the local node that was affected is soon on-line again. And, the battery-powered HP-71 retains its memory when taken off-line as well as during power failures.

## Why Buy HP?

When you buy an HP handheld computer, you're buying a product that's part of a long tradition of innovative, reliable and complete solutions to computing problems. The HP-71 is constructed with the top-of-the-line, high-quality workmanship that people worldwide associate with Hewlett-Packard products. And the HP commitment to quality and service lasts long after the product is installed.

HP provides the single-vendor solution. Your system will be easier to use because all of its individual elements are designed to work together – printers, plotters, mass storage, instruments and larger computers. And by working with just one company, you get the convenience you need when you want to expand your system or require service.

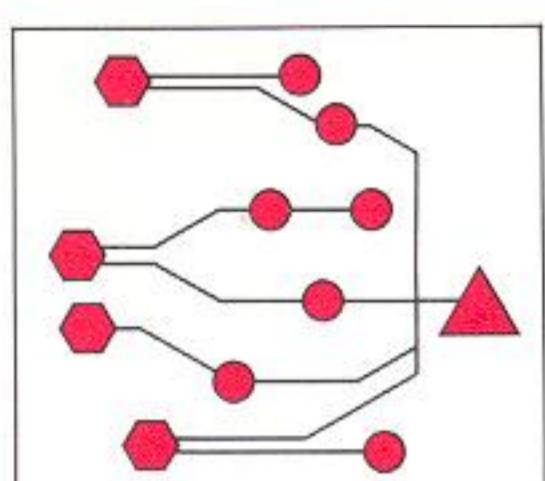
## Put Yourself in Control – With the HP-71

Whether you monitor production processes with HP-71s in local nodes, test at low-cost workstations with HP-71s and instruments, or both, you're controlling your manufacturing operation.

When you connect these HP-71 networks to a supervisory computer that takes the data from the workstations and combines it into an overview of the entire line, you've gone even further toward controlling your operation. You're tracking data on a real-time basis. You see trends and problems as they occur – so you can take immediate corrective action.

Production process monitoring. Low-cost testing. And networking to a supervisory computer. Here's a closer look at each one.

# Production Process Monitoring



Monitoring the production process involves gathering data from the production line to improve the manufacturing process on a real-time basis.

When you use an HP-71 system to monitor the production process, you can:

- Track the number and causes of defects
- Track the time needed to perform an operation
- Track the number of times repair or rework is required
- Track product characteristics, such as size or weight, to determine whether they fall within statistical bounds

With information like this you can prevent lengthy, time-consuming and costly problems.

## Statistical Methods in Production

Statistical quality control methods are usually employed in production process monitoring.

By collecting data at various points in the manufacturing process, any changes that affect quality can be identified. When both the final product and the manufacturing process display consistent behavior, the process is in control. When either the product or the process does not display consistent behavior, the process is out of control.

Using the HP-71 to distribute intelligence puts computing power where you need it. So the production process can be analyzed using statistical quality control methods locally, independent of a mainframe.

Statistical control procedures determine how much the manufacturing process can vary and still be in control. Through statistical methods, performed as data is collected, normal variation is eliminated from consideration and emerging problems are identified.

Benefits of monitoring the production process statistically are:

- Maintenance of tighter controls
- Availability of more accurate controls
- Faster identification of trends and out-of-control processes
- Elimination of subjective evaluation of lines or stations

## Develop a Standard for Measuring Current Processes

Gaining control of existing processes starts with development of a historical data base. Information for this base comes from sources such as customer feedback, analysis of accounting and engineering data, and paperwork.

Using historical data to *control* the manufacturing process is inefficient for two reasons. First, information is available only on past events. Second, changes are made only on the basis of past events which may not reflect current conditions – and, therefore, may take the process even further out of control.

The historical base is valuable when used to help determine a standard for measuring current processes.

For example, a company that manufactures disc drives decides to automate its production processes using an HP-71 system. They begin by developing a historical data base.

Over the period of time for which records are available, they summarize the performance of their manufacturing process in terms of the number of defects, product characteristics and other quantities of interest. This information is used to set a standard that defines the limits of a process that is in control.

The HP-71 then gathers data on the production process and performs statistical quality control analyses. The resulting information is used to track the process and, over time, aid in improving process performance.





The HP-71 Handheld Computer is highly flexible. Use it both as a worker input terminal and as a computer to perform statistical analysis.

For more information about the use of statistical methods in production process monitoring, refer to AT&T's "Statistical Quality Control Handbook" published by Western Electric Co., Inc.

### A Sample Application

Assume a worker is responsible for a final step in assembling disc drives.

In setting up the monitoring system, historical data were used to determine that up to eight failures could be expected in each group of 100 units. The HP-71 is programmed to:

- Keep statistics on a moving window of the most recent 100 disc drives produced
- Reanalyze the data after each unit is entered to see if there are more than eight failures
- Check to see if there are more than four failures in the most recent 25 units

Disc drives fail if they do not turn on or if they fail an internal diagnostic test. After assembling a drive, the worker tests it by turning it on and pressing an HP-71 key defined for a self-diagnostic test. The worker presses different keys on the HP-71 when both tests are passed, when one or both tests are failed, and to identify the cause of each failure.

Meanwhile, the HP-71 calculates statistics such as averages and standard deviations. Line trends are immediately available.

Analysis of this information provides a basis for on-the-spot decisions to establish tighter performance parameters, modify a process, stop a line that is out of control, and initiate appropriate corrective action.

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*The HP-71 gathers data from the production line to help improve the manufacturing process on a real-time basis.*

## Low-Cost Testing

Low-cost testing involves the use of HP-IL instruments controlled by HP-71 Handheld Computers at test stations.

The combination of the HP-71 and HP-IL instruments is an excellent solution for computer-controlled test stations where high-speed processing is not critical and a low-cost solution is required. It is also very effective in environments where bench-space restrictions exist.

The use of HP-IL in low-cost testing serves the same purpose as HP-IB. It implements all the same functions and allows up to 30 devices on a loop. Through the use of software addressing and device and accessory ID, a self-configuring low-cost test and control program can be written which requires only that the devices be connected and turned on.

The benefits of automated test stations over manual testing and calibration are:

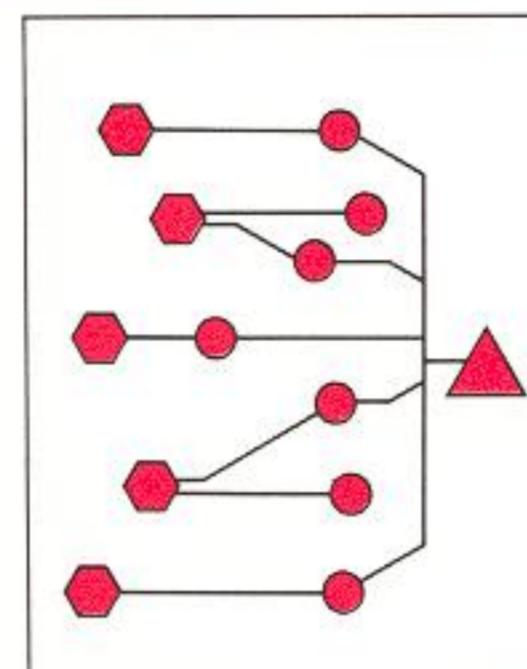
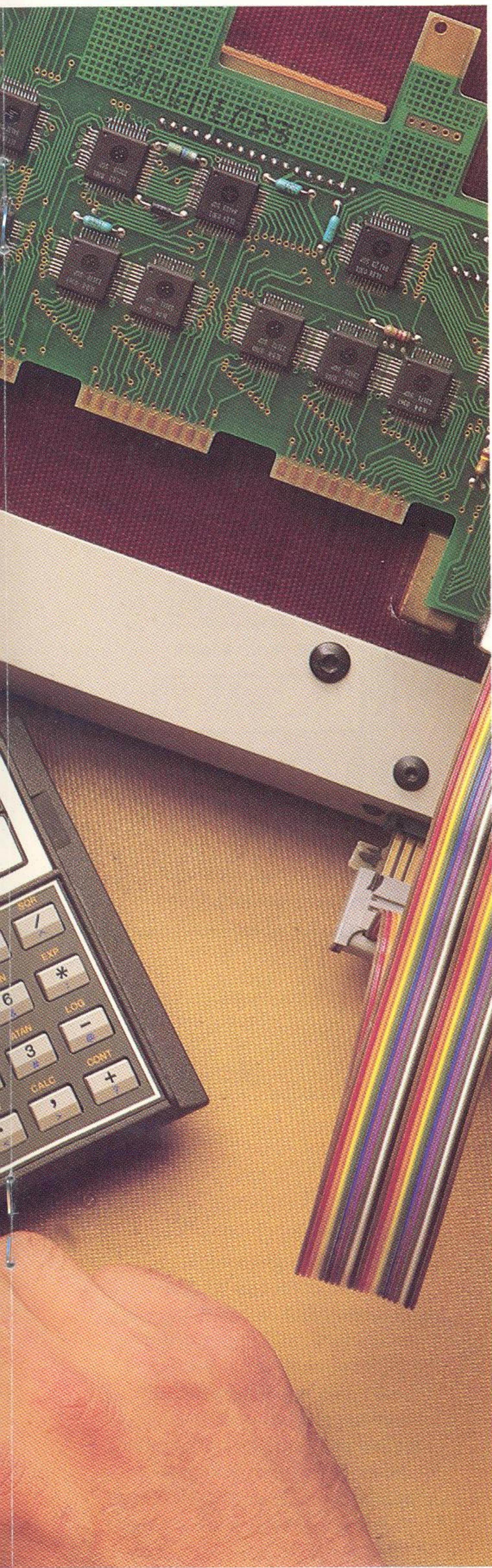
- Higher throughput
- Increased accuracy
- Greater consistency
- Higher productivity

The most effective configuration for manufacturing test environments networks the HP-71 with a supervisory computer. This connection allows data from individual test stations to be integrated into overall line performance information.

By using the HP-71 at test stations and networking these stations to a supervisory computer, you can:

- Track repairs at each station
- Track repair and test station performance
- Track operation times at each station





### The HP-71 and HP-IL Instruments in Low-Cost Test

Among the HP-IL instruments you can use at test stations are:

- HP 3421A Data Acquisition/Control Unit
- HP 3468A Digital Multimeter
- HP 5384A/HP 5385A Frequency Counters
- HP 1630A/D/G Logic Analyzers
- HP 4945A Transmission Impairment Measuring Set

The low-cost Data Acquisition/Control Unit has an extensive capability set that can perform voltage, transducer output, resistance and frequency measurements; digital sequencing; and can switch outside circuits on and off.

Some uses for an HP-71 and Data Acquisition/Control Unit system include testing loaded printed circuit boards, calibration, and burn-in testing.

For example, tests are performed on a product at separate stations as it moves along an assembly line. Results such as "good", "failed" and "cause of failure" are reported on the HP-71 display, a printer or a computer monitor.

### A Sample Application

In the earlier disc drive example, a worker is testing loaded printed circuit (PC) boards that, at this point, have no power supplies. Tests are for idle and active current, oscillator frequency and keystroke simulation. Each test is performed when input voltage is at its lowest and highest allowable levels.

The worker takes a PC board off the line as it goes by, places it in a custom test fixture and secures it. The fixture has built-in minimum and maximum voltage power supplies that are switched on and off by the HP 3421A Data Acquisition/Control Unit.

The worker connects the board to the fixture at points appropriate for measuring current and frequency and simulating key closings. A digital input/output (I/O) line is connected to a button the worker presses to start the test. This system is connected to an HP-71 acting as controller.

The worker presses the button to start the test. This closes the digital I/O line and the HP 3421A sends a service request, via HP-IL interfacing, to the HP-71. The HP-71:

- Receives the service request and branches to a subroutine that performs the tests
- Sets the input voltage to the low state by closing the HP 3421A actuator
- Measures input voltage and current
- Measures oscillator frequency
- Simulates keystrokes by closing, then opening the digital I/O line
- Repeats tests in the high-voltage state

Following each test, the HP-71 displays "good" or "failed" and the cause of the failure. These results are immediately available to be printed or sent to a supervisory computer.

## Networking the HP-71 to a Supervisory Computer

What makes production process monitoring and low-cost testing so effective is the capacity to network to a supervisory computer. Since up to 30 HP-71s can be networked, such a system is very cost effective.

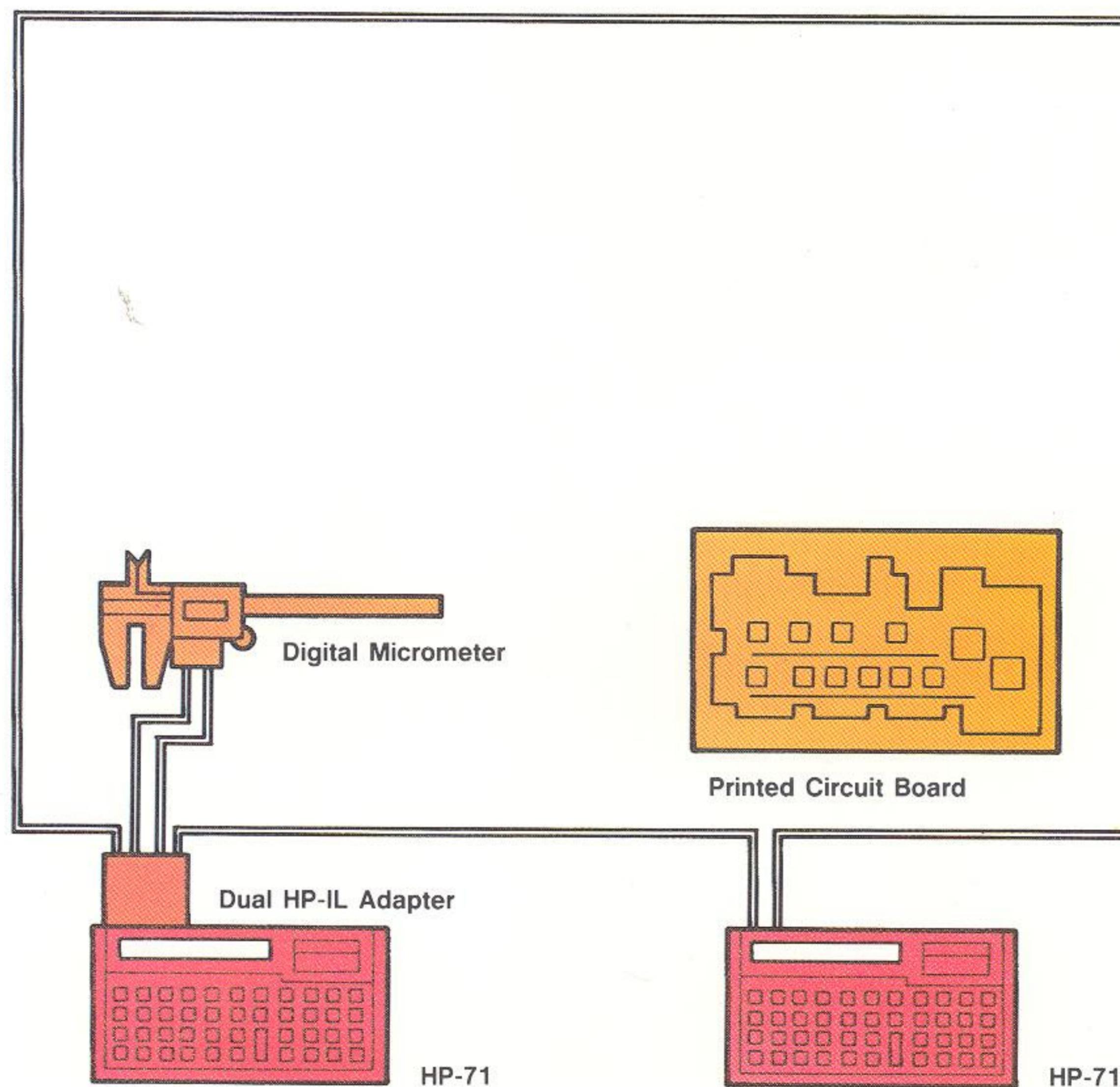
The supervisory computer in this system takes the data from each workstation and combines it into an overview of the entire line. Line trends are tracked, historical data is gathered and information is passed to other stations.

When a workstation goes out of control, the HP-71 at that station notifies the line worker and supervisory computer. The production or manufacturing engineering supervisor is also notified. If the supervisory computer detects an unnatural pattern on the line, it generates an out-of-control message. The supervisor then looks at the statistics for the line and each workstation involved and determines a plan of action.

The supervisory system can archive data, report on historical performance, or pass the data on to the next level through a factory-wide local area network.

### Disc Drive Production Line

In the illustration on this page, HP-71 subsystems are used to monitor the production process and to test disc drives at low-cost workstations as they are manufactured. A supervisory computer links the processes.



### Information Flow and Control

#### ■ Supervisory Computer

The supervisory computer takes data from each workstation and combines it into an overview of the entire line.

It plots line trends, yields, Pareto charts and summary statistics; archives data; and generates out-of-control messages when appropriate.

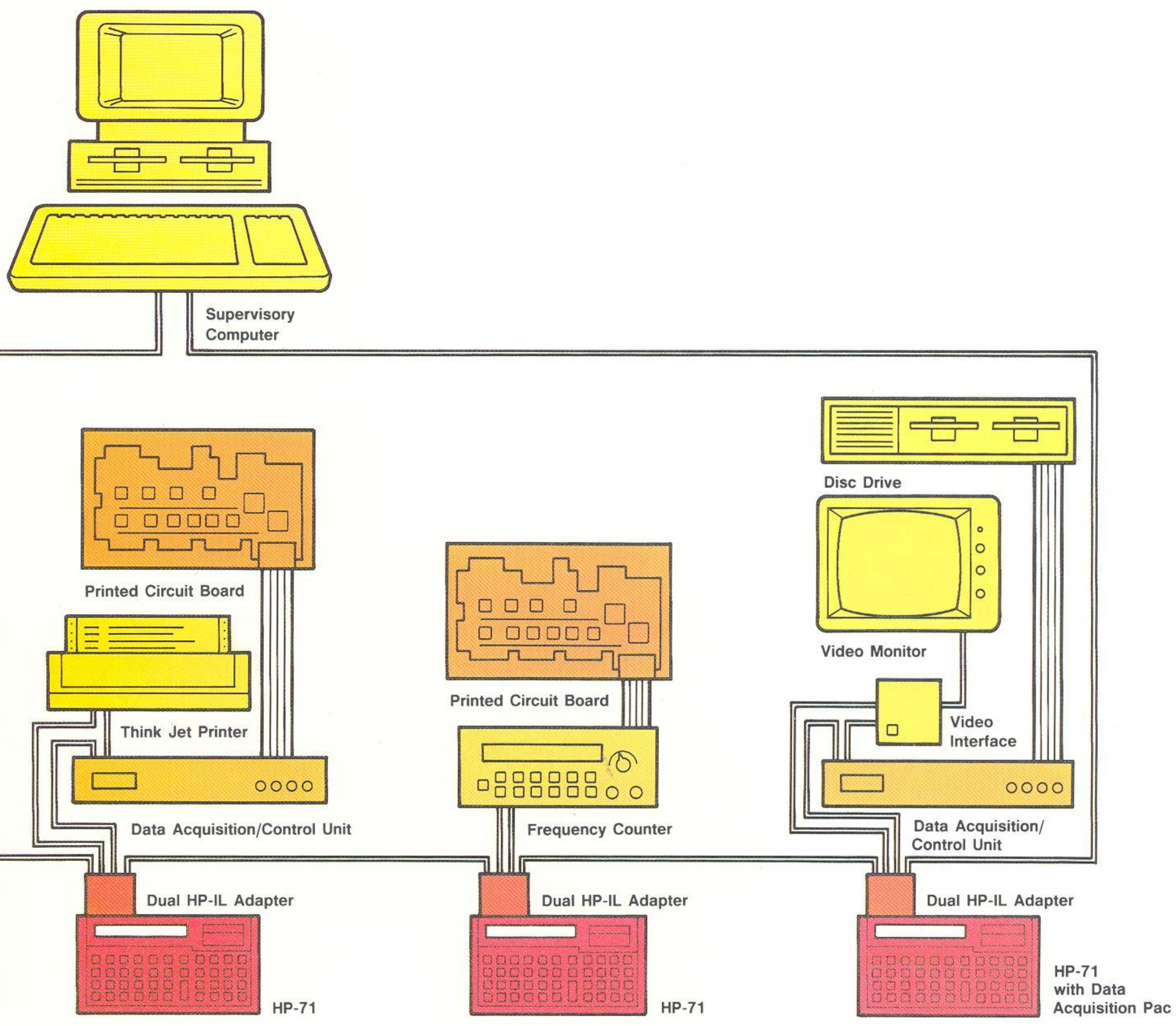
### Production Process Monitoring

#### ■ Measuring Plastic Components

An HP-71 is networked to a digital micrometer and automatically logs readings. Plastic parts are measured to assure that they are within tolerances so they will fit together when assembled. The HP-71 calculates statistics, analyzes bounds, checks to ensure that components are within those bounds, and analyzes how dimensions deviate from target.

#### ■ Failure Monitoring

This station is used to identify unusual patterns and excessive failures. The worker presses an HP-71 key indicating whether or not each unit checked is defective. When patterns or the number of failures exceed parameters, the worker and supervisory computer are notified.



## Low-Cost Testing

### ■ Printed Circuit Boards

PC boards are tested for idle and active current, oscillator frequency and keystroke simulation using an HP-71 and HP 3421A Data Acquisition/Control Unit. Tests are performed when voltage is at its lowest and highest allowable levels. The HP-71 displays "good" or "failed" and the cause of failures. Results can be printed or sent to a supervisory computer.

### ■ Calibration

Using the HP-71 and HP 5384A Frequency Counter, an oscillator is set to a given frequency.

### ■ Burn-in

After the drive is manufactured, it is set to run for a given period of time to make sure it does not fail. The HP-71, HP 3421A, and HP 82479A Data Acquisition Pac are used to monitor performance. Results are displayed continuously on a monitor. The HP-71 performs appropriate limit-action functions if any critical test points are exceeded.

# HP-71 Handheld Computer

The HP-71 Handheld Computer is a portable, 12-ounce (340 g) package that puts powerful calculation, programming and expansion potential right at your fingertips.

It's durable enough to stand up to daily use in industrial environments and provides intelligence for your equipment, instruments and test controllers. It takes up only inches of bench space, and its networking capabilities rival those of much larger computers. And the HP-71 can be integrated into a wide variety of industrial applications, equipment and products.

The highly flexible HP-71 can be programmed with a built-in enhanced BASIC language and, using optional software, with Assembly and FORTH. Its RAM/ROM ports let you expand Random Access Memory or Read Only Memory. And you can add Custom ROM modules designed for your particular needs.

Personalize your HP-71 with a wide variety of enhancements, peripherals and software. For example, the HP 82402A Dual HP-IL Adapter allows two HP-IL interface modules to be plugged into the HP-71 at once. This conserves peripheral battery life and allows the HP-71 to function both in control and communications capacities simultaneously. The HP 82479A Data Acquisition Pac provides software linking the HP-71 to the HP 3421A Data Acquisition/Control Unit to form a powerful, low-cost system.

Through customization, the HP-71 can be tailored with your own software to perform functions to increase your productivity. Custom ROMs, EPROMs, Magnetic Cards and Keyboard Overlays can be developed for you. The services of Independent Custom Consultants (ICCs) make the customization process easy. Consult your dealer or HP Sales Representative for more information about ICCs and the Custom Products program.

## Some HP-71 Features:

### ■ BASIC Programming Language

The HP-71 uses an enhanced BASIC that runs nearly as fast as compiled BASIC. Keywords are translated into tokens to reduce the amount of memory needed to speed program execution. Over 240 functions, statements and operators are available.

### ■ Internal Design Specifications

HP has documented the internal specifications to make the HP-71 an "open machine" and provide you with entry points, source code and schematics – so you can develop your own hardware and interfaces.

#### Typewriter-like Keyboard

*enter alphabetical information quickly and easily. Redefine the keys to suit your changing needs, and store the redefinitions to use later.*

#### Dual HP-IL Adapter

*option for conserving battery life of peripherals; allows the HP-71 to function both in control and communications capacities simultaneously.*

#### HP-IL Interface

*option for connecting to a wide variety of battery-powered devices for mass storage, display, printing, plotting, test and measurement.*

#### BASIC Language

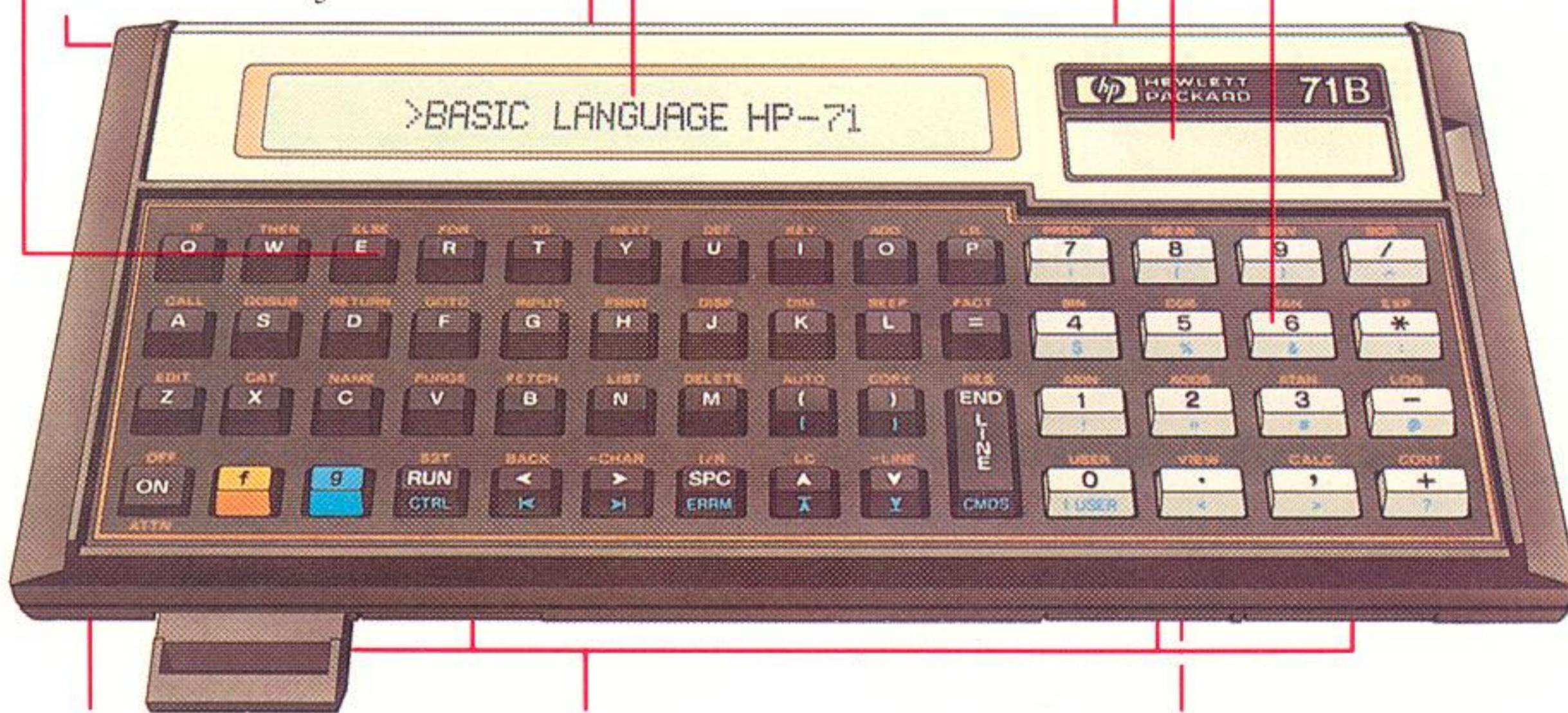
*powerful programming language.*

#### Card Reader

*option to use magnetic cards for mass storage and easy program loading; or to insert a third-party 96K RAM module.*

#### 10-digit Key Pad

*fast, easy input of numeric data.*



#### Continuous Memory

*turn your HP-71 off and return later without losing calculations and programs.*

#### Four Ports

*accept any combination of memory modules or application software to increase computation power.*

#### Battery Power

*four 1.5V, AAA-size batteries assure portability. Or, use the optional AC adapter.*

### ■ Built-in Operating System

The powerful, calculation-oriented 64K-byte operating system allows high-level programming and repetitive calculations.

### ■ Four RAM/ROM Ports

Plug in up to four 4K-byte RAM modules or add third-party modules for up to 96K bytes of RAM. The HP-71 is capable of directly addressing 512K bytes.

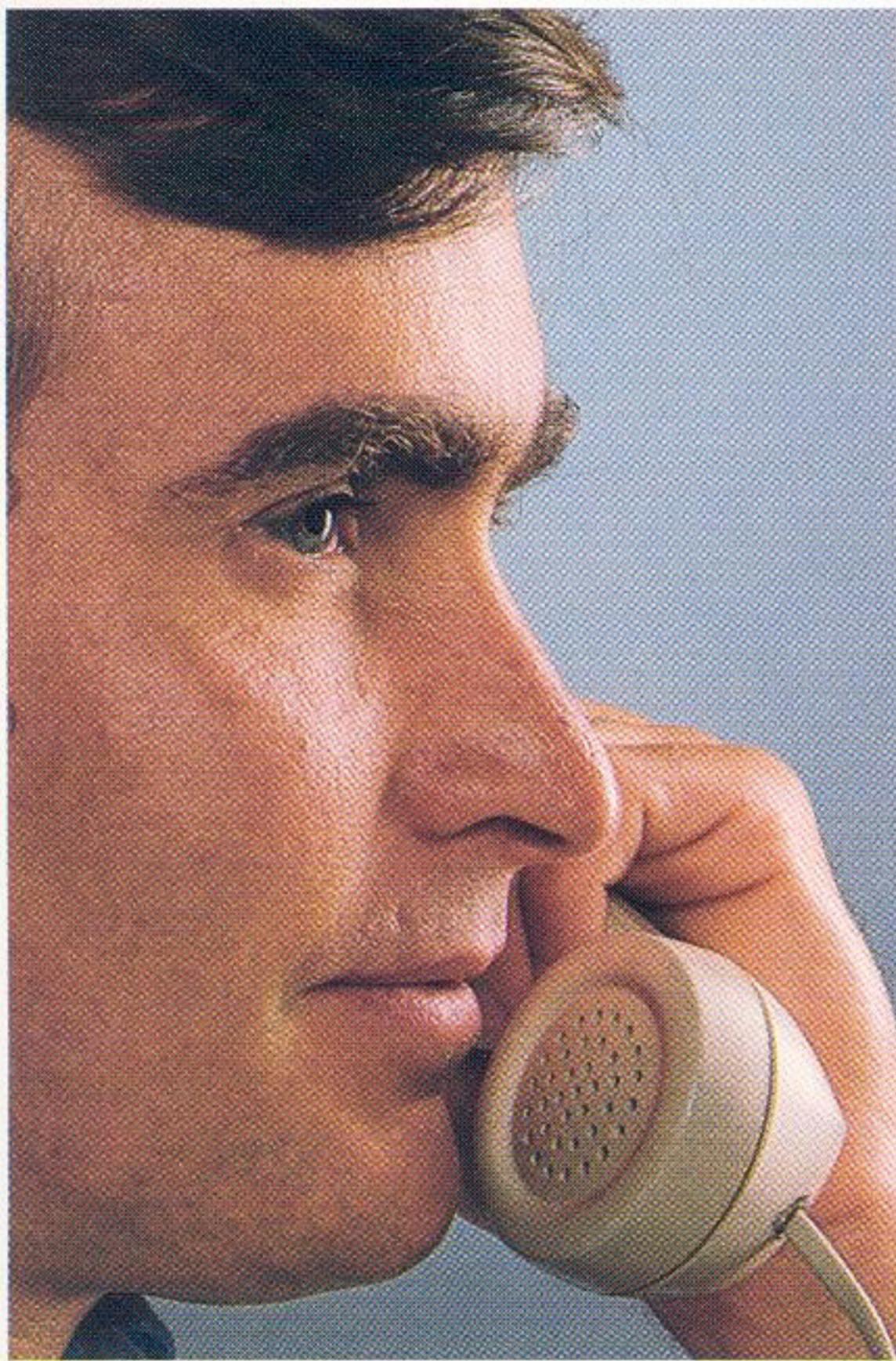
### ■ Multiple File Structure

The number of files in HP-71 memory is limited only by the amount of available RAM. BASIC, BIN, LEX, DATA, TEXT, KEY, and SDATA file types are supported.

### ■ Clock/Calendar

Use the built-in quartz-crystal clock to create and use clock/calendar-dependent programs that begin and end when you can't be there to control the process.

## Warranty, Support and Service



The Technical Calculator Support group daily answers questions raised by customers.



HP's Calculator Service Center provides fast, efficient service and offers a cost-effective service support program.

### Warranty

The HP-71 Handheld Computer is warranted for one full year from the original date of purchase. Refer to the Owner's Handbook for specific details.

### Support\*

For the price of a phone call, thoroughly trained representatives provide answers to a wide variety of questions. These questions may range from simple operational problems to difficulties regarding the use of our software application packages, peripherals and interface converters. Although the Technical Calculator Support group primarily provides post-sale technical support to customers, anyone needing help with a technical question about handheld calculator and computer products may phone.

The phone number for Technical Calculator Support is 503-757-2004. Calls are answered from 8:00 a.m. to 3:00 p.m. PDT, Monday through Friday.

### Service

Hewlett-Packard maintains service centers in most major countries throughout the world. You may have your unit repaired at an HP service center anytime it needs service, whether or not it is under warranty.

*A renewable one-year support agreement* is available that begins at the expiration of the warranty period. The low agreement price provides a cost-effective service support program. Several years of support may be obtained for less than the price of one repair in the event of product failure.

You save time because HP does the paperwork. And since your support agreement is effective for a year, you are not affected by potential increases in the cost of repairs.

Contact the Calculator Service Center at 503-757-2002 for more details.

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For additional information about Hewlett-Packard's handheld computers in manufacturing solutions, call the HP office nearest you and ask for your technical computer or instrument representative. Local HP sales offices are listed in the white pages of your telephone book.

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