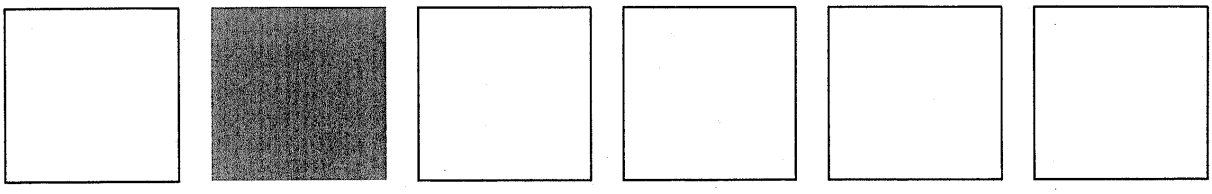
HEWLETT PACKARD

HP 82479A

Data Acquisition Pac

Owner's Manual

For the HP-71



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NOTE

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NOTE

The HP-71 Data Acquisition Pac is designed to operate with Model HP 3421A Data Acquisition and Control Unit mainframes of serial number 2338A03053 and above, manufactured after April 1984. Although limited performance can be obtained with units of earlier serial numbers, it is recommended that users upgrade their mainframes. The upgrade consists of motherboard ROM replacements. For further information, contact your nearest Hewlett-Packard Sales and Service Office referencing Service Note 3421A-8.

CONTENTS

How To Use This Manual ix

Section 1: Introduction

1.1 The HP-71 Computer 1-1
1.2 Hewlett-Packard Interface Loop 1-1
1.3 The HP 3421A Data Acquisition/Control Unit 1-2
1.4 Applications 1-3

Section 2: Getting Started

2.1 Installing and Removing the Module 2-1
2.2 Supplemental Disc 2-2
2.3 Equipment Needed 2-3
2.4 What the Data Acquisition Pac Does 2-3
2.5 Setting the Time and Date 2-4
2.6 Connecting the Interface Loop 2-5
2.7 Specifying HP-IL Devices 2-5
2.8 Data Files 2-7
2.9 Channel Numbering and Addressing 2-8
2.10 Using the Keywords 2-9
2.10.1 Simple Programming 2-10
2.10.2 Using the SCAN Subprogram 2-11
2.10.3 Using Instrument Commands 2-11
2.10.4 Interrupt Programming 2-12
2.10.5 Interrupt Subprograms 2-13
2.10.6 Advanced Interrupt Programming 2-14
2.11 Using the Application Programs 2-16
2.12 Measurement Notes 2-19

Section 3: Keywords

3.1 Syntax Conventions 3-1
3.2 Keyword Syntax 3-2
3.3 Scanning 3-18
3.4 Interrupt Subprograms 3-19

Section 4: Status Program

Section 5: Front Panel Program

5.1 Front Panel Operation 5-2
5.2 Front Panel Functions 5-3

Section 6: Strip Chart Program

6.1	Measurement Choices	6-1
6.2	Strip Chart Operation	6-1
6.3	Creating A New Setup	6-3
6.3.1	Signals	6-4
6.3.2	Digital Functions	6-5
6.3.3	Custom Program	6-7
6.4	Running The Strip Chart Program	6-8
6.5	Storing Strip Chart Setups	6-10
6.6	Retrieving Strip Chart Setups	6-11
6.7	Verifying The Setup	6-12
6.8	Adding A Trace	6-13
6.9	Deleting A Trace	6-14
6.10	Replacing A Trace	6-15
6.11	Printing The Strip Chart Setup	6-16
6.12	Ending The Strip Chart Program	6-17
6.13	Strip Chart Example	6-18

Section 7: System Monitoring

7.1	Measurement Choices	7-2
7.2	Limit Tests	7-3
7.3	Monitor Program Operation	7-3
7.4	Creating A New Setup	7-5
7.4.1	Signals	7-7
7.4.2	Digital Functions	7-9
7.4.3	Custom Program	7-10
7.5	Limits	7-11
7.5.1	Analog	7-11
7.5.2	Digital Bit	7-11
7.5.3	Limit Actions	7-12
7.6	Running The Monitor	7-14
7.7	Error Recovery	7-16
7.8	Storing Trace Setups	7-17
7.9	Retrieving Trace Setups	7-18
7.10	Verifying The Trace Setup	7-19
7.11	Adding A Trace	7-20
7.12	Deleting A Trace	7-21
7.13	Replacing A Trace	7-22
7.14	Printing The Setup File	7-23
7.15	Ending The Monitor Program	7-24
7.16	Monitor Example	7-25

Section 8: Defining a Data Logging Problem

8.1 Data Logging Procedure 8-1
8.2 Channel Groups. 8-2
8.3 Power Consumption Considerations. 8-2
8.4 Data Storage Requirements. 8-4
8.5 Data Logging Example 8-4

Section 9: The SETUP Program

9.1 Measurement Choices. 9-1
9.2 Limit Tests 9-2
9.3 Setup Program Operation. 9-3
9.4 Creating A New Setup 9-4
9.4.1 Signals 9-6
9.4.2 Digital Functions. 9-8
9.4.3 Control. 9-9
9.4.4 Custom Program 9-9
9.5 Limits. 9-10
9.5.1 Analog 9-10
9.5.2 Digital Bit 9-11
9.5.3 Limit Actions 9-11
9.6 Storing Group Setups 9-13
9.7 Retrieving Group Setups 9-14
9.8 Verifying The Setup File 9-15
9.9 Adding A Group 9-16
9.10 Deleting A Group. 9-17
9.11 Replacing A Group 9-18
9.12 Printing The Setup File. 9-19
9.13 Ending The Setup Program 9-20
9.14 Setup Example 9-21

Section 10: The LOG Program

10.1 Log Program Operation. 10-2
10.2 LOG Example. 10-3

Section 11: The REPORT Program

11.1 Listing File Contents 11-2
11.2 Printing The Data 11-3
11.3 Printing Summary Statistics 11-4
11.4 Printing A Strip Chart 11-7
11.5 Ending The Report Program 11-10

Section 12: The TRANSFER Program

12.1 Data Transfer Options 12-1
12.2 Starting The Series 200 Program 12-3
12.3 Starting The Transfer Program 12-4
12.4 If Something Goes Wrong. 12-6
12.5 Handling of Numeric Exceptions 12-6
12.6 Using The FROM71 Subprogram 12-7

Section 13: The MSDOSXFR Program

13.1 Introduction 13-1
13.2 Hardware And Software Requirements. 13-1
13.3 Format of Target File. 13-2
13.4 Communications Between HP-71 and Target Device 13-2
13.5 Sample Destination Names 13-3
13.6 Running MSDOSXFR. 13-3
13.7 Reading Data Into Lotus 1-2-3 13-5
13.8 Handling of Numeric Exceptions 13-6
13.9 Memory Requirements of MSDOSXFR 13-6

Section 14: Operational Verification

14.1 Relay Card Test. 14-1
14.2 Digital Card Test 14-3
14.3 Running The Test. 14-4

Appendix A: Care, Warranty, and Service Information

A.1 Care of the Module A-1
A.2 Limited One-Year Warranty A-1
A.3 Service A-3
A.4 When You Need Help. A-6

Appendix B: HP 3421A Command Reference

Appendix C: Custom Programs

C.1 STRIP and MONITOR Subprograms C-1
C.2 LOG Subprograms C-1
C.3 Using Multiple HP 3421A Instruments. C-3

Appendix D: Conversion Programs

D.1 STRIP and MONITOR Conversions. D-1
D.2 LOG Conversions D-1

Appendix E: Limit Programs

E.1 Syntax E-1
E.2 Continuous Events E-1
E.3 Transition Events E-2

Appendix F: Alternative Peripheral Options

F.1 Specifying Alternate Printers F-1
F.2 Specifying Alternate Video Displays F-2
F.2.1 Subprogram For the HP 2392 Terminal F-3
F.2.2 Subprogram For the HP 2648 Terminal F-3
F.3 Working Without an HP 3421A F-4
F.4 Working With Several HP 3421A Instruments F-5

Appendix G: Error Recovery

G.1 Low Memory Conditions G-1
G.2 Corrupt Setup Information G-2
G.3 Loop And Device Errors G-2
G.4 The RECOVER Subprogram G-2
G.5 Writing Your Own RECOVER Program G-3
G.6 Recovering Buffered Data G-5

Appendix H: HPAF File Standard

H.1 Header Information H-2
H.2 Data Records H-2
H.3 Descriptor Block H-2
H.4 Tag Examples H-3

Appendix I: File Structures

I.1 Strip Chart Setup Files I-1
I.2 Monitor Setup Files I-2
I.3 Logger Setup Files I-5
I.4 Data Files I-7

Appendix J: File Names Used In This Pac

Appendix K: Error and Warning Messages

Subject Index

HOW TO USE THIS MANUAL

This manual describes the Data Acquisition Pac for the HP 71B Handheld Computer. Before you attempt to use the pac, you should be familiar with the HP-71B Handheld Computer, the HP 82401A HP-IL Interface, and the HP 3421A Data Acquisition/Control Unit. In particular, you should be familiar with the following HP-71 operations: keyboard operation, file operations, writing and running simple subprograms, manipulating data, using flags, and correcting error conditions (refer to the *HP-71 Owner's Manual*). You should have a general understanding of the following HP-IL operations: device assignment, printer and display operations, mass storage operations, and simple I/O operations for instrument control (refer to the *HP 82401A HP-IL Interface Owner's Manual*). You should have a general understanding of the HP 3421 including channel numbering, option configuration, and standard instrument control commands (refer to the *HP 3421A Data Acquisition/Control Unit Operating, Programming and Configuration Manual*).

To become familiar with the Data Acquisition Pac, you should start by reading sections 1 and 2 in this manual. Section 1 "Introduction," gives a general description of the HP-71, the HP 3421A, and the applications provided by this pac. Section 2, "Getting Started," tells how to install the ROM module and prepare a data acquisition system. Section 2 also gives examples that show how to use the keywords and application programs in the pac.

After you have read sections 1 and 2, go on to the sections that describe the features of the pac that you want to use:

- Section 3, "Keywords," describes the functions, statements, and keywords that the Data Acquisition Pac adds to the BASIC language.
- Section 4, "Status Program," describes a program used to determine the status of the HP 3421A.
- Section 5, "Front Panel Program," describes a program that makes the HP-71 a front panel for the HP 3421A.
- Section 6, "Strip Chart Program," describes a program that creates strip charts on a ThinkJet printer.
- Section 7, "System Monitoring," describes a program that allows you to monitor a system on a video dipslay.
- Section 8, "Defining A Data Logging Problem," outlines the process of defining and running a long-term data logging experiment. Section 8 refers to two sections: section 9, "The SETUP Program," which describes the program used to define a data logging experiment; and section 10, "The LOG Program," which describes the program used to carry out the data logging experiment.
- Section 11, "The REPORT Program," describes a program that generates printed reports from data files generated by the strip chart, system monitor, and log programs.
- Section 12, "The TRANSFER Program," describes a program used to transfer data to the HP 44456 System Software package for HP Series 200 computers.
- Section 13, "The MSDOSXFR Program," describes a program used to transfer data to the MS-DOS environment.
- Section 14, "Operational Verification," describes a program used to check the proper operation of option cards plugged into the HP 3421A Data Acquisition/Control Unit.

There are several appendixes for your reference:

- Appendix A, "Care, Warranty, and Service Information," provides warranty and service information.
- Appendix B, "HP 3421A Command Reference," provides a quick reference to the commands that control the HP 3421A.
- Appendix C, "Custom Programs," provides details about writing and using your own subprograms for making measurements and returning the results to the STRIP, MONITOR, and LOG programs.
- Appendix D, "Conversion Programs," provides details about writing and using your own subprograms to perform numerical conversions on readings taken by the STRIP, MONITOR, and LOG programs.
- Appendix E, "Limit Programs," provides details about writing and using your own subprograms to perform special procedures when the MONITOR or LOG program detects an out-of-limit condition.
- Appendix F, "Alternative Peripheral Options," provides details about using alternate display devices for the strip chart program and the system monitoring program.
- Appendix G, "Error Recovery," provides details about system error recovery.
- Appendix H, "HPAF File Standard," describes the HPAF file standard, to which all files created by this pac conform.
- Appendix I, "File Structures," describes the format and contents of the files created by this pac.
- Appendix J, "File Names Used In This Pac," lists the file names in the ROM module and the file names used in HP-71 memory.
- Appendix K, "Error and Warning Messages," lists the error messages that the pac may generate.

INTRODUCTION

SECTION 1

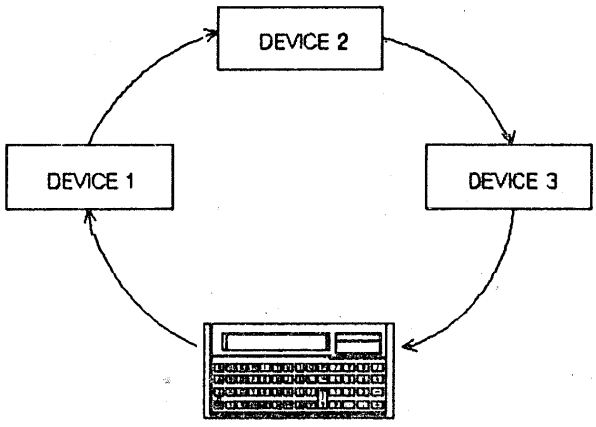
The HP 82479A Data Acquisition Pac, together with the HP-71B Handheld Computer and the HP 3421A Data Acquisition/Control Unit, provide a powerful, low-cost data acquisition system. These devices may be used in the laboratory, the field, or on the production line to gather data, control devices, or report on equipment status. When combined with devices such as the ThinkJet printer or an 80-column video interface, the data acquisition system provides system capabilities equivalent to larger, more expensive systems at a fraction of the cost. Also, in space-critical environments the HP-71 takes less space than the keyboard of a standard personal computer, leaving room for production or test equipment.

1.1 THE HP-71 COMPUTER

The HP-71 is a powerful computer that has the following standard features:

- 17.5K-bytes of user memory.
- Powerful BASIC language with over 240 keywords.
- Clock, calendar, and timer system.
- Battery operation (continuous memory)
- User definable keyboard.

1.2 HEWLETT-PACKARD INTERFACE LOOP



Information Flow In The Interface Loop

The Hewlett-Packard Interface Loop (HP-IL) provides additional power and versatility to the HP-71. HP-IL is a bit-serial interface designed for low-cost, battery-powered systems. The HP-71, acting as system controller, is capable of transmitting and receiving data to a wide variety of computers and peripherals. In an HP-IL system, the HP-71 and peripherals are connected by two-wire cables leading from the output port of of one device to the input port of the next, until all devices form a closed loop.

This loop structure provides several unique capabilities:

- **Auto address assignment.** The HP-71 addresses the devices on the loop automatically.
- **Device capability identification.** The HP-71 can match the appropriate device with the command (for example, the printer with a PRINT command), so software can be written and run without regard to addresses.
- **Power ON/OFF control.** The HP-71 can power peripherals on or off in order to conserve battery life in remote, unattended applications.
- **Automatic error checking.** HP-IL allows data being transmitted on the loop to be checked automatically for errors.

The HP 82401A HP-IL Interface allows the HP-71 to control devices such as printers, video interfaces, disc drives, and instruments. The HP-IL module adds over 45 additional keywords to HP-71 BASIC, which are used to control up to 30 devices, and through secondary addressing, up to 930 devices. Through individual converters, the HP-71 can link to HP-IB, RS-232C, and GPIO devices.

The HP 82402A Dual HP-IL Adapter allows two HP 82401A HP-IL Interfaces to be connected to the HP-71, making sophisticated data acquisition/control systems possible. For instance, several HP-71 computers might share a loop with a host desktop computer, while maintaining individual loops for dedicated data acquisition at individual production stations.

1.3 THE HP 3421A DATA ACQUISITION/CONTROL UNIT

The HP 3421A Data Acquisition/Control Unit is a fully programmable instrument that combines precision measurement capabilities with process control and monitoring functions. It can provide you with accurate measurements of voltage, resistance, temperature, and frequency, or it can monitor and control digital inputs and outputs (including actuators), or both. Standard equipment for the HP 3421A includes a front panel display, a built-in 5 1/2-digit voltmeter, a 10 kHz frequency counter, and an HP-IL interface.

The HP 3421A mainframe can accommodate up to three measurement/control option assemblies. The following options are available:

- HP 3421A Option 020 - 8 Channel Multiplexer/2 Channel Actuator Assembly.
- HP 3421A Option 021 - 9 Channel Multiplexer/1 Channel Actuator Assembly.
- HP 3421A Option 022 - 10 Channel Multiplexer Assembly
- HP 3421A Option 040 - Breadboard Assembly (with connnector block).
- HP 3421A Option 050 - 8 bit in/8 bit out Digital I/O Assembly (with connector block).

Throughout the rest of this manual the term "multiplexer assembly" is used to mean either an option 020, 021, or 022 multiplexer. The term "digital I/O assembly" refers to the option 050 8-bit digital I/O assembly.

In addition to the measurement/control option assemblies, the HP 3421A can accommodate an option 214 12-Volt power assembly (which allows long-term remote operation using an external battery) or an HP-IB option board (which allows the HP 3421A to operate from an HP-IB controller).

WARNING

Some applications may require the system to go to a known-safe state in case of an equipment or power failure. For example, if a furnace heater is being controlled, it should go to the off state in case of failure. Note the following:

The HP 3421A Data Acquisition/Control Unit and the Option 020, 021, and 022 Multiplexer Assemblies use latching relays. The state of these relays can only be altered under program control. Under most conditions of failure, the relays will remain in whatever state the program last set them.

The HP 3421A Option 050 Digital I/O Assembly output switches are not latched. Under most conditions of failure the switches will go to the open state.

It is up to the programmer to provide the appropriate circuitry and recovery programs to ensure that the system under control goes to a known-safe state in case of an equipment or power failure. In some applications serious damage or injury may otherwise occur.

1.4 APPLICATIONS

The HP-71 Data Acquisition Pac simplifies HP 3421A control by extending BASIC with a series of instrument-control statements and keywords, and by providing application programs that use the new keywords.

The statements and keywords are used to initialize the instrument (for example, `INIT3421`), close a channel on a multiplexer card (for example, `CLOSE 1`), or take measurements (for example, `DCVOLTS(4)`). Additional statements and keywords are provided for string manipulation, temperature, and time/date conversions.

The application programs are built on the foundation of the new keywords and statements. The major applications provided are the front panel program, a strip chart program, a system monitoring program, a data logging package, and a data transmission program. The front panel program allows the user to interactivly control the HP 3421A and take readings from various sensors. The strip chart program prints a "real time" strip chart from various sensors. The system monitoring program provides a low cost solution for monitoring the status of a system on a video interface. The data logging package allows the user to specify and execute a data capture sequence. The data transmission programs can send data to the HP 44456 software package for the HP Series 200 computer family, or to MS-DOS® computers such as the HP 150.

MS-DOS is a registered trademark of Microsoft Corporation.

GETTING STARTED

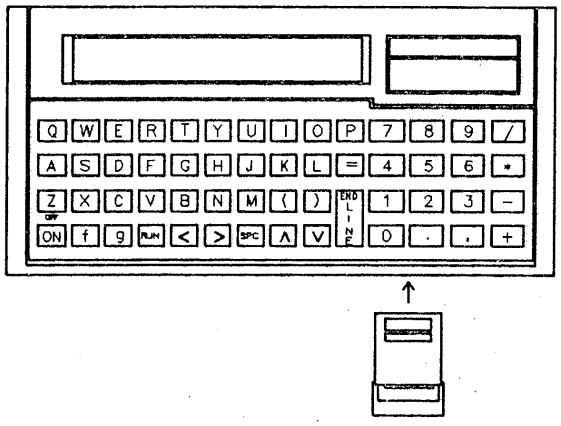
SECTION 2

2.1 INSTALLING AND REMOVING THE MODULE

The HP-71 Data Acquisition Pac ROM module can be plugged into any of the four ports on the front edge of the HP-71B Handheld Computer.

CAUTION

- Do not place fingers, tools, or other objects into the plug-in ports. Damage to plug-in module contacts and the computer's internal circuitry may result. Such actions could result in minor electrical shock hazard and interference with pacemaker devices worn by some persons.
- Turn off the computer (press f OFF) before installing or removing a plug-in module.
- If a module jams when inserted into a port, it may be upside down. Attempting to force it further may result in damage to the computer or the module.
- Handle the plug-in modules very carefully while they are out of the computer. Do not insert any objects in the module connector socket. Always keep a blank module in the computer port when a module is not installed. Failure to observe these cautions may result in damage to the module or the computer.



To insert the module, hold the HP-71 with the keyboard facing up and the module with the label facing up. Push the module into the port until it snaps into place. Be sure to observe the precautions described above.

To remove the module, use your fingernails to grasp the module by the lip on the bottom of its front edge. Pull the module straight out of the port. Install a blank module in the port to protect its contacts.

2.2 SUPPLEMENTAL DISC

The HP-71 Data Acquisition Pac Supplemental Disc (HP part number 82479-12001) enclosed with the pac contains six files:

XFER200	A BASIC 3.0 program for HP Series 200 computers used in conjunction with the TRANSFER program (refer to section 12, "The Transfer Program").
FROM71	The FROM71 subprogram from XFER200, for use in building a custom data transfer program with other subprograms from the HP 44456 System Software package.
MSDOSXFR	The HP-71 program for transferring data to an MS-DOS mass storage medium. Refer to section 13, "The MSDOSXFR Program" for further details about data transfer to MS-DOS based computers.
FATLEX	The LEXfile that is necessary for MSDOSXFR to run.
MON2392	A MONSET (MONitor SETup) subprogram customized for the HP 2392 terminal. Allows the use of MONITOR with that terminal instead of an HP 92198A HP-IL 80-Column Video Interface. Refer to appendix F, "Alternative Peripheral Options" for further details about MONSET.
PRT82905	A PRINTSET (PRINTer SETup) subprogram customized for the HP 82905B Printer. Allows the use of an HP 82905B Printer for strip chart generation from the STRIP or REPORT programs instead of a ThinkJet printer. Refer to appendix F, "Alternative Peripheral Options" for further details about PRINTSET.

2.3 EQUIPMENT NEEDED

The programs in this pac require an HP 82401A HP-IL Interface installed in the HP-71, an HP 3421A Data Acquisition/Control Unit, and the HP-IL cables to connect them. In addition, the strip chart program requires a printer, and generates charts specifically for the HP 2225 ThinkJet Printer. The system monitor program requires an HP 92198A Mountain Computer HP-IL 80-Column Video Interface and an appropriate monitor. (If you wish to use an alternate display device, refer to appendix F.)

You can use either the HP 82161A Digital Cassette Drive or the HP 9114A Disc Drive with the application programs. However, because of media wear and power consumption considerations, the HP 9114A Disc Drive is strongly recommended.

The addition of a printer (for example, a ThinkJet) allows the system monitor and data logger programs to print messages when unusual events occur.

Although not required by this pac, the HP 82402A Dual HP-IL Adapter may be used for advanced data acquisition and control applications that require more than one HP-IL loop. To communicate with an instrument equipped with with an HP-IB, RS-232, or GPIO interface, use the HP 82169A HP-IL/HP-IB Interface, the HP 82164A HP-IL/RS-232C Interface, or the HP 82165A HP-IL/GPIO Interface, respectively.

2.4 WHAT THE DATA ACQUISITION PAC DOES

The Data Acquisition Pac provides five main capabilities:

- A toolbox of keywords for controlling the HP 3421A Data Acquisition/Control Unit.
- A front panel for the HP 3421A.
- Strip chart generation from HP 3421A measurements.
- System monitoring (with limit tests) to a video interface.
- Long term data logging (with limit tests).

The strip chart, system monitor, and data logging programs may optionally store measurements in a data file for future analysis. A report program may be used to generate printed listings and summary statistics from the collected measurements. A data transfer program may be used to move selected measurements to the HP 44456 System Software package for HP Series 200 computers. A disc is included which provides a program for data transfer to the MS-DOS environment.

2.5 SETTING THE TIME AND DATE

The HP-71 contains an accurate quartz-crystal clock and calendar that runs whether the HP-71 is on or off, and begins running as soon as batteries are installed. The application programs in the Data Acquisition Pac use the clock to schedule events, and to record the time when measurements are made. Unless the batteries in the HP-71 become completely discharged, the time and date need only be set once.

If you have not already done so, follow the example below to set the clock to the correct time and date.

Example: Set the date for September 12, 1985.

Input/Result

```
SETDATE'85/09/12'
```

Sets the date. The HP-71 requires a 6-digit year/month/day (YY/MM/DD) format, including leading zeros.

```
>SETDATE'85/09/12'
```

[ENDLINE]

Enters the date.

```
>
```

```
DATE$ [ENDLINE]
```

Displays the date.

```
85/09/12
```

To set the clock within an accuracy of 1 second or better, key in a time about 30 seconds ahead of the actual time and press [ENDLINE] when the actual time catches up with the keyed-in time.

Input/Result

```
SETTIME'16:14:00' [ENDLINE]
```

This statement sets the time. The HP-71 clock uses the 24-hour format, and six digits must always be entered, including leading zeros.

```
>
```

```
TIME$ [ENDLINE]
```

Displays the time.

```
16:14:19
```

This is the time you executed TIME$.

2.6 CONNECTING THE INTERFACE LOOP

The HP 3421A Data Acquisition/Control Unit and other peripherals are connected to the HP-71 using the Hewlett-Packard Interface Loop (HP-IL). To use the loop an HP 82401A HP-IL Interface must be installed in the HP-71. A typical loop configuration for bench measurements with the Data Acquisition Pac consists of the HP-71, the HP 3421A, and optionally, a video interface. The peripheral devices in the interface loop may be connected in any sequence, but all of the interface cables must form a continuous loop. All connections are designed to ensure proper orientation.

To connect any peripheral device, first turn off the HP-71 (f OFF). Then merely disconnect the loop in any place and connect the new device at that place. All devices must be turned on for the interface to work properly. When the HP-71 is turned on, new addresses are assigned to all devices.

2.7 SPECIFYING HP-IL DEVICES

For many HP-IL operations that you perform using the HP-71, you'll need to specify the peripheral device that you want to use. The HP-71 provides six ways for you to identify HP-IL devices, that is, six types of *device specifiers*:

- Address
- Assign code
- Device word
- Device ID
- Accessory ID
- Volume label

The first two specifiers, *address* and *assign code*, send information to a known location in the loop. These specifiers provide fastest program execution.

The next three specifiers, *device word*, *device ID*, and *accessory ID*, check each device in the loop until the desired one is found. These specifiers provide convenient ways to identify devices. Programs that use these specifiers aren't noticeably slower than programs that use the methods mentioned above.

The last specifier, *volume label*, is intended primarily for mass storage operations. Because this specifier relates to the medium in the device, the HP-71 must read data from the medium, making this specifier somewhat slower than the other methods, although it ensures that the proper medium is being used.

An example of each type of device specifier is presented below. Further details may be found in section 1 of the *HP 82401A HP-IL Interface Owner's Manual.*

Address

```
PRINTER IS :2 [ENDLINE]
```

Assigns the second device (address 2) as the "printer" device.

```
PRINTER IS A [ENDLINE]
```

Uses the value of variable A as the address to assign the "printer" device.

Assign code

```
ASSIGN IO ":IN,:PR"
[ENDLINE]
```

Associates codes with the first two devices in the loop.

```
PRINTER IS ":PR" [ENDLINE]
```

Assigns the device with assign code PR as the "printer" device.

Device Word

```
PRINTER IS PRINTER
[ENDLINE]
```

Assigns the first printer class device as the "printer" device.

```
PRINTER IS PRINTER(2)
[ENDLINE]
```

Assigns the second printer class device as the "printer" device.

Device ID

```
PRINTER IS :HP2225
[ENDLINE]
```

Assigns the first ThinkJet printer as the "printer" device.

```
PRINTER IS :HP82164(2)
[ENDLINE]
```

Assigns the second HP-IL/RS-232 interface in the loop as the "printer" device.

Accessory ID

```
PRINTER IS %32 [ENDLINE]
```

Assigns the device with an accessory ID of 32 as the "printer" device.

```
PRINTER IS %32(2) [ENDLINE]
```

Assigns the second device in the loop with an accessory ID of 32 as the "printer" device.

Volume Label

```
CAT .DATA [ENDLINE]
```

Accesses the catalog of directory entries on the medium with the volume label DATA.

2.8 DATA FILES

The programs in the Data Acquisition Pac use data files to store setup information and record measurements. The data files are organized to conform to the Hewlett-Packard Applications Format (HPAF). The HPAF file standard and the structure of the files created are discussed in appendix H, "HPAF File Standard" and appendix I, "File Structures."

Data files may reside in three places:

- In the main RAM of the HP-71.
- In an independent RAM in the HP-71.
- On a mass storage device such as the HP 82161A Digital Cassette Drive or the HP 9114A Disc Drive.

File names must begin with a letter, and may have up to eight characters (ten for a file written to a disc). A file name may not include spaces or punctuation characters. When the programs prompt for a file name, the device name (if applicable) must be included in the response. If no device name is included, the file will be created in the main RAM of the HP-71.

Example file names with device names are:

DATAPTS	A file called DATAPTS residing in main RAM.
EVENTS:PORT(2)	A file called EVENTS residing in independent RAM.
LOGDATA:HP9114	A file called LOGDATA residing on a disc drive.
DATAFILE:TAPE:2	A file called DATAFILE residing on a tape drive on loop 2.

For more information about file and device names, refer to section 6, "File Operations" in the *HP-71 Owner's Manual.*

2.9 CHANNEL NUMBERING AND ADDRESSING

Throughout this manual, the term "channel" will be used to refer to either a relay on a multiplexer assembly or an input/output bit on a digitial I/O assembly. Channel numbers are repeated on each multiplexer assembly (numbers 0-9) and digital I/O assembly (numbers 0-7). Channel addresses are determined by which HP 3421A slot the option assembly is plugged into plus the channel number. Channel 4 for an assembly in slot 2 would be addressed as 24. The following table shows the addressing scheme for the three different slots.

Channel Number	Channel Address if Assembly is in Slot #:		
	Slot 0	Slot 1	Slot 2
0	00	10	20
1	01	11	21
2	02	12	22
3	03	13	23
4	04	14	24
5	05	15	25
6	06	16	26
7	07	17	27
8*	08	18	28
9*	09	19	29

* The digital I/O assemblies contain only channels 0-7.

2.10 USING THE KEYWORDS

The keywords provided in the Data Acquisition Pac simplify the use of the HP 3421A while providing speed enhancements. To make accurate and valid measurements with the HP 3421A, the following steps must take place:

- Identify the address of the HP 3421A to be used.
- Reset the HP 3421A to a known state.
- Read the status and configuration into a *status buffer* in the HP-71.
- Establish default modes of operation.

The statement INIT3421 is used to perform these functions. Once the instrument has been identified, the remaining keywords may be used to carry out measurement or control functions.

Example: Using the keywords, make a voltage measurement from the front panel terminals on the HP 3421A.

Input/Result

INIT3421 [ENDLINE]	Establishes the status buffer and initializes the HP 3421A.
>_	The system is ready.
DCVOLTS [ENDLINE]	Use the DCVOLTS function to measure the voltage from the front panel terminals.
1.455	The voltage is displayed.
A=DCVOLTS [ENDLINE]	Load the variable A with a new voltage measurement.
>_	The variable now contains the new measurement.
DISP A [ENDLINE]	Display the contents of A to view the result.
1.457	

2.10.1 Simple Programming

Functions such as DCVOLTS and ACVOLTS may be used from the keyboard or in BASIC programs. To illustrate this, build a simple program that displays the average of 10 voltage measurements from multiplexor channel 3 in slot 0 in the HP 3421A. *NOTE: depending on the configuration of your HP 3421A, this channel number may need to vary.*

Input/Result

```
EDIT SAMPLE [ENDLINE]
```

Create and name a new BASIC program file called SAMPLE.

```
SAMPLE      BASIC      0
```

Enter the following BASIC program lines, followed by [ENDLINE].

```
10 ! SAMPLE
20 REAL A,I,S              ! Declare variables
30 FIX 4                   ! Set display format
40 S=0                     ! Clear accumulator
50 INIT3421                ! Establish status buffer
60 FOR I=1 TO 10           ! Begin loop of 10 readings
70 S=S+DCVOLTS(3)          ! Accumulate voltages
80 NEXT I                  ! End of loop
90 A=S/10                  ! Compute average
100 DISP "AVERAGE:";A      ! Display average
110 END
```

Press [RUN] to run the program.

```
AVERAGE:  1.4467
```

The program displays the result.

This program will work regardless of the position of the HP 3421A in the loop, but does assume that a multiplexer assembly is in slot 0.

2.10.2 Using the SCAN Subprogram

The binary subprogram SCAN may be used to specify a series of measurements in the HP 3421A and load the results into an array. As an example, use SCAN to make a two wire ohms reading on channels 3 through 9 and store the results in the vector R() beginning in the first element of R. The readings will be made with autorange on, autozero on, and four digits of resolution.

```
10 OPTION BASE 1
20 DIM R(7)
30 USE3421
40 CALL SCAN("RA1Z1F3N4LS3-9;T3",R(),1,7,E)
50 IF E THEN DISP "ERROR:";E
```

Section 3, "Keywords", contains a detailed description of the syntax for SCAN. Appendix B, "HP 3421A Command Reference", contains a quick reference to the commands that control the HP 3421A.

2.10.3 Using Instrument Commands

The keywords CMD3421, GET3421, and SEND3421 are used to send and receive low level commands and messages to and from the HP 3421A. CMD3421 is a function which expects a single number back from the instrument while SEND3421 does not return a result. The combination of SEND3421 and GET3421 is equivalent to CMD3421. The following examples suggest the various uses of these keywords:

`A=CMD3421("T2")`	Do a software single trigger and read the result into A.
`SEND3421 "UC18"`	Unconditionally close channel 18.
`SEND3421 "TOT4"`	Begin counting events on channel 4.
`WAIT 10`	Wait 10 seconds.
`C=GET3421`	Read the subtotal into C.

Appendix B contains a quick reference for the commands that control the HP 3421A.

2.10.4 Interrupt Programming

The HP 3421A may be configured to cause an interrupt (SRQ) which signals the HP-71 that an event has occurred. The following example illustrates the use of the keywords in the Data Acquisition Pac for an interrupt programming problem. For further details, refer to section 3, "Keywords," and to chapter 6 in the *HP 3421A Data Acquisition/Control Unit Operating, Programming, and Configuration Manual.*

In this example, the HP 3421A monitors a switch connected to a frozen food locker in a restaurant. When the door opens or closes, it momentarily closes a switch connected to a 5 volt power supply and the input channel 0 of a digital I/O card in slot 2. A T type thermocouple inside the locker is connected to channel 3 of a multiplexer card in slot 0. The restaurant manager wants a printout of the time of each switch closure and the temperature inside the locker when the switch closes. The program waits 5 seconds after each closure to avoid switch bounce problems as the door closes. The HP-71 is connected to the HP 3421A and a ThinkJet Printer. The program will run until the [Q] key is pressed.

```
10 INIT3421 @ OPTION DEGREES F          ! Initialize HP3421
20 PRINT "Program starts: ";TIME$
30 ON INTR GOTO 100                     ! Set up branch
40 ENABLE INTR 8                        ! Enable interrupts
50 SETSRQ 8                             ! Enable SRQ in HP3421
60 MONITOR HIGH 20                      ! Monitor channel 20
70 AUTOIDY ON                           ! Enable auto IDY messages
80 IF KEY$="Q" THEN 140 ELSE 80         ! End program on [Q] key
90 !
100 ! Interrupt service routine
110 OFF INTR
120 PRINT TIME$;" ";TCOUPLE("T",DCVOLTS(3),REFTEMP(3))
130 WAIT 5 @ GOTO 30                    ! Return to main program
140 !
150 PRINT "Program ends: ";TIME$
160 OFF INTR @ END
```

The keywords INIT3421, OPTION DEGREES, SETSRQ, MONITOR, AUTOIDY, TCOUPLE, DCVOLTS, and REFTEMP are discussed in section 3, "Keywords." Line 120 of the program prints the time and temperature using the TIME$ and TCOUPLE functions. Note that the DCVOLTS function is used to obtain the thermocouple voltage, and the REFTEMP function is used to obtain the reference temperature for the TCOUPLE function, which then returns the calculated temperature.

2.10.5 Interrupt Subprograms

The UTILITY file in the Data Acquisition Pac contains three general purpose subprograms for use in new application programs. They incorporate all of the statements required to prepare the HP-71 and the HP 3421A for a service request interrupt when a digital input channel goes high or low or when all digital input channels meet a given pattern. The subprograms are:

- **MONLOW** - Monitor a digital input channel until it goes low (page 3-19).
- **MONHIGH** - Monitor a digital input channel until it goes high (page 3-19).
- **MONSLOT** - Monitor all digital input channels on a digital I/O card until a specific condition occurs (page 3-20).

The following example uses the MONHIGH subprogram to wait until channel 4 on a digital I/O card (mounted in slot 1) goes high before measuring a frequency on channel 5:

```
10 INIT3421                              ! Initialize HP3421
20 PRINT "Program starts: ";TIME$        ! Print starting time
30 CALL MONHIGH(14,E) IN UTILITY         ! Call and wait for SRQ
40 IF E THEN PRINT "ERROR";E @ END       ! Test errorcode
50 PRINT "SRQ received: ";TIME$          ! Print time of SRQ
60 PRINT "Frequency =";FREQ(5)           ! Print frequency
70 END
```

The next example uses the MONSLOT subprogram to wait until channels 0 and 2 are high and all other channels in slot 2 are low before the frequency is measured:

```
10 INIT3421                                ! Initialize HP3421
20 PRINT "Program starts: ";TIME$          ! Print start time
30 CALL MONSLOT(2,5,255,E) IN UTILITY      ! Wait for SRQ
40 IF E THEN PRINT "ERROR";E @ END         ! Test errorcode
50 PRINT "SRQ received: ";TIME$            ! Print time of SRQ
60 PRINT "Frequency =";FREQ(5)             ! Print frequency
70 END
```

Section 3, "Keywords," contains a detailed description of these subprograms.

2.10.6 Advanced Interrupt Programming

Advanced interrupt driven applications which need to service interrupts from more than one device are possible using the keywords in the HP 82401A HP-IL Interface and the Data Acquisition Pac. The following example illustrates the combined use of the HP 3421A and the HP 3468A Digital Multimeter in an interrupt-driven environment. The program monitors both devices and reads a voltage "on demand".

In this program the HP-71 waits for a service request from either the HP 3421A or the HP 3468A and takes a voltage reading on the instrument that sent the request. The example assumes the HP 3421A has multiplexer cards in slots 0 and 1, and a digital I/O card in slot 2. A switch connected to input channel 20 can momentarily raise the input voltage to 5 volts, causing an interrupt. The HP 3468A sends an SRQ when the [SRQ] button on the front panel is pressed.

```
10 V=DEVADDR("HP3468")                          Find HP 3468A
20 INIT3421 @ H=DEVADDR(ADR3421$)               Find HP 3421A
30 SETSRQ 8                                     Set HP 3421A intr mask
40 OUTPUT :V ;"M20F1N3T1D2WAITING"              Set HP 3468A for front panel
                                                Service request and dc volts
50 !
60 'TOP':
70 MONITOR HIGH 20                              HP 3421A starts
80 ON INTR GOTO 120                             Tell HP-71 where to go
90 ENABLE INTR 8 @ AUTOIDY ON                   Allow HP-71 to respond
100 IF KEY$#"Q" THEN 100 ELSE 'QUIT'            Monitor keyboard
110 !
120 IF NOT BIT(READINTR,3) THEN 'TOP'           Confirm SRQ interrupt
130 !
140 ! HP3468 service routine
150 S=SPOLL(V)                                  Did HP 3468A source SRQ?
160 IF NOT BIT(S,4) THEN 220                    Goto HP 3421A if not.
170 DISP TIME$;" HP3468 Voltage:";              Display time, source,
180 ENTER :V ;A @ DISP A                        and voltage.
190 OUTPUT :V ;"D2WAITING"                      Refresh HP 3468A display
200 GOTO 'TOP'                                  Re-enable interrupts
210 !
220 ! HP3421 service routine
230 S=SPOLL(H)                                  Did HP 3421A source SRQ?
240 IF NOT BIT(S,3) THEN 'TOP'                  Re-enable intrs if not
250 DISP TIME$;" HP3421 Voltage:";DCVOLTS(15)   Display voltage
260 GOTO 'TOP'                                  Re-enable interrupts
270 !
280 'QUIT':
290 OFF INTR @ OUTPUT :V ;"D1"                  Clear devices
300 DISP "Done" @ END
```

The program enables the service request masks in both the HP 3468A and the HP 3421A. The HP-71 receives an SRQ when the [SRQ] button on the HP 3468A is pressed or channel 20 goes high in the HP 3421A. Line 120 confirms that the interrupt is actually a device requesting service.

The HP 3468A is polled in line 150 to determine if it was the source of the SRQ. If bit 4 of the HP 3468A status is clear, the program branches to the HP 3421A service routine. Otherwise, a voltage

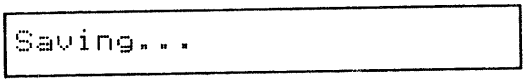
reading is taken and displayed. Line 190 refreshes the "WAITING" message prior to the return to re-enable the interrupts.

The HP 3421A is polled in line 230 to determine if it was the source of the SRQ. The program branches to re-enable the interrupts if bit 3 of the HP 3421A status register is clear. Otherwise, a voltage reading is taken and displayed before returning to re-enable the interrupts.

When the [Q] key is pressed the program branches to the shutdown routine. The interrupts are disabled and the HP 3468A is switched back to local mode before the program ends.

2.11 USING THE APPLICATION PROGRAMS

The application programs in the Data Acquisition Pac use a variety of prompts and messages to control the flow of the application. Some messages in the display are status messages that inform you of the current activity. These are characterized by three periods after the message, and do not require a response.



This message indicates that the computer is saving information to a file.

Any time an application program (such as STRIP or SETUP) displays a menu or prompt, the HP-71 will pause, awaiting a response. Prompts have a : or ?, and require a response appropriate to the message in the display.

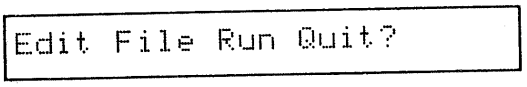
There are six types of messages that require a response:

- **Keystroke menus** - used to select various options in a program.
- **Revolving menus** - used to select a measurement function or limit action.
- **Choices** - used to select an option, such as the temperature units *Fahrenheit* or *Celsius*.
- **Prompts** - used to enter information, such as a channel number in the HP 3421A.
- **Time** - used to enter the time of an event.
- **Date** - used to enter the date of an event.

Keystroke Menus

Keystroke menus are used to select from various available options in a program. Some menu options activate secondary menus that provide additional options.

For instance, this is the main menu from the MONITOR program:



The capital letters show which key on the HP-71 to press for each choice. When this menu is in the display, you can press [R] to run the monitor.

Revolving Menus

Revolving menus allow you to select one of the available HP 3421A functions. Revolving menus are distinguished by a tilde (~) in the display. Use the vertical arrow keys to choose among the available options in a revolving menu.

For example, the STRIP program asks for the function to be measured with this prompt:

```
FN~ DC Volts
```

Press the arrow keys ([^][v]) until the desired option appears, then press [ENDLINE] to select the option. The menu "wraps around", so that pressing [v] repeatedly will eventually display the first option.

Choices

Choices allow you to select one option from a short list. The choices are usually presented in parentheses or after a colon:

```
Degrees: (C F K or R)?
```

This message asks you to press [C] for Celsius units, [F] for Fahrenheit units, [K] for Kelvin units, or [R] for Rankine units.

```
Overwrite file (Y/N)?
```

This message asks you to press [Y] to overwrite a file, or [N] to preserve the file.

Prompts

Prompts request you to enter numbers or file names. They are also distinguished by the presence of a blinkng cursor just after the question mark. Unlike choices, prompts require an [ENDLINE] keystroke to complete the entry. The character editing keys such as [<], [>], and [I/R] are available for use as you enter the response.

```
Data file?
```

The program is asking you to type the name of a file, followed by [ENDLINE].

In response to a prompt for a number, you can enter a numeric expression. For example:

```
No. of scans?
```

Entering 32*14 is the same as entering 448.

32*14 [ENDLINE]

Time Prompts

Time prompts are used to enter a time of day or a time interval. These times are represented in hours-minutes-seconds format:

```
Start time?  HH:MM:SS
```

The program is asking for the time of day for an event. The cursor will be blinking over the first H.

Times are entered in *protected fields* - you can only type over specific characters. The keys [0] - [9], [-], [<], [>], and [ENDLINE] are active. Notice that after typing over the second H, the cursor skips over the colon (:) to the first M. Likewise, the cursor skips the colon when pressing the [<] key to move backwards.

Times are entered in 24-hour format. Any digit not specified will be interpreted as 0.

The SETUP program has an extended convention to indicate events which should begin immediately upon startup of the LOG program. Immediate events are denoted by entering -1 in the hours field.

Date Prompts

Date prompts are used to enter a date. Dates are represented in year/month/day format:

```
Start date?  YY/MM/DD
```

The program asks for the date of an event. (The cursor will be blinking over the first Y.)

Dates are entered in *protected fields* - you can only type over specific characters. The keys [0] - [9], [<], [>], and [ENDLINE] are active. Notice that after typing over the second Y, the cursor skips over the slash (/) to the first M. Likewise, the cursor skips the slash when pressing the [<] key to move backwards.

2.12 MEASUREMENT NOTES

The programs in this pac can use a variety of sensors with the HP 3421A. The following notes provide additional information about some of the measurements.

Current Measurement

The multiplexer assembly (option 020, 021, or 022) is capable of sensing the current in a 4-20 mA industrial current loop. A resistor must be placed in shunt with the current path. The HP 3421A voltmeter monitors the resulting voltage drop. The software in this pac assumes that the shunt resistor is 50Ω, and divides the dc voltage reading by 50 to obtain the loop current, returning the result in milliamps.

Thermocouples

The thermocouple types supported in this pac are as follows:

- **T** - Copper/Constantan
- **E** - Chromel/Constantan
- **J** - Iron/Constantan
- **K** - Chromel-P Alumel
- **R** - Pt-Pt 13% Rh
- **S** - Pt-Pt 10% Rh

Thermocouples are measured using DC Volts, 5 1/2 digits, autorange on, and autozero on. The reference temperature is measured using the reference junction on the multiplexer card for each reading, and is used as the reference temperature parameter in the TCOUPLE keyword (refer to section 3, "Keywords"). In cases where long leads are used, the entire system should be calibrated to account for the effects of lead resistance. If needed, a custom program can be used to make the voltage measurement, provide correction factors, and then convert from voltage to temperature.

Thermistors & RTD's

The thermistors supported in this pac are as follows:

- **2252Ω** @ 25 °C
- **5000Ω** @ 25 °C
- **RTD**: 100Ω @ 0 °C (European curve, α=.00385)

Resistance measurements are made with 5 1/2 digits, autorange on, and autozero on. In cases where long leads are used, the entire system should be calibrated to account for the effects of lead resistance. Four wire ohm measurements will provide additional accuracy.

Application Notes

Hewlett-Packard publishes several application notes which may be useful in the design and implementation of a test system:

- *Floating Measurements and Guarding*, Application note 123.
- *Practical Temperature Measurements*, Application note 290.
- *Practical Strain Gage Measurements*, Application note 290-1.
- *Practical Test System Signal Switching*, Application note 328-1.

Application notes may be obtained by contacting your local Hewlett-Packard sales office.

KEYWORDS

SECTION 3

The Data Acquisition Pac provides several new BASIC keywords for your HP-71. You can use these keywords in a BASIC program to control the operation of the HP 3421A Data Acquisition/Control Unit, or you can use the programs provided by the pac, which also use these keywords. Thus, these keywords form the basis of the Data Acquisition Pac. Each of the keywords performs a function that would normally take several BASIC statements. Thus, the keywords make programming easier, and speed up the response of a control program.

NOTE

Many of the keywords communicate directly with the HP 3421A Data Acquisition/Control Unit (to obtain readings or send commands). When executed, such keywords automatically clear flag -23 in the HP-71. (The flag is left clear when the keyword completes execution.)

3.1 SYNTAX CONVENTIONS

When you use BASIC keywords, you must use proper **syntax** in order for the computer to understand their meaning. The following syntax guidelines are used throughout this section:

DOT MATRIX TYPE	Words in dot matrix type may be keyed in using either lowercase or uppercase letters, but otherwise must be entered exactly as shown. Commands, statements and functions entered in lowercase are converted internally to uppercase.
italics type	Items in italics are the parameters you supply, such as a *filename*.
' ' , " "	Filenames and other character strings can be enclosed with single or double quotation marks and can be entered in lowercase or uppercase letters. Quoted filenames are converted to uppercase internally.
[ ]	Square brackets enclose optional items.
|	If items are separated with a vertical bar, you may choose one or the other of the items, but not both.
{ }	Braces indicate that an item is required. Usually, the braces are used in conjunction with the vertical bar to indicate that one of a series of items is required. For example, { ON | OFF } indicates that either ON or OFF must be selected.

Note that a *string expression* can be either a string of ASCII characters enclosed in quotation marks (' ' or " "), or a string variable (for example: A$). A *numeric expression* can be either a number, or an expression that can be evaluated to obtain a number.

3.2 KEYWORD SYNTAX

This subsection defines the syntax and describes the operation of each keyword.

ACVOLTS

```
ACVOLTS [ (channel number) ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns an ac voltage reading from the HP 3421A instrument. If no channel number is specified, the reading will be taken from the currently closed channel.

ADR3421$

```
ADR3421$
```

This function returns the device specifier of the current HP 3421A (specified by USE3421 or INIT3421). If no HP 3421A is active, the null string is returned.

AUTOIDY

```
AUTOIDY {ON|OFF}
```

When AUTOIDY is enabled, the HP-IL module sends IDY frames during every idle moment, allowing an instrument to send a service request back to the HP-71. The IDY frames are sent until a service request is received, the loop is broken, an AUTOIDY OFF is executed, or a RESET HPIL is executed. Note that AUTOIDY ON increases power consumption in the HP-71.

AUTORANGE

```
AUTORANGE {ON|OFF}
```

This function turns on or off the autoranging of the HP 3421A instrument. The default is autorange *on*.

AUTOZERO

```
AUTOZERO {ON|OFF}
```

This function controls the autozero function in the HP 3421A. The default is autozero *on*.

BUF3421$

```
BUF3421$
```

This function returns the contents of the status buffer that is used to update the HP 3421A. The first three characters contain the current gate time, the fourth and fifth characters contain the number of digits of resolution, the sixth through eighth characters contain the range, the ninth through eleventh characters contain the autorange on|off command, and the final two characters contain the autozero command.

For example, immediately after an `INIT3421` is executed, `BUF3421$` returns the following string: `"G 0N5R 2RA1Z1 "`.

BYTEREAD

```
BYTEREAD(slot)
```

slot - an HP 3421A slot number (range = 0 - 2).

This function reads a byte from a digital card in the specified slot.

BYTEWRITE

```
BYTEWRITE slot, value
```

slot - an HP 3421A slot number (range = 0 - 2).

value - value of the byte to be written (range = 0 to 255).

This statement writes a byte to a digital card in the specified slot.

CHANTYPE

```
CHANTYPE(channel number)
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns the type of the specified channel. The type returned is a "1" for an acquisition channel, a "2" for a digital channel, or a "3" for an actuator channel. If the channel does not exist, "0" will be returned.

CLOSE

```
CLOSE [PAIR] channel number
```

channel number - an HP 3421A channel number (range = 00 - 29).

This statement closes a multiplexer channel in the HP 3421A. If the PAIR parameter is present, a second channel ((*channel number* + 10) MOD 30) will be closed using the CLP command resident in the HP 3421A.

CMD3421

```
CMD3421 (string expression)
```

string expression - a command string to be output to the HP 3421A.

This function sends the *string expression* to the HP 3421A and expects a single numeric value in return. The point is to speed execution of a custom sequence by combining into one function the ENTER and OUTPUT statements that would normally be used.

DCNV

```
DCNV (string expression)
```

string expression - a date expressed as a string in the form YY/MM/DD.

This function converts a string expression of the form YY/MM/DD to an integer date of the form YYDDD.

DCNV$

```
DCNV$ (numeric expression)
```

numeric expression - a date in integer form (YYDDD).

This function converts an integer date of the form YYDDD to a string in the form YY/MM/DD.

DCVOLTS

```
DCVOLTS [ (channel number) ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns a dc voltage reading from the HP 3421A from the specified channel. If no channel is specified, the reading is taken from the currently closed channel.

DIGITS

```
DIGITS {3|4|5}
```

This statement sets the number of digits to be returned from the HP 3421A instrument. A 3 specifies 3.5 digits; a 4, 4.5 digits; and a 5, 5.5digits. The default is 5.5 digits.

FREQ

```
FREQ [ (channel number) ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns a frequency measurement from the HP 3421A from the specified channel using the current gate time. If no channel is specified, the reading is taken from the currently closed channel.

GATE

```
GATE seconds
```

seconds - the desired gate time in seconds (0.1, 1, or 10).

This statement sets the gate time for the counter. The valid times are 0.1, 1, and 10 seconds. The default is one second.

GET3421

```
GET3421
```

This function reads a number from the HP 3421A. This function is useful when the instrument has been instructed to take a series of measurements, (using the SEND3421 statement, for instance) and one reading is to be read and processed at a time.

HGL$

```
HGL$( string expression [ , numeric expression ] )
```

string expression - a string of ASCII characters.

numeric expression - an optional parameter evaluating to zero or non-zero.

This statement sets the high bit in each byte of a string expression if the optional numeric expression is not present or evaluates to zero. If the optional numeric expression is non-zero, the highlight command is ignored.

IMAGE$

```
IMAGE$( string expression )
```

string expression - an IMAGE string.

This function prepares a pre-parsed IMAGE token stream for use with PRINT USING statements. The use of a pre-parsed token stream greatly increases the speed of the PRINT USING statements.

INIT3421

```
INIT3421 [ device specifier | * ]
```

device specifier - device specifier of the desired HP 3421A instrument.

This statement finds the specified HP 3421A instrument, resets it, reads the internal configuration and sets default conditions to match the instrument configuration. If the optional *device specifier* is omitted, the first HP 3421A found is used. All subsequent commands refer to the specified HP 3421A until a new INIT3421 or USE3421 command is issued. If * is specified, the current HP 3421A status buffer will be purged.

Note that if the specified device is not an HP 3421A, unpredictable results may occur.

KEYSLP$

```
KEYSLP$
```

This function is identical to KEYWAIT$ except that if an ON TIMER expires during statement execution, a null string is returned immediately.

KEYWAIT$

```
KEYWAIT$
```

This function puts the HP-71 to sleep (leaving the LCD turned on), and waits for a keystroke. The result is in the same form as a KEY$ result, but reduces HP-71 power consumption.

LTRIM$

```
LTRIM$( string expression [ , string expression ] )
```

string expression - a string of ASCII characters

If the optional second string expression is omitted, the function returns the first string expression with all leading spaces removed.

If the second string expression is included, the first character in the second string is used as the "trim" character, rather than the space. The function returns the first string expression with all leading "trim" characters removed. For example, if the first string is "aardvark" and the second string is "abc", the function will return "rdvark".

MONITOR

```
MONITOR {HIGH|LOW} channel number
```

channel number - an HP 3421A channel number (range = 00 - 29).

This statement sets up the HP 3421A to monitor the specified bit on a digital I/O assembly. If the service request has been enabled in the HP 3421A, a service request is generated when the bit changes to the desired state.

Use the SETSRQ statement to set the service request mask in the HP 3421A.

MONITOR SLOT

```
MONITOR SLOT number, XOR mask value , AND mask value
```

number - slot number of digital card (0, 1, or 2).

XOR mask value - value in the range 0 to 255.

AND mask value - value in the range 0 to 255.

This statement sets up the HP 3421A to monitor the digital card. Byte values read from the input port are XORed with the XOR mask, then ANDed with the AND mask. Effectively, the 1 bits in the AND mask specifiy which bits affect the result, and the XOR mask determines the 1/0 choice for each bit. If the service request bit has been set in the HP 3421A, a service request is generated when the result of the comparison is 0. Use the SETSRQ statement to set the service request mask in the HP 3421A.

OHMS2

```
OHMS2 [ (channel number) ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns a 2 wire ohms measurement from the current HP 3421A instrument on the specified channel. If no channel is specified, the reading is taken from the currently closed channel.

OHMS4

```
OHMS4 [ (channel number) ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns a 4 wire ohms measurement from the current HP 3421A instrument on the specified channel. If no channel is specified, the reading is taken from the currently closed channel pair.

OPEN

```
OPEN [ channel number ]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This statement opens the specified channel in the HP 3421A. If a channel pair has been closed, the paired channel is also opened. If no channel number is specified, all channels are opened.

OPTION DEGREES

```
OPTION DEGREES {C|F|K|R|string expresion}
```

string expression - any ASCII string with C, F, K, or R as the first character.

This statement sets the returned units for temperature functions. The default is Celsius. The other scales are Fahrenheit, Kelvin, and Rankine.

PRINT TO

```
PRINT TO string variable [ USING image ] ; item list
```

string variable - string to which the output will go.

image - image specifier.

item list - string or numeric expressions separated by commas or semicolons.

This statement allows formatted output from a PRINT or PRINT USING statement to be placed in a string variable instead of being sent to an output device. All characters that would be sent to the display device (including control characters, CR and LF) are written to the string variable. The characters used in the *endline string* are used as in a normal PRINT or OUTPUT statement. A PWIDTH of Inf is used. See the *HP-71 Reference Manual* for details about formatted printing using IMAGE.

RANGE

```
RANGE numeric expression
```

numeric expression - a numeric expression that rounds to an integer in the range -1 through 7.

This statement sets the voltmeter range in the HP 3421A. The numeric expression must round to an integer between -1 and 7 inclusive.

READBIT

```
READBIT(channel number)
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function reads the value of a bit on a digital card.

REFTEMP

```
REFTEMP [(channel number)]
```

channel number - an HP 3421A channel number (range = 00 - 29).

This function returns the reference temperature for the multiplexer card containing the specified channel. If no channel is specified, the reading is taken from the lowest numbered slot containing a multipexer card with a closed channel. The returned result is in the units specified by the OPTION DEGREES statement.

RPT$

```
RPT$(string expression, numeric expression)
```

string expression - a string of ASCII characters.

numeric expression - a numeric expression that rounds to an integer in the range 0 to 1,048,575.

This function constructs a string of the specified number of repetitions of *string expression*.

RTD

```
RTD(resistance)
```

resistance - a resistance value in ohms.

This function returns a temperature assuming the resistance is measured on a European curve (alpha=.00385) RTD. The returned result is in the units specified by the OPTION DEGREES statement, or in degrees Celsius if no instrument buffer has been established.

RTNERR

```
RTNERR
```

If an ON ERROR ... GOSUB trap is active, this statement may be used to return to the statement that caused the error. If no error trap is active, RTNERR behaves the same way as RETURN, which returns to the statement *following* the statement that caused the error.

RTRIM$

```
RTRIM$( string expression [, string expression ] )
```

string expression - a string of ASCII characters

If the optional second string expression is omitted, the function returns the first string expression with all trailing spaces removed.

If the second string expression is included, the first character in the second string is used as the "trim" character, rather than the space. The function returns the first string expression with all trailing "trim" characters removed. For example, if the first string is "abbbaaaa" and the second string is "abc", the function will return "abbb".

SEND3421

```
SEND3421 string expression
```

string expression - a command string to be output to the HP 3421A.

This statement sends a command string to the HP 3421A without expecting a reply.

SET3421

```
SET3421  string expression
```

string expression - a string of ASCII characters

This statement is used to update the contents of the instrument buffer and send the new contents to the HP 3421A. The contents of the string expression must match the organization of the string returned by BUF3421$.

SETSRQ

```
SETSRQ  mask value
```

mask value - a value in the range 0 through 255.

This statement sets the service request mask in the HP 3421A to *mask value*.

STD$

```
STD$(numeric expression)
```

numeric expression - any numeric value.

This function returns a string representation of the numeric expression formatted in the standard display (STD) format. In standard display format, numbers are displayed with the smallest number of digits consistent with presenting maximum accuracy.

TCNV

```
TCNV(string expression)
```

string expression - a string expression of the form HH:MM:SS.

This function converts a string of the form HH:MM:SS to an integer representing the number of seconds since midnight.

TCNV$

```
TCNV$(numeric expression)
```

numeric expression - the number of seconds since midnight.

This function converts a number representing the number of seconds since midnight into a string of the form HH:MM:SS.

TCOUPLE

```
TCOUPLE(string expression, voltage [, reference])
```

string expression - any ASCII string with the first character indicating the type of thermocouple (E, J, K, R, S, or T).

voltage - measured thermocouple voltage.

reference - reference temperature in the units specified by OPTION DEGREES.

This function returns the temperature from a thermocouple voltage, sensor type, and optional reference temperature. If no reference temperature is provided, zero degrees Celsius is assumed. The reference temperature *must* be in the current temperature units. The returned result is in the units specified by the OPTION DEGREES statement, or in degrees Celsius if no instrument buffer has been established.

THMST2

```
THMST2(resistance)
```

resistance - measured thermistor resistance.

This function returns a temperature assuming the resistance is measured on a 2252Ω thermistor. The returned result is in the units specified by the OPTION DEGREES statement, or in degrees Celsius if no instrument buffer has been established.

THMST5

```
THMST5(resistance)
```

resistance - measured thermistor resistance.

This function returns a temperature assuming the resistance is measured on a 5000Ω thermistor. The returned result is in the units specified by the OPTION DEGREES statement, or in degrees Celsius if no instrument buffer has been established.

TRIM$

```
TRIM$(string expression [ , string expression ])
```

string expression – a string of ASCII characters.

If the optional second string expression is omitted, the function returns the first string expression with all leading and trailing spaces removed.

If the second string expression is included, the first character in the second string is used as the "trim" character, rather than the space. The function returns the first string expression with all leading and trailing "trim" characters removed. For example, if the first string is "level" and the second string is "list", the function will return "eve".

USE3421

```
USE3421 [ device specifier | * ]
```

device specifier - device specifier of the desired HP 3421A instrument.

This statement is the same as INIT3421 execpt that it does not reset the instrument to the power-on state. Note that if the specified device is not an HP 3421A, unpredicable results may occur.

WRITEBYTE

```
WRITEBYTE slot number, numeric expression
```

slot number - The number of a slot in the HP 3421A containing a digital card.

numeric expression - Value to be written to the output port.

This statement writes a decimal value to the output port of a digital I/O card.

3.3 SCANNING

A binary subprogram called SCAN is used to send a command string to the HP 3421A and return a series of readings, such as 30 readings from one channel or 7 readings from consecutive channels. This permits faster scanning than would be possible with individual commands in a FOR ... NEXT loop. The syntax for this subprogram call is as follows:

SCAN

```
CALL SCAN(command string, vector, index, #readings, errorcode)
```

The parameters are as follows:

command string - A string expression containing a command for the HP 3421A.

vector - The vector (one-dimensional array) into which the numbers from the HP 3421A are placed. The vector should be large enough to accommodate all the readings received from the instrument.

index - The index of the vector element to receive the first number returned from the HP 3421A. Subsequent numbers received from the HP 3421A are placed into the next vector elements.

#readings - The number of readings to be stored in the vector.

errorcode - Returns 0 if there were no errors, or the number of the error generated.

3.4 INTERRUPT SUBPROGRAMS

Three BASIC subprograms provided in the UTILITY file may be used for convenient interrupt programming. They are:

MONLOW

```
CALL MONLOW( channel number, errorcode )
```

The parameters are as follows:

channel number - an HP 3421A channel number (range = 00 - 29).

errorcode - Returns 0 if there were no errors, or the number of the error generated.

This subprogram sets up the HP 3421A to source a service request (SRQ) when the specified input channel goes low and waits for the SRQ.

MONHIGH

```
CALL MONHIGH( channel number, errorcode )
```

The parameters are as follows:

channel number - an HP 3421A channel number (range = 00 - 29).

errorcode - Returns 0 if there were no errors, or the number of the error generated.

This subprogram sets up the HP 3421A to source a service request (SRQ) when the specified input channel goes high and waits for the SRQ.

MONSLOT

```
CALL MONSLOT( slot number, XOR mask, AND mask, errorcode )
```

The parameters are as follows:

slot number - an HP 3421A slot (range = 0 - 2) containing a digital card.

XOR mask - value in the range of 0 to 255.

AND mask - value in the range of 0 to 255.

errorcode - Returns 0 if there were no errors, or the number of the error generated.

This subprogram sets up the HP 3421A to monitor the digital card. Byte values read from the input port are XORed with the XOR mask, then ANDed with the AND mask. Effectively, the "1" bits in the AND mask specify which bits affect the result, and the XOR mask determines the "1"/"0" choice for each bit. When the result of the comparison is "0", a service request is sent to the HP-71 and the subprogram ends.

STATUS PROGRAM

SECTION 4

The program STATUS is used to read the status of an HP 3421A Data Acquisition/Control Unit and print out the hardware and software configuration. The program interrogates the HP 3421A and prints the report on the current PRINTER IS device. The HP 3421A must be the first instrument on loop 1 in order to work with the status program.

To print a configuration report, invoke the STATUS program:

Input/Result

RUN STATUS [ENDLINE]	Run the status program.
Reading the HP3421...	The program interrogates the HP 3421A.
Printing...	The program prints the report.
Done	The program is finished.

The following page contains an example of a status printout for an HP 3421A configured with an option 020 multiplexer card in slot 0, an option 022 multiplexer card in slot 1, and an option 050 digital card in slot 2. The address :X88 is the default used by the keyword INIT3421. The instrument has multiplexer channel 3 closed.

Status Report Example

```
Status as of 14:30:05 85/10/8

Instrument configuration:
-------------------------

Address :%83

Service request mask = 84

Board configurations:
---------------------

Slot 0  contains a relay board
Slot 1  contains a relay board
Slot 2  contains a digital board

Chnl#   Type    Chnl#   Type    Chnl#   Type
-----   ----    -----   ----    -----   ----
  0      ACT      10      ACQ     20      DIG
  1      ACT      11      ACQ     21      DIG
  2      ACQ      12      ACQ     22      DIG
  3      ACQ      13      ACQ     23      DIG
  4      ACQ      14      ACQ     24      DIG
  5      ACQ      15      ACQ     25      DIG
  6      ACQ      16      ACQ     26      DIG
  7      ACQ      17      ACQ     27      DIG
  8      ACQ      18      ACQ     28
  9      ACQ      19      ACQ     29

Channel 8  is closed

Function status:
----------------

DC Volts
Gate: 1 second
Range: 2
Calibration disabled
Integration rate: 60Hz
Autozero on
Autorange on
Trigger: internal, 1
Number of digits: 5.5
Channel list is mux channels

Digital registers:
------------------

AND register is 0
XOR register is 0
```

FRONT PANEL PROGRAM

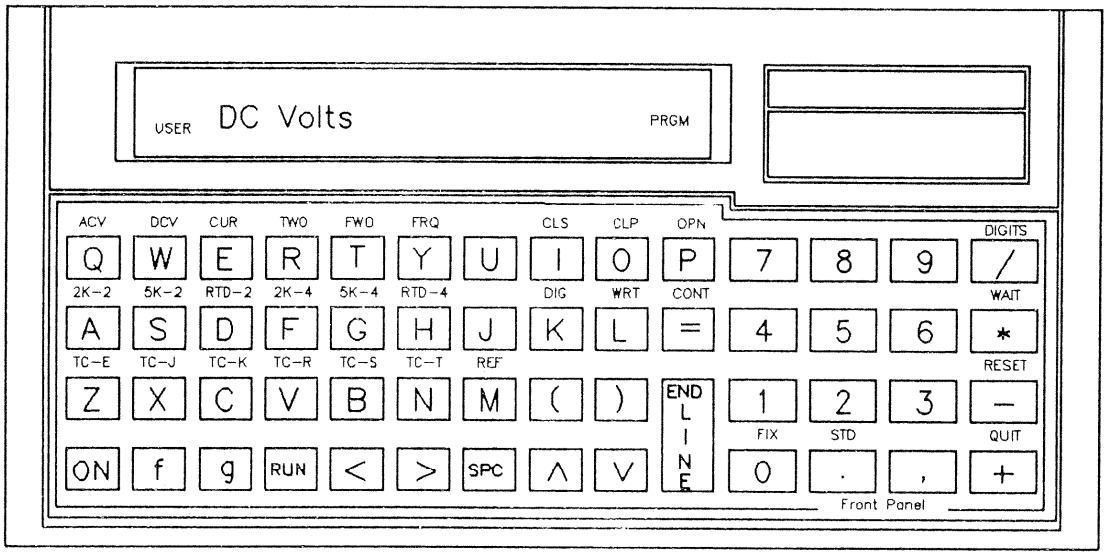
SECTION 5

The front panel program FRONT allows you to use the HP 3421A Data Acquisition/Control Unit as a bench instrument in much the same way that you would use a conventional instrument. The program redefines the functions of many of the HP-71 keys. These *command keys* control the front panel program, and through it, the operation of the HP 3421A. In effect, the HP-71 becomes the front panel of the HP 3421A.

Upon startup, the program performs the following functions in order:

- Displays the message Reading the HP3421...
- Finds the first HP 3421A on the loop.
- Reads the configuration of the HP 3421A into memory.
- Sets the program to read DC Volts.
- Prepares to service keyboard requests for program options.
- Begins reading the HP 3421A and displaying the result in the display.

You can identify the front panel command keys using the keyboard overlay provided. The overlay, installed on the HP-71, is shown below:



The identity of each command key is shown *above* the key on the overlay. For example, to select DC Volts, press **[DCV]** (the W key). To select AC Volts, press **[ACV]** (the Q key). For convenience, each command key will be identified in this section by its name on the overlay.

5.1 FRONT PANEL OPERATION

To use the front panel program, place the overlay on the HP-71 and invoke the program:

Input/Result

RUN FRONT [ENDLINE]	Run the front panel program.
Reading the HP3421...	The program finds the first HP 3421A on the loop.*
DC Volts	The program begins measuring DC Volts from the front panel input terminals.
1.567 **[ACV]**	To select another function, press the desired key. For example, to select AC Volts, press **[ACV]**.
AC Volts	
0.001	

*By using a substitute CHANLIST subprogram in main memory, you may use an HP 3421A that is either a) not the first HP 3421A on the loop or b) on the second loop. Refer to appendix F, "Alternative Peripheral Options" for further details.

5.2 FRONT PANEL FUNCTIONS

The functions of the individual front panel command keys are as follows:

Voltage: [ACV] [DCV]

Measures AC Volts and DC Volts, respectively. The measurements are made with Autorange on and Autozero on.

Current: [CUR]

Measures DC current in the 4-20mA range (assuming a 50Ω shunt resistor).

Resistance: [2WO] [4WO]

Measures resistance using the two-wire ohm or four-wire ohm test method, respectively.

Frequency: [FRQ]

Measures frequency using the current gate time (refer to the GATE keyword in section 3). The default gate time is one second.

Close Channel: [CLS]

Used to close a relay channel or set an output bit on a digital card. Press **[CLS]** and enter the number of the channel to close. Any closed multiplexer channels will be opened first, and the requested channel will be closed.

Close Channel Pair: [CLP]

Used to close a channel pair for four-wire ohm measurements. Press **[CLP]** and enter the lowest channel number of the desired pair. For instance, to close the channel pair of 4 and 14, enter 4. Any previously closed multiplexer channels will be opened.

Open Channel: [OPN]

Used to open a relay channel or clear an output bit on a digital card. Press **[OPN]** and enter the number of the channel to open. If a channel pair has been closed, the paired channel will also be opened.

Digits Of Resolution: [DIGITS]

Sets the number of digits of resolution in the HP 3421A. Press **[DIGITS]** and press 3, 4, or 5 to set the resolution.

2K Thermistor Two-Wire Ohms: [2K-2]

Measures temperature assuming the sensor is a 2252Ω thermistor using a two-wire resistance measurement and five digits of resolution. Press **[2K-2]** and enter the desired temperature units.

5K Thermistor Two-Wire Ohms: [5K-2]

Measures temperature assuming the sensor is a 5000Ω thermistor using a two-wire resistance measurement and five digits of resolution. Press **[5K-2]** and enter the desired temperature units.

100 Ohm RTD Two-Wire Ohms: [RTD-2]

Measures temperature assuming the sensor is a 100Ω RTD (European curve: alpha = .00385) using a two-wire resistance measurement and five digits of resolution. Press **[RTD-2]** and enter the desired temperature units.

2K Thermistor Four-Wire Ohms: [2K-4]

Measures temperature assuming the sensor is a 2252Ω thermistor using a four-wire resistance measurement and five digits of resolution. Press **[2K-4]** and enter the desired temperature units.

5K Thermistor Four-Wire Ohms: [5K-4]

Measures temperature assuming the sensor is a 5000Ω thermistor using a four-wire resistance measurement and five digits of resolution. Press **[5K-4]** and enter the desired temperature units.

100 Ohm RTD Four-Wire Ohms: [RTD-4]

Measures temperature assuming the sensor is a 100Ω RTD (European curve: alpha = .00385) using a four-wire resistance measurement and five digits of resolution. Press **[RTD-4]** and enter the desired temperature units.

Read Digital Byte: [DIG]

Reads a byte from the input of a digital card and displays the value in binary representation. Press **[DIG]** and enter the slot to be read.

Write Digital Byte: [WRT]

Writes a value to the output of a digital card. Press **[WRT]** and enter the decimal value to be output.

Continuity: [CONT]

Continuity tester. This function measures two wire ohms and sounds a beep any time the measured resistance falls below ten ohms. This works faster when using three digits of resolution.

Wait: [WAIT]

Sets a pause between readings. The program takes measurements as fast as the instrument will permit unless you specify a wait time greater than zero. Press [WAIT] and enter the desired interval between measurements in seconds.

Thermocouples: [TC-E] - [TC-T]

These functions measure thermocouples of type E, J, K, R, S, and T. The program measures DC Volts using five digits of resolution, takes a reference temperature from the multiplexer assembly reference junction, and returns the temperature in the specified units.

Reference Temperature: [REF]

This function returns the reference temperature from the reference junction on a multiplexer assembly. If no channels are closed, the reading is taken from the lowest numbered slot containing a multiplexer assembly. Otherwise the reading is taken for the lowest numbered closed channel. Press **[REF]** and enter the desired temperature units.

Reset: [RESET]

This function resets the HP 3421A to the power-on state and returns the program to DC Volts.

Fix Display Format: [FIX]

This function sets the number of digits to be displayed after the decimal point. You can select any number of digits in the range 0 through 11. Numbers too large or too small to be viewed in the current fixed format are displayed in scientific format. In FIX2 display format, the result of 1/3 is displayed as 0.33. To set the number of display digits, press [FIX] and enter the desired number of digits.

Standard Display Format: [STD]

This function sets the standard display format, in which numbers are displayed with the smallest number of digits consistent with presenting maximum accuracy. The result of 1/2 is displayed as .5, while 1/3 is displayed as .333333333333. Press [STD] to select STD display format.

End The Program: [QUIT]

Press [QUIT] to end the program. The HP 3421A will remain in its current state.

STRIP CHART PROGRAM

SECTION 6

The strip chart program simulates the operation of an analog strip chart recorder by taking readings from the HP 3421A Data Acquisition/Control Unit and producing a strip chart on the HP 2225B ThinkJet Printer. The program supports up to nine traces, each with its own scale. Each scale has 100 divisions, and is presented across the page. The time axis is presented down the page, so one set of readings is represented on each line of the printout. The program gives you the option to store the readings in a data file. (To avoid excessive power consumption, the file should reside in RAM.) The minimum components in a strip chart system are an HP-71B Handheld Computer, an HP 82401A HP-IL Interface, an HP 3421A Data Acquisition/Control Unit, and an HP 2225B ThinkJet Printer. (If you are using some other printer device, refer to appendix F, "Alternative Peripheral Options".)

6.1 MEASUREMENT CHOICES

Each trace takes a measurement from the HP 3421A using one of 20 available functions:

SIGNALS	TEMPERATURE	DIGITAL
DC Volts	T,E,J,K,R,S Thermocouples	Digital Bit
AC Volts	2252 Ohm Thermistor (2WΩ)	Digital Byte
4-20mA Current	2252 Ohm Thermistor (4WΩ)	
2-Wire Ohms	5000 Ohm Thermistor (2WΩ)	
4-Wire Ohms	5000 Ohm Thermistor (4WΩ)	
Frequency	European RTD (α=.00385) (2WΩ)	
	European RTD (α=.00385) (4WΩ)	

Most functions may call a user-written *conversion program* which may be used do perform additional processing on each measurement, such as a unit conversion.

As an alternative to these functions, a trace may call a user-written *custom program*. This allows the user to include a measurement from a sensor or instrument that is not directly supported by the STRIP program.

6.2 STRIP CHART OPERATION

The STRIP program is driven by a *setup*, which contains a list of the specifications for each trace. If you want to use a setup repeatedly, you should store it in a *setup file* before exiting the program. A strip chart setup consists of the following information:

- The number of traces.
- The sensor and channel number to be used for each trace.
- The scale to be used (minimum and maximum bounds) for each trace.
- The conversion subprogram to be called (optional) for each trace.

To run the program, connect the HP-71 to the HP 3421A, the ThinkJet printer, and any other peripherals that will be used in the system. Start the program as follows:

```
RUN STRIP [ENDLINE]
```

Run the strip chart program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Run Quit?
```

The main menu.

The program has 11 commands which are selected from three menus as follows:

Main Menu

```
Edit File Run Quit?
```

Edit - Select the *edit* menu (press [E]).

File - Select the *file* menu (press [F]).

Run - Run the strip chart (press [R]).

Quit - End the program (press [Q]).

Edit Menu

```
Add Del Rpl Prt Main?
```

Add - Add a trace to the setup (press [A]).

Del - Delete a trace from the setup (press [D]).

Rpl - Replace a trace in the setup (press [R]).

Prt - Print the strip chart setup (press [P]).

Main - Return to the main menu (press [M]).

File Menu

```
Get New Save Ver Main?
```

Get - Get an existing setup file (press [G]).

New - Create a new setup file (press [N]).

Save - Save the current setup file (press [S]).

Ver - Verify the current setup file (press [V]).

Main - Return to the main menu (press [M]).

To select a command, press the key corresponding to the first letter of the command. For instance, to select the Run command, press [R].

The FLAG 0 annunciator in the display reminds you that the current setup has not been saved to a file. The annunciator will go on when a setup is created or edited, and will go off when the setup is saved.

6.3 CREATING A NEW SETUP

The New command is used to create a new list of traces that are to be printed. Each trace requires one or more of the following specifications:

- The function to be measured (see subsection 6.1, "Measurement Choices").
- The number of digits of resolution to be used by the HP 3421A.
- The temperature units (C, F, K, or R).
- The conversion subprogram to be called, if needed.

When New is selected the program prompts for the number of traces in the new setup. If a setup is currently defined, the program confirms that you wish to start a new setup.

`Get New Save Ver Main?`	The file menu.
[N]	Press [N] to select the New command.
`Destroy setup (Y/N)?`	If a setup exists, the program asks if it may be destroyed.
[Y] or [N]	Press [Y] to begin a new setup, or [N] to escape back to the file menu.
`Number of traces?`	The program prompts for the number of traces to be printed.
number of traces [ENDLINE]	Enter the number of traces, up to 9.
`* * Trace 1 * *`	The program displays the number of the trace being entered.
`FN~ DC Volts`	The function menu.
[v], [^], or [ENDLINE]	Press the arrow keys to choose the function to be measured, then press [ENDLINE] to select that function.

What you do next depends on the function that you have selected. Refer to the appropriate subsection: 6.3.1, "Signals"; 6.3.2 "Digital Functions"; or 6.3.3, "Custom Program." When you have entered all of the specifications for one trace, you will be prompted to begin entering information for the next trace. When all traces have been entered, the main menu will reappear.

6.3.1 Signals

`# Digits (3, 4, or 5)?`	The program prompts for the number of digits of resolution. This prompt does not appear if the function is *frequency* or *temperature*. (Frequency measurements are made with 5.5-digit resolution and a 1-second gate time.)
3, 4, or 5	Press 3, 4, or 5 to use 3.5, 4.5, or 5.5 digits in the HP 3421A.
`Degrees: (C F K or R)?`	If the function is *temperature*, the program prompts for the desired temperature unit. Temperature measurements are made with 5.5-digit resolution.
C, F, K, or R	Press C to select Celsius units, F for Fahrenheit units, K for Kelvin units, or R for Rankine units.
`Channel?`	The program prompts for the channel number in the HP 3421A which should be measured.
channel number ENDLINE	Enter the channel number, then press ENDLINE.
`Scale minimum?`	The program prompts for the scaling values for the strip chart.
scale minimum ENDLINE	Enter the value which represents the *lower bound* of the scale for this trace.
`Scale maximum?`	
scale maximum ENDLINE	Enter the value which represents the *upper bound* of the scale for this trace.
`Conversion (Y/N)?`	The program asks if a *conversion subprogram* should be called.
Y or N	Press Y if a conversion subprogram is needed.
`Subprogram?`	If a conversion is requested, the program prompts for the name of the subprogram.
subprogram name ENDLINE	Enter the name of the subprogram and press ENDLINE.

`File name?`	If a conversion is requested, the program prompts for the name of the file containing the subprogram.
file name [ENDLINE]	Enter the name of the file and press [ENDLINE].

6.3.2 Digital Functions

Two digital input functions are available: digital *bit*, and digital *byte*:

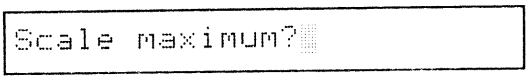
Digital Bit

`Channel?`	The program prompts for the input bit to be read.
input bit address [ENDLINE]	Enter the address of the bit to be read, and press [ENDLINE].
`Scale minimum?`	The program prompts for the scaling values for the strip chart.
scale minimum [ENDLINE]	Enter the value which represents the *lower bound* of the scale for this trace.
`Scale maximum?`	
scale maximum [ENDLINE]	Enter the value which represents the *upper bound* of the scale for this trace.

Note that several digital channels can be traced in the same manner as a timing diagram. To do this adjust the scaling parameters to place the traces side by side. For instance, set the scale for trace 1 from 0 to 11; the second trace from -1 to 10; the third trace from -2 to 9, and so on.

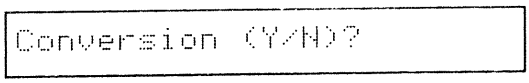
Digital Byte

`Slot (0, 1, or 2)?`	The program asks which slot to read a byte from. The readings from the digital card are returned as a decimal value in the range 0 - 255.
[0], [1], or [2]	Press [0], [1], or [2] to select the slot containing a digital card.
`Scale minimum?`	The program prompts for the scaling values for the strip chart.
scale minimum [ENDLINE]	Enter the value which represents the *lower bound* of the scale for this trace.



scale maximum ENDLINE

Enter the value which represents the *upper bound* of the scale for this trace.



The program asks if a *conversion subprogram* should be called (for example, to decode readings from a BCD device).

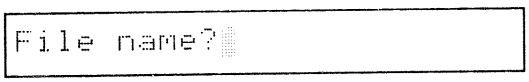
Y or N

Press Y if a conversion subprogram is needed.

If a conversion is requested, the program prompts for the name of the subprogram.

subprogram name ENDLINE

Enter the name of the subprogram and press ENDLINE.



If a conversion is requested, the program prompts for the name of the file containing the subprogram.

file name ENDLINE

Enter the name of the file and press ENDLINE.

6.3.3 Custom Program

A custom program may be called which takes a reading from another instrument, or uses a custom sequence with the HP 3421A. The program must return a value for display purposes. *No conversion subprogram calls are available for custom program calls.* Refer to appendix C, "Custom Programs," for further details about custom programs.

`Scale minimum?`	The program prompts for the scaling values for the strip chart.
scale minimum [ENDLINE]	Enter the value which represents the *lower bound* of the scale for this trace.
`Scale maximum?`	
scale maximum [ENDLINE]	Enter the value which represents the *upper bound* of the scale for this trace.
`Subprogram?`	The program prompts for the subprogram name.
subprogram name [ENDLINE]	Enter the name of the subprogram and press [ENDLINE].
`File name?`	The program prompts for the file containing the subprogram.
file name [ENDLINE]	Enter the file name and press [ENDLINE].

6.4 RUNNING THE STRIP CHART PROGRAM

Once you have established the strip chart setup, execute the Run command to acquire the data and print the chart.*

`Edit File Run Quit?`	The main menu.
R	Press R to begin the strip chart.
`No. of measurements?`	The program prompts for the number of readings to record.
number of measurements ENDLINE	Enter the number of readings, and press ENDLINE. The program can be interrupted by pressing a key, so a large number can be entered for runs of indeterminate length.
`Interval: HH:MM:SS`	The program prompts for the interval between readings.
interval ENDLINE	Enter 0 to take data at the fastest rate (which will depend upon the traces specified), or the interval between start times for each reading. "On demand" readings can be taken by specifying a large interval and pressing RUN when a reading is desired.
`Chart title?`	The program prompts for the title of the chart.
chart title ENDLINE	Enter the title (useful for identifying the experiment), up to 50 characters, and press ENDLINE.
`Store readings (Y/N)?`	The program asks if the readings should be stored in a data file.
Y or N	Press Y to store the readings, or N to continue.
`Data file?`	If you have elected to store the readings, the program prompts for the file in which to store the readings.
file name ENDLINE	Enter the file name, and press ENDLINE.

*By using a substitute CHANLIST subprogram in main memory, you may use an HP 3421A that is either a) not the first HP 3421A on the loop or b) on the second loop. Refer to appendix F, "Alternative Peripheral Options" for further details.

```
Print setup (Y/N)?
```

The program asks if the strip chart setup should be printed first.

[Y] or [N]

Press [Y] to print the setup, or [N] to begin the chart.

```
Press [fQ] to abort...
```

While the strip chart is running, the LCD display contains this message.

[f][Q] or [RUN]

To stop the program before all the readings have been taken, simply press [f][Q]. If the reading interval is greater than zero, the next scan may be taken early by pressing [RUN]. Successive readings may be taken "on demand" by scheduling a long interval and pressing [RUN] when a scan is desired.

```
Edit File Run Quit?
```

After the strip chart is complete, the program returns to the main menu.

```
ER:Edit File Run Quit?
```

If an error occured that could not be handled by the RECOVER subprogram, the program returns to the main menu with the ER: prefix. Refer to appendix G, "Error Recovery" for details about error recovery.

6.5 STORING STRIP CHART SETUPS

Use the Save command to save the current strip chart setup to a data file, either in RAM or on a mass storage device.

To use this command, press [S] from the file menu:

`Get New Save Ver Main?`	The file menu.
[S]	Press [S] to select the Save command.
`SAVE: File name?`	The program prompts for the file in which to store the setup.
file name [ENDLINE]	Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].
`Overwrite file (Y/N)?`	If the file already exists, the program asks if the file should be overwritten.
[Y] or [N]	Press [Y] to overwrite the file with the current strip chart setup, or press [N] to escape back to the file menu.
`Saving...`	The program displays a status message while the setup is being stored in the file.
`Edit File Run Quit?`	The program returns to the main menu.

6.6 RETRIEVING STRIP CHART SETUPS

Use the Get command to retrieve a strip chart setup from storage. *Note that when this command is used, any currently-active setup information will be lost!*

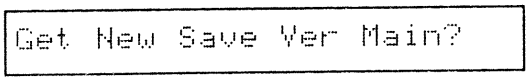
To use this command, press [G] from the file menu:

`Get New Save Ver Main?`	The file menu.
[G]	Press [G] to select the Get command.
`Destroy setup (Y/N)?`	If a setup currently exists, the program reminds you that it will be destroyed.
[Y] or [N]	Press [Y] to proceed, or [N] to escape back to the main menu.
`GET: File name?`	The program prompts for the name of the file to read.
file name [ENDLINE]	Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].
`Reading...`	The program displays a status message while the file is being read.
`Edit File Run Quit?`	The program returns to the main menu.

6.7 VERIFYING THE SETUP

The Verify command is used to verify that the current setup correctly matches the hardware configuration of the HP 3421A Data Acquisition/Control Unit connected to the HP-71. This command should be used when an existing strip chart setup has been retrieved from storage, prior to running the strip chart session.

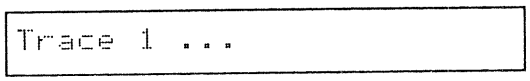
To use the Verify command, press [U] from the file menu:



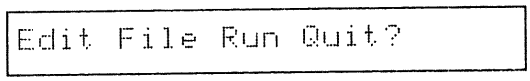
The file menu.

[U]

Press [U] to select the Verify command.



As each trace is examined, the program displays a status message. If an error is encountered, it will be displayed, and the program will proceed to the next trace.



When all of the traces have been examined, the program returns to the main menu.

6.8 ADDING A TRACE

The Add command is used to add a new trace to the current setup. The program can accommodate up to 9 traces in one setup.

To use the Add command, press [A] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[A]	Press [A] to select the Add command.
`* * Trace 5 * *`	The program displays the number of the channel being added. This will always be at the end of the setup file. If there are 4 traces in the current setup, the display will read "Trace 5"
`FN~ DC Volts`	The program begins to prompt for the specifications for the new trace. Follow the same procedure described under the New command.
`Add Del Rpl Prt Main?`	When the new trace has been specified, the program returns to the edit menu.

6.9 DELETING A TRACE

The Delete command is used to delete a trace from the current setup.

When a trace is deleted, remaining traces are renumbered to preserve sequential numbering. If trace #4 of 5 traces is deleted, the original trace #5 will become trace #4.

To use the Delete command, press [D] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[D]	Press [D] to select the Delete command.
`Trace number?`	The program prompts for the number of the trace to be deleted.
trace number [ENDLINE]	Enter the trace number, and press [ENDLINE].
`Delete trace n (Y/N)?`	The program confirms that you wish to delete the trace.
[Y] or [N]	Press [Y] to delete the trace, or [N] to cancel the request.
`Working...`	The program displays a status message while the trace is being deleted.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

6.10 REPLACING A TRACE

The Replace command is used to alter the specifications for a trace in the current setup.

To use the Replace command, press [R] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu
[R]	Press [R] to select the Replace command.
`Replace trace?`	The program prompts for the trace to be replaced.
trace number [ENDLINE]	Enter the trace number, and press [ENDLINE].
`Replace trace n(Y/N)?`	The program asks if you wish to replace the trace.
[Y] or [N]	Press [Y] to replace the trace, or [N] to return to the edit menu.
`* * Trace n * *`	The program begins to prompt for the new setup information. Follow the same procedure for trace entry as described under the New command.
`Add Del Rpl Prt Main?`	When the new specifications for the channel have been entered, the program returns to the edit menu.

6.11 PRINTING THE STRIP CHART SETUP

The Print command prints the specifications for each trace in the current setup. The output appears on the current PRINTER IS device. To use the Print command, press [P] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[P]	Press [P] to select the Print command.
`Printing...`	The program displays a status message while the strip chart setup is being printed.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

6.12 ENDING THE STRIP CHART PROGRAM

The Quit command is used to end the program. If you want to reuse the current strip chart setup, be sure to save it to a file.

To end the program, press [Q] from the main menu:

`Edit File Run Quit?`	The main menu.
[Q]	Press [Q] to end the program.
`Save setup (Y/N)?`	If the current setup has not been saved to a file, the programs asks if you want to save the setup before the program ends.
[Y] or [N]	Press [Y] to save the setup, or [N] to end the program and loose the current setup.
`Done`	The program is finished.

6.13 STRIP CHART EXAMPLE

Let's look at a practical application of the strip chart program. Suppose you want to monitor the temperature of a photographic darkroom, and of a controlled-temperature bath within that darkroom, using two type T thermocouples. Assume that the room-temperature thermocouple is connected to channel 3 of the HP 3421A Data Acquisition/Control Unit, and the bath-temperature thermocouple is connected to channel 4. The HP-71 is connected to the HP 3421A and an HP 2225B ThinkJet Printer, as shown in figure 6-1:

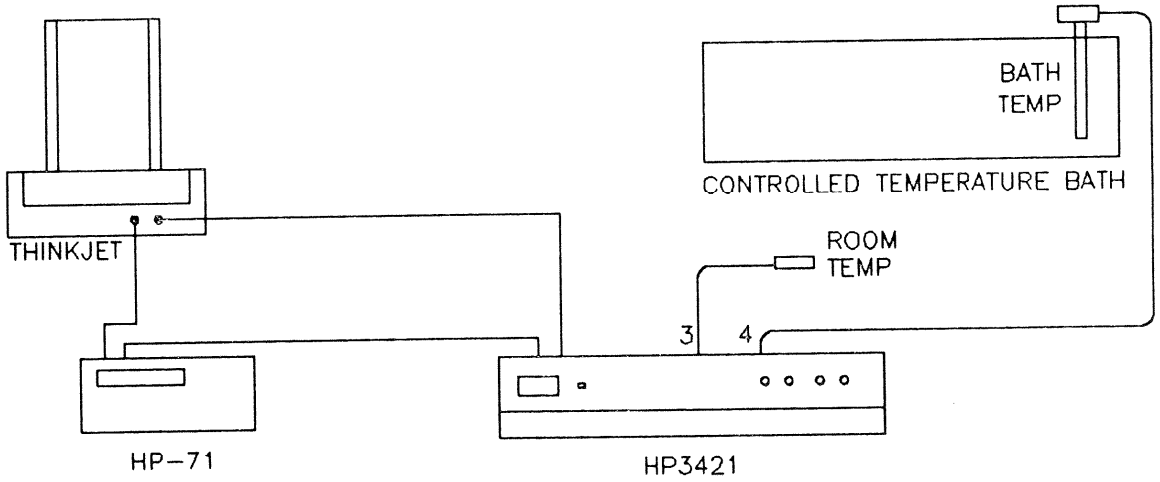


Figure 6-1. Temperature Recording System

Once all of the components are connected, the procedure is as follows:

```
RUN STRIP [ENDLINE]
```

Run the strip chart program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Run Quit?
```

The main menu appears. Press [F] to select the file menu.

```
F
```

```
Get New Save Ver Main?
```

Press [N] to start a new setup.

```
N
```

```
Number of traces?
```

2 [ENDLINE]

The program prompts for the number of traces to be printed. Enter 2.

```
* * Trace 1 * *
```

Now the program prompts you to begin entering specifications for trace 1.

```
FN~ DC  Volts
```

[v], [v], [v], [v], [v], [v]

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
```

[ENDLINE]

```
Degrees: (C F K or R)?
```

[C]

You are prompted for the temperature units for trace 1. Press [C] to select Celsius.

```
Channel?
```

3 [ENDLINE]

You are prompted for the number of the HP 3421A channel to be measured for trace 1. Channel 3 is the room-temperature thermocouple.

```
Scale minimum?
```

20 [ENDLINE]

The program prompts you for the lower bound of the temperature scale. Set the lower bound to 20 °C.

```
Scale maximum?
```

30 [ENDLINE]

Set the upper bound of the temperature scale to 30 °C.

```
Conversion (Y/N)?
```

[N]

No conversion subprogram is needed.

```
* * Trace 2 * *
```

Now the program prompts you to begin entering specifications for trace 2.

```
FN~ DC  Volts
```

[v], [v], [v], [v], [v], [v]

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
```
ENDLINE

```
Degrees: (C F K or R)?
```
C

You are prompted for the temperature units for trace 2. Press C to select Celsius.

```
Channel?
```
4 ENDLINE

You are prompted for the number of the HP 3421A channel to be measured for trace 2. Channel 4 is the bath-temperature thermocouple.

```
Scale minimum?
```
20 ENDLINE

The program prompts you for the lower bound of the temperature scale. Set the lower bound to 20 °C.

```
Scale maximum?
```
30 ENDLINE

Set the upper bound of the temperature scale to 30 °C.

```
Conversion (Y/N)?
```
N

No conversion subprogram is needed.

```
Edit File Run Quit?
```
R

Once the setup file is created, the main menu reappears. Press R to begin the strip chart.

```
No. of measurements?
```
50 ENDLINE

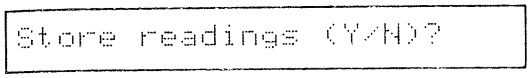
The program prompts for the number of readings to record. Enter 50 to plot 50 sets of readings.

```
Interval: HH:MM:SS
```
ENDLINE

The program prompts for the interval between readings. Enter 0 to take data at the fastest rate (you can do this by just pressing ENDLINE).

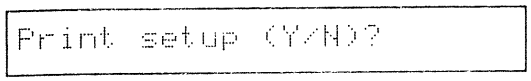
```
Chart title?
```
DARKROOM STRIP CHART
ENDLINE

The program prompts for a title for the chart.



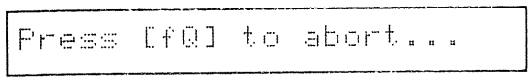
[N]

The program asks if the readings should be stored in a data file. Press [N] if you just want to generate a strip chart.

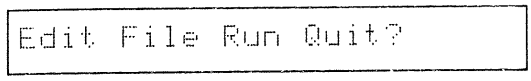


[Y]

The setup information will be printed at the top of the stripchart.

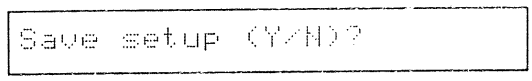


You may stop the program during the strip chart by pressing [f][Q].



[Q]

After the strip chart is complete, the program returns to the main menu. Press [Q] to quit.

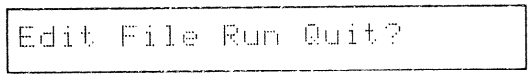


[Y]

So far the strip chart setup has not been saved to a file. To save the example setup, press [Y].

CHARTSET [ENDLINE]

The program saves the setup in the CHARTSET file in RAM.



[Q]

The program again prompts for the desired action. Press [Q] to quit.

The program is finished.

The setup of this example produces a strip chart like the one below. The setup information is printed at the top (if desired), followed by the scale information and the plotted data. Note the effect of an off-scale reading, and the effect of intersecting traces.

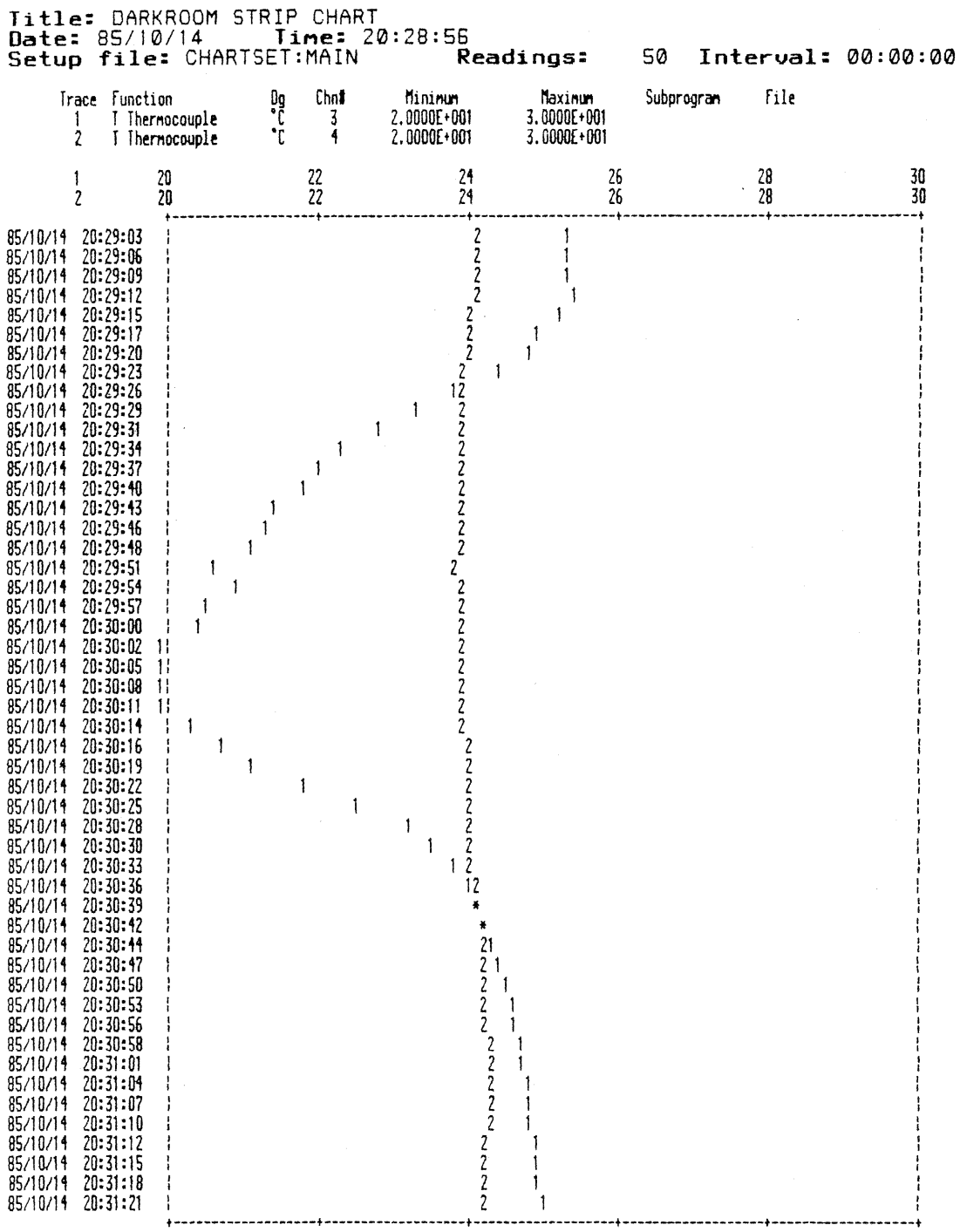


Figure 6-2. Darkroom Temperature Strip Chart

SYSTEM MONITORING

SECTION 7

You can use the system monitoring program, MONITOR, to continuously display the status of a system on a video monitor, and to respond to unusual events or conditions. The program can automatically control a system and/or notify an operator of conditions that require human intervention. The MONITOR program is particularly suited for production environments since an HP-71 based monitoring system requires less space than a full-size computer and instrument system, and is less costly.

The minimum components in a monitoring system are an HP-71B Handheld Computer, an HP 82401A HP-IL Interface, an HP 3421A Data Acquisition/Control Unit, an HP 92198A Mountain Computer HP-IL 80-Column Video Interface, and a suitable monitor. (If you are using some other display device, refer to appendix F, "Alternative Peripheral Options.") If the system includes a printer (for example, a ThinkJet), a printed record of unusual events can be recorded. Since the program is designed to run continuously, all the devices in the system should be connected to ac power.

The program presents up to 18 *traces* on the video monitor. Each trace represents a single measurement, such as the temperature of a vat or the setting of a switch. The MONITOR program allows you to choose one of three formats for the video display.

The default display format presents the label for each trace on the screen, followed by the current value and a pictorial representation of the reading on a *scale*. The scale is used to represent the reading within specified "nominal bounds." For example, if the temperature of a vat is supposed to stay within the range 190 to 200°C, the left edge of the scale could represent 190°C and the right edge could represent 200°C. This allows an operator to see at a glance if the temperature of the vat is drifting low or high. The default display format is shown in figure 7-1:

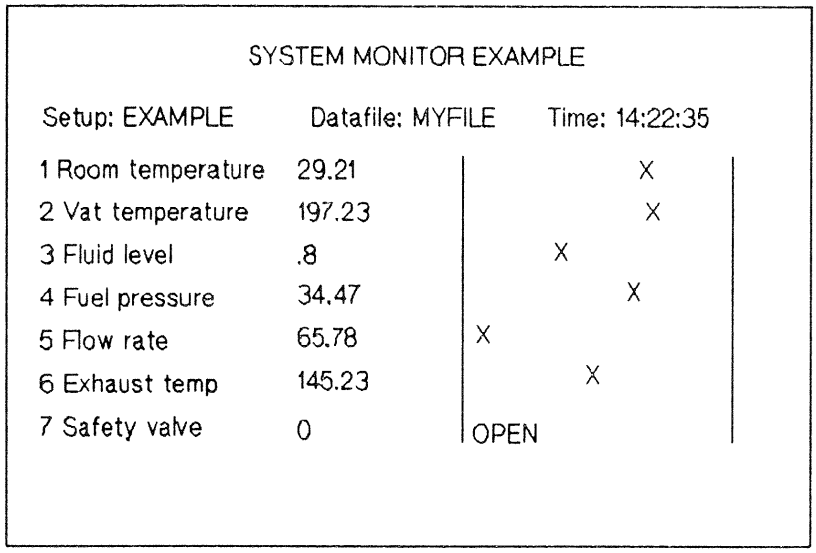


Figure 7-1. Video Display With Seven Traces

The second display option is the *bar graph* format. This format is the same as the default format except that the reading is shown on the scale in bar graph form using inverse video.

The third display option is the *column* format. This format displays the label for each trace followed by three columns of numbers. The columns list, in order, the lower nominal bound, the current reading, and the upper nominal bound.

The MONITOR program provides two capabilities in addition to the display of data on a video monitor. The program can *log* data during a monitoring session, and it can perform *limit tests* for control and alarm purposes.

The data logging option allows you to store a "snapshot" of the system in a data file at regular intervals. For example, the status of a wave-soldering system could be stored every 15 minutes during a shift. Once the MONITOR program is done, you can use the REPORT program to generate a report on the stored data (refer to section 11), the TRANSFER program to send the data to a Series 200 computer (refer to section 12), or the MSDOSXFR program to send the data to an MS-DOS based computer (refer to section 13).

The limit test option allows you to use the MONITOR program for control purposes. You can specify up to five limit tests for each trace. The program continuously checks the current value of a trace against any limit that you have specified for it, and takes the specified *limit action* if the value goes past the limit. The limit action may merely signal an operator, or it may actively control the system. Refer to subsection 7.2, "Limit Tests" for more information.

7.1 MEASUREMENT CHOICES

Each trace represents one measurement from a channel or bit in the HP 3421A. There are 20 functions available:

SIGNALS	TEMPERATURE	DIGITAL
DC Volts	T,E,J,K,R,S Thermocouples	Digital Bit
AC Volts	2252 Ohm Thermistor (2WΩ)	Digital Byte
4-20mA Current	2252 Ohm Thermistor (4WΩ)	
2-Wire Ohms	5000 Ohm Thermistor (2WΩ)	
4-Wire Ohms	5000 Ohm Thermistor (4WΩ)	
Frequency	European RTD (α=.00385) (2WΩ)	
	European RTD (α=.00385) (4WΩ)	

Most functions may call a user-written *conversion program* which is used to perform additional processing on each measurement, such as a unit conversion.

As an alternative to these functions, a trace may call a user-written *custom program*. This allows the user to include a measurement from a sensor or instrument that is not directly supported by the MONITOR program, or to create custom limit action capabilities (refer to appendix E for an example).

7.2 LIMIT TESTS

You can specify up to five *limit tests* for each trace. For each limit test a *limit point* and a *limit action* are specified. The current value of the trace must go past the limit test for the limit action to occur. That is, the limit point is *not inclusive*. For a lower limit, the limit action occurs when the current value for the trace goes *below* the value of the limit point. For an upper limit, the limit action occurs when the current value for the trace goes *above* the limit point. The available limit actions are:

- **BEEP** - Sound a beep on the HP-71
- HIGHLIGHT - Display the trace label in inverse video.
- **PRINT** - Print a message on the system printer.
- **OPEN ACT/BIT** - Open an actuator channel or clear a bit on a digital output card.
- **CLOSE ACT/BIT** - Close an actuator channel or set a bit on a digital output card.
- **LIMIT PROGRAM** - Call a user-written subprogram.

You can use a limit test to either warn an operator of a condition, or to directly control a system. For example, in a temperature monitoring application, two limit tests could be used: the first opens an actuator channel if the temperature goes above 200 °C, while the second closes the actuator if the temperature goes below 200 °C. The actuator channel could be connected to a warning light to signal an operator, or it could directly control a heater circuit through a relay.

7.3 MONITOR PROGRAM OPERATION

The MONITOR program is driven by a *setup* which consists of a list of the traces and the corresponding specifications for each trace. The setup file specifies how many traces to read, the function for each trace, the scale for the display, and what limit tests (if any) should be used. You may store the setup in a file for repeated use.

To run the program, connect the HP-71 to the HP 3421A, video interface, and any other peripherals that will be used in the system.

`RUN MONITOR` [ENDLINE] — Run the `MONITOR` program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Run Quit?
```

The main menu.

The program has 11 commands which are selected from three menus as follows:

Main Menu

```
Edit File Run Quit?
```

`Edit` - Select the *edit* menu (press [E]).

`File` - Select the *file* menu (press [F]).

`Run` - Run the monitor (press [R]).

`Quit` - End the program (press [Q]).

Edit Menu

```
Add Del Rpl Prt Main?
```

`Add` - Add a trace to the setup (press [A]).

`Del` - Delete a trace from the setup (press [D]).

`Rpl` - Replace a trace or its limits (press [R]).

`Prt` - Print the setup file (press [P]).

`Main` - Return to the main menu (press [M]).

File Menu

```
Get New Save Ver Main?
```

`Get` - Get an existing setup file (press [G]).

`New` - Create a new setup file (press [N]).

`Save` - Save the current setup file (press [S]).

`Ver` - Verify the current setup file (press [V]).

`Main` - Return to the main menu (press [M]).

To select a command, press the key corresponding to the first letter of the command. For instance, to select the `Run` command, press [R].

The FLAG 0 annunciator in the display reminds you that the current setup has not been saved to a file. The annunciator will go on when a setup is created or edited, and will go off when the setup is saved.

7.4 CREATING A NEW SETUP

The New command is used to create a new list of traces that are to be scanned. Each trace requires one or more of the following specifications:

- The function to be measured (see subsection 7.1, "Measurement Choices").
- The number of digits of resolution to be used by the HP 3421A.
- The temperature units (C, F, K, or R).
- The conversion subprogram to be called, if needed.
- Up to five limit tests.

When New is selected the program prompts for the number of traces in the new setup. If a setup is currently defined, the program asks if the setup may be destroyed.

`Get New Save Ver Main?`	The file menu.
N	Press N to select the New command.
`Destroy setup (Y/N)?`	If a setup is currently defined, the program asks if the setup may be destroyed.
Y or N	Press Y to proceed with the new setup, or N to escape back to the file menu.
`Screen title?`	The program prompts for the title to be centered at the top of the monitor screen.
screen title ENDLINE	Enter the title, up to 80 characters, and press ENDLINE.
`Number of traces?`	The program prompts for the number of traces to be scanned.
number of traces ENDLINE	Enter the number of traces, up to 18.
`* * Trace 1 * *`	The program displays the number of the trace being entered.
`Label?`	The program prompts for the trace label. This is the label that will appear on the video display, so be sure that it will be understandable.
trace label ENDLINE	Enter the trace label, up to 20 characters.

FN= DC Volts	The function menu.
▽, △, or [ENDLINE]	Press the arrow keys to choose the function to be measured, then press [ENDLINE] to select that function.

What you do next depends on the function that you have selected. Refer to the appropriate subsection: 7.4.1, "Signals"; 7.4.2, "Digital Functions"; or 7.4.3, "Custom Program"; then follow the instructions in subsection 7.5, "Limits." When you have entered all of the specifications for one trace, you will be prompted to begin entering information for the next trace. When all traces have been entered, the main menu will reappear.

7.4.1 Signals

`# Digits (3, 4, or 5)?`	The program prompts for the number of digits of resolution. This prompt does not appear if the function is *frequency* or *temperature*. (Frequency measurements are made with 5.5-digit resolution and a 1-second gate time.)
3, 4, or 5	Press 3, 4, or 5 to use 3.5, 4.5, or 5.5 digits in the HP 3421A.
`Degrees: (C F K or R)?`	If the function is *temperature*, the program prompts for the desired temperature unit. Temperature measurements are made with 5.5 digit resolution.
C, F, K, or R	Press C to select Celsius units, F to select Fahrenheit units, K to select Kelvin units, or R to select Rankine units.
`Channel?`	The program prompts for the channel number in the HP 3421A which should be measured.
channel number ENDLINE	Enter the channel number, then press ENDLINE.
`Scale minimum?`	The program prompts for the scaling values for the pictorial representation in the video display.
scale minimum ENDLINE	Enter the value which represents the *lower bound* of the nominal operating range for this trace.
`Scale maximum?`	
scale maximum ENDLINE	Enter the value which represents the *upper bound* of the nominal operating range for this trace.
`Conversion (Y/N)?`	The program asks if a *conversion subprogram* should be called.
Y or N	Press Y if a conversion subprogram is needed.
`Subprogram?`	If a conversion is requested, the program prompts for the name of the subprogram.
subprogram name ENDLINE	Enter the name of the subprogram and press ENDLINE.

`File name?`	If a conversion is requested, the program prompts for the name of the file containing the subprogram.
file name ENDLINE	Enter the name of the file and press ENDLINE.

When these specifications for the function have been entered, proceed to subsection 7.5, "Limits."

7.4.2 Digital Functions

Two digital input functions are available: digital *bit*, and digital *byte*:

Digital Bit

`Channel?`	The program prompts for the input bit to be read.
input bit address [ENDLINE]	Enter the address of the bit to be read, and press [ENDLINE].

The monitor scale for digital bit is fixed: the scale will read "OPEN" on the left side of the scale or "CLOSED" on the right side of the scale, depending on the state of the bit.

Digital Byte

`Slot (0, 1, or 2)?`	The program asks which slot to read a byte from. The readings from the digital card are returned as a decimal value in the range 0 - 255.
[0], [1], or [2]	Press [0], [1], or [2] to select the slot containing a digital card.
`Scale minimum?`	The program prompts for the scaling values for the pictorial representation in the video display.
scale minimum [ENDLINE]	Enter the value which represents the *lower bound* of the nominal operating range for this trace.
`Scale maximum?`	
scale maximum [ENDLINE]	Enter the value which represents the *upper bound* of the nominal operating range for this trace.
`Conversion (Y/N)?`	The program asks if a *conversion subprogram* should be called (for example, to decode readings from a BCD device).
[Y] or [N]	Press [Y] if a conversion subprogram is needed.
`Subprogram?`	If a conversion is requested, the program prompts for the name of the subprogram.
subprogram name [ENDLINE]	Enter the name of the subprogram and press [ENDLINE].

File name?	If a conversion is requested, the program prompts for the name of the file containing the subprogram.
file name [ENDLINE]	Enter the name of the file and press [ENDLINE].

When the specifications for the digital functions have been entered, proceed to subsection 7.5, "Limits."

7.4.3 Custom Program

A custom program may be called which takes a reading from another instrument, or uses a custom sequence with the HP 3421A. The program must return a value for display purposes. *Note that no conversion subprogram calls are available for custom program calls.* Refer to appendix C, "Custom Programs", for further details about custom programs.

Subprogram?	The program prompts for the subprogram name.
subprogram name [ENDLINE]	Enter the name of the subprogram and press [ENDLINE].
File name?	The program prompts for the file containing the subprogram.
file name [ENDLINE]	Enter the file name and press [ENDLINE].
Scale minimum?	The program prompts for the scaling values for the pictorial representation in the video display.
scale minimum [ENDLINE]	Enter the value which represents the *lower bound* of the nominal operating range for this trace.
Scale maximum?	
scale maximum [ENDLINE]	Enter the value which represents the *upper bound* of the nominal operating range for this trace.

When the name of the custom program and the scaling information have been entered, proceed to subsection 7.5, "Limits."

7.5 LIMITS

Each trace can have up to five limit tests. Thus, you are given the limit test option up to five times for each trace. Once you decline a limit test option for a trace, or you have specified all five limit tests for a trace, the program begins the trace-entry procedure for the next trace. Once all traces have been specified, the main menu reappears.

`Limit test 1 (Y/N)?`	The program asks if a limit test is required.
Y or N	Press Y to request a limit test, or N to begin entering the next trace.

The prompt for the *limit type* depends upon the function being measured by the current trace. For all functions except "Digital Bit," look under the heading "Analog."

After the limit type has been specified, proceed to subsection 7. 5. 3, "Limit Actions."

7.5.1 Analog

`Limit type: Low High?`	The program asks if the limit should be triggered when the measurement falls below the limit point (`Low`) or if the measurement rises above the limit point (`High`).
L or H	Press L to select a *low* limit, or press H to select a *high* limit.
`Limit point?`	The program prompts for the value to be compared with each reading.
limit point ENDLINE	Enter the limit point, and press ENDLINE.

7.5.2 Digital Bit

`Limit type: Set Clear?`	The program asks if the limit should be triggered when the bit is set (`Set`) or if the bit is clear (`Clear`).
S or C	Press S to select a *set* limit, or press C to select a *clear* limit.

7.5.3 Limit Actions

The available limit actions are:

- **BEEP** - Sound a beep on the HP-71.
- **HIGHLIGHT** - Display the trace label in inverse video.
- **PRINT** - Print a message on the system printer.
- **OPEN ACT/BIT** - Open an actuator channel or clear a bit on a digital output card.
- **CLOSE ACT/BIT** - Close an actuator channel or set a bit on a digital output card.
- **LIMIT PROGRAM** - Call a limit subprogram. Refer to appendix E.

`Action~ BEEP`	The program presents the limit action menu.
[v], [^], or [ENDLINE]	Press the arrow keys to choose the desired limit action, then press [ENDLINE] to select that action.

Depending upon the limit action selected, the program may present one of the following prompts:

`Message?`	If the limit action selected is PRINT, the program prompts for the message to appear on the system printer.
message [ENDLINE]	Enter the message, up to 32 characters, and press [ENDLINE].
`Channel?`	If the limit action selected is OPEN ACT/BIT or CLOSE ACT, the program prompts for the number of the channel to open or close.
actuator or bit [ENDLINE]	Enter the channel number, and press [ENDLINE]. The channel must be either an actuator channel or an output bit on a digital card.
`Limit subprogram?`	If the limit action selected is LIMIT PROGRAM, the program prompts for the name of the subprogram to call.
subprogram name [ENDLINE]	Enter the subprogram name, and press [ENDLINE].

```
File name?
```

After the subprogram name has been entered, the program asks for the file containing the subprogram.

file name [ENDLINE]

Enter the file name, and press [ENDLINE].

7.6 RUNNING THE MONITOR

Once the trace setup has been established, use the Run command to run the system monitor.*

Four options are available when the monitor is running. They are:

- Store a "snapshot" of the system in a data file at regular intervals. The file name and number of readings to be stored are specified at the beginning of the run.
- Display the readings as they are taken on a scale (default).
- Display the readings as they are taken on a bar graph.
- Display the readings in columnar form with the numerical scale limits.

Press [R] from the main menu to select the Run command:

`Edit File Run Quit?`	The main menu.
[R]	Press [R] to begin the monitor session.
`Store readings (Y/N)?`	The program asks if you wish to store data periodically.
[Y] or [N]	Press [Y] to select the data storage option. Press [N] to run the monitor without data storage, and skip the next three steps.
`Data file?`	The program prompts for the name of the data file.
file name [ENDLINE]	Enter the name of the data file, including the device specifier, and press [ENDLINE].
`Number of scans?`	The program prompts for the number of scans to store in the data file.
number of scans [ENDLINE]	Enter the number of scans, and press [ENDLINE].
`Interval: HH:MM:SS`	The program prompts for the interval between scans which should be stored. This interval must be at least 15 seconds.
reading interval [ENDLINE]	Enter the reading interval in HH:MM:SS form, and press [ENDLINE].

*By using a substitute CHANLIST subprogram in main memory, you may use an HP 3421A that is either a) not the first HP 3421A on the loop or b) on the second loop. Refer to appendix F, "Alternative Peripheral Options" for further details.

```
Display:BCR Abort:[fQ]
```

B, C, R, or fQ

This message appears in the HP-71 display during the monitoring session if readings are being stored to a data file. While the monitor is running, the video display is constantly updated with new readings, and any limit actions are taken if limit tests are met. You are given several display options:

Press B to toggle between the default and *bar graph* display formats. Press C to toggle between the default and *column* display formats. Press R to refresh the entire video display. To abort the session before all specified scans have been taken, press fQ.

```
Display:BCR  Quit:[fQ]
```

B, C, R, or fQ

After all the specified scans have been stored, or if no readings are to be stored, the program displays this message, permitting the program to end when fQ is pressed. Press B, C, or R to select the display options.

```
Edit File Run Quit?
```

After the monitor session has ended, the program returns to the main menu.

Data files created by the MONITOR program use the HPAF file format (refer to appendix H). You can use the REPORT program to generate reports using the data in such files.

NOTE

The data storage interval for the monitor program is a *nominal* interval. A timer is used to set a flag when the data should be stored, but data is stored only between traces. Some combinations of measurement and limit tests take longer than others, which will result in minor deviations from the exact interval. The *average* interval will be the interval you specify.

7.7 ERROR RECOVERY

While MONITOR is running, an error trap is in place which facilitates recovery from loop errors. An unusual event such as a power interruption can lead to an error condition that may or may not result in an actual error such as LOOP BROKEN. When such an error occurs, the RECOVER subprogram is called in an attempt to fix the problem (refer to appendix G for details). If the subprogram is able to handle the problem, the system continues to run. Otherwise, the program returns to the main menu:

```
ER:Edit File Run Quit?
```

The program returns to the main menu with the ER: prefix.

In some instances MONITOR will survive a power interruption, but the video interface will be blank and no error will have been generated. In this case, press [R] to refresh the video display and restore normal operation.

7.8 STORING TRACE SETUPS

Use the Save command to save the current trace setup to a data file, either in RAM or on a mass storage device.

To use this command, press [S] from the file menu:

`Get New Save Ver Main?`	The file menu.
[S]	Press [S] to select the Save command.
`File name?`	The program prompts for the file in which to store the trace setup.
file name [ENDLINE]	Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].
`Overwrite file (Y/N)?`	If the file already exists, the program asks if the file should be overwritten.
[Y] or [N]	Press [Y] to overwrite the file with the current trace setup, or press [N] to escape back to the file menu.
`Saving...`	The program displays a status message while the trace setup is being stored in the file.
`Edit File Run Quit?`	The program returns to the main menu.

7.9 RETRIEVING TRACE SETUPS

Use the Get command to retrieve a setup file from storage. *Note that when this command is invoked, any currently-active setup information will be lost!*

To use this command, press [G] from the file menu:

```
Get New Save Ver Main?
```

[G]

The file menu. Press [G] to select the Get command.

```
Destroy setup (Y/N)?
```

If a trace setup currently exists, the program reminds you that it will be destroyed.

[Y] or [N]

Press [Y] to proceed, or [N] to escape back to the main menu.

```
File name?
```

The program prompts for the name of the file to read.

file name [ENDLINE]

Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].

```
Reading...
```

The program displays a status message while the file is being read.

```
Edit File Run Quit?
```

The program returns to the main menu.

7.10 VERIFYING THE TRACE SETUP

Use the Verify command to verify that the trace setup correctly matches the hardware configuration of the HP 3421A Data Acquisition/Control Unit connected to the HP-71. This command should be used when an existing trace setup has been retrieved from storage, prior to running the monitor session.

If errors are encountered in the trace setup, the commands in the edit menu may be used to adjust the trace specifications.

To use the Verify command, press [V] from the file menu:

```
Get New Save Ver Main?
```

The file menu.

[V]

Press [V] to select the Verify command.

```
Trace 1 ...
```

As each trace is examined, the program displays a status message. If an error is encountered, it will be displayed, and the program will proceed to the next trace.

```
Edit File Run Quit?
```

When all of the traces have been examined, the program returns to the main menu.

7.11 ADDING A TRACE

The Add command is used to add a new trace to the current setup. The program can accommodate up to 18 traces in one setup.

To use the Add command, press [A] from the edit menu:

Add Del Rpl Prt Main?	The edit menu.
[A]	Press [A] to select the Add command.
* * Trace 9 * *	The program displays the number of the trace being added. This will always be at the end of the setup file. If there are 8 traces in the current setup, the display will read "Trace 9".
Label?	The program begins to prompt for the specifications for the new trace. Follow the same procedure for trace entry as described under the New command.
Add Del Rpl Prt Main?	When the new trace has been specified, the program returns to the edit menu.

7.12 DELETING A TRACE

The Delete command is used to delete a trace from the current setup.

When a trace is deleted, remaining traces are renumbered to preserve sequential numbering. If trace #4 of 5 traces is deleted, the original trace #5 will become trace #4.

To use the Delete command, press [D] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[D]	Press [D] to select the Delete command.
`Trace number?`	The program prompts for the number of the trace to be deleted.
trace number [ENDLINE]	Enter the trace number, and press [ENDLINE].
`Delete trace n (Y/N)?`	The program confirms that you wish to delete the trace.
[Y] or [N]	Press [Y] to delete the trace, or [N] to cancel the request.
`Working...`	The program displays a status message while the trace is being deleted.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

7.13 REPLACING A TRACE

The Replace command is used to replace all or part of the specifications for a trace in the current setup. To use the Replace command, press [R] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[R]	Press [R] to select the Replace command.
`Chn Scl Lim Title Ext?`	The *replace* menu.
[C], [S], [L], [T], or [E]	Press [C] to replace all the specifications for a trace. Press [S] to replace the scale for the screen display, or [L] to replace the limit specifications for a trace. Press [T] to replace the screen title, or [E] to return to the edit menu.
`Screen title?`	If the screen title is to be replaced, the program prompts for the new title.
screen title [ENDLINE]	Enter the new title, up to 80 characters, and press [ENDLINE]. After the new title has been entered, the program returns to the replace menu.
`Trace?`	If an entire trace is to be replaced, or just the scale or limits, the program prompts for the trace to be modified.
trace number [ENDLINE]	Enter the trace number, and press [ENDLINE].
`* * Trace n * *`	If the entire trace is to be replaced, the program begins to prompt for the new setup information. Follow the same procedure for trace entry as described under the New command. After the new trace specifications have been entered, the program returns to the replace menu.
`Scale minimum?`	If the scale for the trace is to be replaced, the program prompts for the scale minimum and maximum values, and returns to the replace menu.
`Limit test 1 (Y/N)?`	If the limits are to be replaced, the program begins to prompt for the limit test information. Follow the instructions in subsection 7.5, "Limits." After the new limits have been entered, the program returns to the replace menu.

7.14 PRINTING THE SETUP FILE

The Print command is used to print the specifications for each trace in the current setup.

To use the Print command, press the [P] key from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[P]	Press the [P] key to select the Print command.
`Printing...`	The program displays a status message while the setup file is being printed.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

A sample printout of one trace looks like this:

```
TRACE 1: Fuel Pressure
    Function: 2-Wire Ohms in channel 4
    Conversion: CONVERT in CFILE
    Digits of resolution: 8.5
    Scale minimum: 0
    Scale maximum: 25
    Limit 1: LOW 3 PRINT: Low fuel pressure!
    Limit 2: HIGH 300 OPEN ACT/BIT 4
    Limit 3: HIGH 300 PRINT: Heater off
```

7.15 ENDING THE MONITOR PROGRAM

The Quit command is used to end the program. If you want to reuse the current trace setup, be sure to save it to a file.

To end the program, press [Q] from the main menu:

`Edit File Run Quit?`	The main menu.
[Q]	Press [Q] to end the program.
`Save setup (Y/N)?`	If the current setup has not been saved, the program asks if you wish to save it.
[Y] or [N]	Press [Y] to save the setup, or [N] to end the program and loose the current setup.
`Done`	The program is finished.

7.16 MONITOR EXAMPLE

Now let's look at an application of the monitor program. In the darkroom problem of section 6 the strip chart program was used to monitor the temperature of a darkroom, and of a controlled-temperature bath within the darkroom. Let's expand upon this example.

The MONITOR program allows you not only to *monitor* a system, but to *control* the system using limit tests. Consider a production darkroom with a controlled-temperature bath that must be maintained within one degree of 25 °C. As in the example of section 6, two type T thermocouples are used to monitor the temperatures. The room-temperature thermocouple is connected to channel 3 of the HP 3421A Data Acquisition/Control Unit, and the bath-temperature thermocouple is connected to channel 4. In addition, the bath heater is controlled by a relay, which in turn is controlled by actuator channel 0 of the HP 3421A. The HP-71 is connected to the HP 3421A, and to an 80-column video interface and video monitor, as shown in figure 7-2:

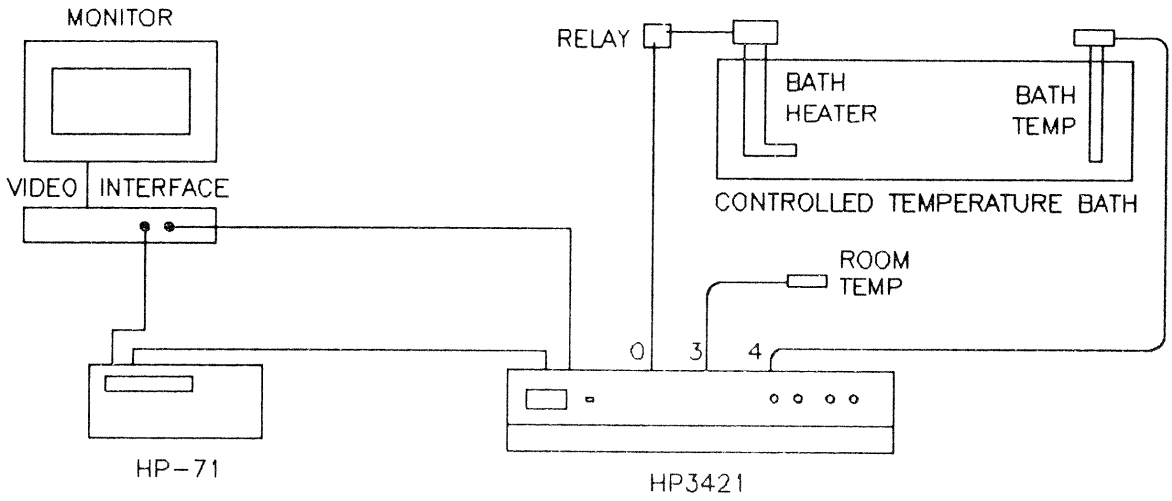


Figure 7-2. Temperature Monitoring System With Actuator Control

In our example the MONITOR program continuously displays the room temperature and bath temperature on the video monitor. In addition, two sets of limit tests are specified: the lower and upper *control* limits, and the lower and upper *alarm* limits. The lower and upper control limits are set at 24.5 and 25.5 °C. When the temperature falls below 24.5 °C, the actuator channel is closed, turning on the heater by means of a relay. When the temperature rises above 25.5 °C, the actuator channel is opened, turning the heater off. The lower and upper alarm limits are set at 24 and 26 °C. If the control system fails, one of the alarm limits will be reached and the HP-71 will beep.

In our example, the MONITOR program performs one other function. Temperature readings are stored in a file in RAM every 15 minutes.

Once all of the components are connected, the procedure is as follows:

```
RUN MONITOR [ENDLINE]
```

Run the MONITOR program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Run Quit?
F
```

The main menu appears. Press [F] to select the file menu.

```
Get New Save Ver Main?
N
```

Press [N] to start a new setup.

```
Screen title?
DARKROOM TEMPERATURE
MONITOR [ENDLINE]
```

The program prompts a title for the monitor screen.

```
Number of traces?
2 [ENDLINE]
```

The program prompts for the number of traces to be displayed. Enter 2.

```
* * Trace 1 * *
```

Now the program prompts you to begin entering specifications for trace 1.

```
Label?
Room temp. [ENDLINE]
```

The program prompts you for a label for trace number 1.

```
FN~ DC Volts
[v], [v], [v], [v], [v], [v]
```

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
[ENDLINE]
```

```
Degrees: (C F K or R)?
C
```

You are prompted for the temperature units for trace 1. Press [C] to select Celsius.

```
Channel?
```

3 [ENDLINE]

You are prompted for the number of the HP 3421A channel to be measured for trace 1. Channel 3 is the room-temperature thermocouple.

```
Scale minimum?
```

20 [ENDLINE]

The program prompts you for the lower bound of the temperature scale. Set the lower bound to 20°C.

```
Scale maximum?
```

30 [ENDLINE]

Set the upper bound of the temperature scale to 30°C.

```
Conversion (Y/N)?
```

[N]

No conversion subprogram is needed.

```
Limit test 1 (Y/N)?
```

[N]

The program gives you the option of setting limit tests. Press [N] to set no limit tests for trace 1.

```
* * Trace 2 * *
```

Now the program prompts you to begin entering specifications for trace 2.

```
Label?
```

Bath temp. [ENDLINE]

The program prompts you for a label for trace number 2.

```
FN~ DC Volts
```

[v], [v], [v], [v], [v], [v]

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
```

[ENDLINE]

```
Degrees: (C F K or R)?
```

[C]

You are prompted for the temperature units for trace 2. Press [C] to select Celsius.

```
Channel?
```

4 [ENDLINE]

You are prompted for the number of the HP 3421A channel to be measured for trace 2. Channel 4 is the bath-temperature thermocouple.

```
Scale minimum?
```

20 [ENDLINE]

The program prompts you for the lower bound of the temperature scale. Set the lower bound to 20 °C.

```
Scale maximum?
```

30 [ENDLINE]

Set the upper bound of the temperature scale to 30 °C.

```
Conversion (Y/N)?
```

[N]

No conversion subprogram is needed.

```
Limit test 1 (Y/N)?
```

[Y]

Although no limit tests were set for trace 1, you are given the option of setting limit tests for trace 2. Two sets of upper and lower limits are to be set for trace 2; first the alarm (beep) limits, then the control (actuator) limits. Press [Y] to request the first limit test.

```
Limit type: Low High?
```

[L]

To set a lower limit, press [L].

```
Limit point?
```

24 [ENDLINE]

Set the lower alarm limit to 24 °C. The program will compare each reading with this limit.

```
Action~ BEEP
```

[ENDLINE]

The limit action menu appears. Just press [ENDLINE] to select BEEP as the action.

```
Limit test 2 (Y/N)?
```

[Y]

Now you can set a second limit test. Press [Y].

```
Limit type: Low High?
```

[H]

To set an upper limit, press [H].

```
Limit point?
```

26 [ENDLINE]

Set the upper limit to 26 °C.

```
Action^  BEEP
```

ENDLINE

The limit action menu appears. Just press ENDLINE to select BEEP as the action. The HP-71 will beep if the temperature either rises above 26 °C or falls below 24 °C. Note that if the beep is not a satisfactory alarm, you could use an actuator channel to trigger an external alarm bell or other signal.

```
Limit test 3 (Y/N)?
```

Y

Now you can set the control (actuator) limits.

```
Limit type: Low High?
```

L

To set a lower limit, press L.

```
Limit point?
```

24.5 ENDLINE

Set the lower limit to 24.5 °C. The program will compare each reading with this limit.

```
Action^  BEEP
```

v, v, v, v

The limit action menu appears. Use the v key to select CLOSE ACT/BIT as the action.

```
Action^  CLOSE ACT/BIT
```

ENDLINE

```
Channel?
```

0 ENDLINE

Select channel 0 as the actuator channel. Whenever the temperature of the bath drops below 24.5 °C, the HP-71 will close actuator channel 0 on the HP 3421A, which actuates the heater relay.

```
Limit test 4 (Y/N)?
```

Y

Now you can set the upper control limit.

```
Limit type: Low High?
```

H

To set an upper limit, press H.

```
Limit point?
```

25.5 ENDLINE

Set the upper limit to 25.5 °C.

```
Action~  BEEP
```

[v], [v], [v]

```
Action~  OPEN ACT/BIT
```

[ENDLINE]

The limit action menu appears. Use the [v] key to select OPEN ACT/BIT as the action.

```
Channel?
```

0 [ENDLINE]

Select channel 0 as the actuator channel. Whenever the temperature of the bath rises above 25.5 °C, the HP-71 will open actuator channel 0 on the HP 3421A, which turns off the heater relay. Thus, the bath temperature is maintained between the control limits of 24.5 and 25.5 °C. If the control system fails, the HP-71 will beep when the temperature goes outside the range 24 to 26 °C.

```
Limit test 5 (Y/N)?
```

[N]

The program gives you the option of another limit test. Press [N].

```
Edit File Run Quit?
```

[R]

Once the setup is completed, the main menu reappears. Press [R] to begin the monitor session.

```
Store readings (Y/N)?
```

[Y]

The program asks if you wish to store data periodically. Press [Y] to select the data storage option.

```
Data file?
```

TESTDATA [ENDLINE]

The program prompts for the name of the data file in which to store the readings.

```
Number of scans?
```

32 [ENDLINE]

The program prompts for the number of scans to store in the data file. Enter 32 to store 32 scans.

```
Interval: HH:MM:SS
```

00:15:00 [ENDLINE]

You are prompted to enter the interval between scans. Enter 00:15:00 to store readings every 15 minutes.

```
Display:BCR Abort:[f0]
```

This display appears until the 32 scans have been stored.

```
Display:BCR  Quit:[fQ]
```

f Q

After all 32 scans have been stored (at the end of an eight-hour shift) this message appears. Press f Q to quit.

```
Edit File Run Quit?
```

Q

The program returns to the main menu. Press Q to end the program.

```
Save setup (Y/N)?
```

Y

So far the monitor setup has not been saved to a file. To save the example setup, press Y.

```
File name?
```

MONITSET ENDLINE

Enter a name for a file to store the setup.

```
Saving...
```

The program saves the setup in the MONITSET file in RAM.

```
Edit File Run Quit?
```

Q

The program again prompts for the desired action. Press Q to quit.

```
Done
```

The program is finished.

The following is a typical monitor screen that might be displayed as the MONITOR program runs for our example:

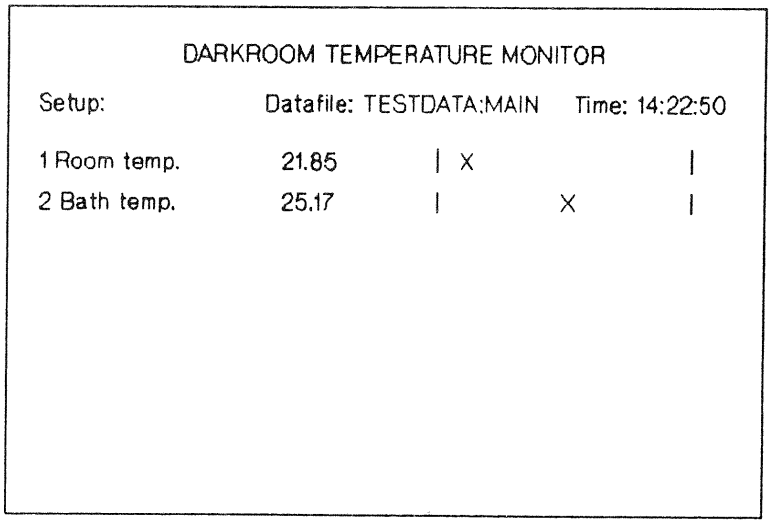


Figure 7-3. Typical Video Display for Example

At the end of the MONITOR session you can generate a report on the readings in the TESTDATA file using the REPORT program (refer to section 11).

DEFINING A DATA LOGGING PROBLEM

SECTION 8

In a data logging application the HP-71B Handheld Computer, with an HP 82401A HP-IL Interface installed, performs a series of measurements without operator intervention. The HP-71 sends commands to an HP 3421A Data Acquisition/Control Unit and records the resulting data. The LOG program controls the actual data logging session, following the specifications contained in a *setup* file. You can use the following programs for data logging applications:

- SETUP - This program is used to interactively create setup files which drive the LOG program. A setup file specifies one or more channel *groups*. Each group contains a channel list, the function to be measured, limit tests, and so on. One group might direct LOG to read temperature from three channels, while another group might direct LOG to measure a frequency. The SETUP program is described in section 9.

- LOG - This program is driven by an input file (the *setup* file), and records data in output files as specified at run time. The data files correspond to the HPAF file format (appendix H). The LOG program is described in section 10.

- REPORT - The report program reads the data files created by the LOG program and generates printed reports or charts. This program is described in section 11.

- TRANSFER - The transfer program sends data from files created by the LOG program to the HP 44456 System Software package on an HP Series 200 computer. This program is described in section 12.

- MSDOSXFR - The MS-DOS transfer program sends data from files created by the LOG program to the MS-DOS environment. This program is described in section 13.

8.1 DATA LOGGING PROCEDURE

The process of data logging involves the following steps:

1) Use the SETUP program to create a setup file which describes the channels to be scanned, functions to be measured, limit tests, and limit actions.

2) Run the LOG program. LOG reads the setup file, prompts for the name of the file in which to store the data, and collects the data.

3) Analyze the data. You can use the REPORT program to generate a written report on the data from the HP-71, or you can transfer the data to another computer. Use the TRANSFER program if you want to move the data to the HP 44456 System Software package on an HP Series 200 computer. Use the MSDOSXFR program if you want to move the data to an MS-DOS based computer.

8.2 CHANNEL GROUPS

A setup file contains a list of one or more *channel groups*. Each channel group includes one or more *consecutive* HP 3421A channels, and a set of measurement specifications. *Note that a particular HP 3421A channel may appear in more than one channel group.*

The following information must be specified for *each* channel group in the setup file:

- **Group label** - A label (up to 20 characters) indicating the purpose of the group.
- **Start time** - The time of day when the group will begin to execute. This time may be set two ways: immediate execution when the LOG program starts, or scheduled start time within 24 hours of the time LOG starts.
- **Active at start** - Groups scheduled to execute at regular intervals may be prevented from executing by making them "not active". Limit actions are used to switch a group between active on/off states. The state of the group is set at the beginning. If a group is not active at the start, the scheduler will still count down the scans for the group at the appointed times, but the measurement or control functions will not happen unless another group specifically activates the group.
- **Interval** - The time interval between group executions may be from five seconds up to 99 hours, 59 minutes, and 59 seconds.
- **Number of scans** - The number of times a group should be scanned, up to 99999.
- **Function** - The measurement or control function. The program can make a measurement on the HP 3421A, control an actuator on the HP 3421A, or call a custom program. Section 9, "The Setup Program," lists the available functions. For some functions the SETUP program will prompt for the number of digits of resolution or temperature units.
- **Channel list** - The channel(s) to be measured. A group may make one or more readings on a single channel, or one reading on each of a sequence of channels. If multiple readings are made on a single channel, they may be averaged and stored as a single reading.
- **Conversion** - Most functions may call a user-written *conversion program* for further processing of each reading, such as a unit conversion.
- **Limit tests** - Up to five limit tests may be made against each reading. If a limit test is true, one of seven limit actions may be performed. The limit actions are: beep, print a message, open/close an actuator, activate or deactivate another group, or call a custom limit program for further actions.

8.3 POWER CONSUMPTION CONSIDERATIONS

Short runs of continous data acquisition (less than one hour) are possible if you begin with the batteries fully charged. You can extend the operating period by powering down the loop between measurements, and by minimizing disc drive access and printer operation. If you are planning an extended data logging run, you need to give special attention to the power consumption requirements for each device in the

system. Frequent data transmission on the loop can drain the batteries in some peripherals faster than the trickle charge rate.

For an extended data acquisition run, printer and/or disc drive power consumption may be the limiting factor. Both the HP 2225B ThinkJet Printer and the HP 9114A Disc Drive use more power in continuous operation than the a.c. trickle charger can provide.

Typically, the HP 2225B ThinkJet Printer will run continuously for two to three hours on a full battery charge. The a.c. trickle charger will extend this period only slightly.

The HP 9114A Disc Drive can operate intermittently for about six hours assuming the following conditions:

1) The battery starts with a full charge

2) The loop is powered down between disc accesses.

3) The period between disc accesses is five minutes (minimum).

Depending on how much data is written to the disc at each access, an a.c. trickle charger may allow the system to run for longer periods of time.

If you need to operate a data acquisition system where there is no a.c. power, you can use the HP 3421A Option 214 12-Volt Power Assembly to extend the period of operation. The option 214 assembly can be used to power the HP 3421A Data Acquisition/Control Unit from an external battery, and to trickle charge peripherals such as the HP 9114A Disc Drive and the HP 2225B ThinkJet Printer.

As the interval between loop activity periods gets longer, the overall duration of an experiment can increase, especially if a.c. trickle chargers or the option 214 are able to restore some or all of the lost power to the batteries. The LOG program uses three techniques to reduce the overall system power consumption requirements:

- **Loop power down:** The event scheduler in the LOG program may, as an option, issue a loop power down command between clusters of scanning activity. If multiple groups are scheduled to scan at the same time, they will run in order with no intermediate loop power down. *Note that the digital output channels on the option 050 digital cards are not latched, so they will clear when the HP 3421A receives a loop power down command.*

- **Internal data storage:** If the data being acquired will fit in a sufficiently small file, the disc drive does not need to be in the system at all. The HP-71 can store the data file in RAM.

- **Buffered data storage:** If the data file will not fit in the available RAM, a disc drive must be used. Rather than write each scan to the disc as it is acquired, a file called BUFFER is created in HP-71 memory. All group scans are written to this file until there is no memory left in the HP-71. At that time, all scans are written out to the disc. This technique greatly increases the interval between actual disc writing activity, depending on the amount of available memory in the HP-71.

You can also conserve power by connecting the disc drive to a second loop using the HP 82402A Dual HP-IL Adapter and two HP 82401A HP-IL Interfaces. Connect the HP 3421A and any other devices required for measurement on loop 1. Connect the disc drive on loop 2. With this configuration the disc

drive can remain in the power-off state during periodic measurement activity. Loop 2 only needs to power up for disc drive access.

8.4 DATA STORAGE REQUIREMENTS

To compute the total storage required for a data logging session, determine the "worst case" record size for the group that stores the most readings. In addition to the channel readings, each scan stores the time, date, and group number, adding three numbers to each scan. The storage requirement for a complete scan is 1 byte plus 8 bytes for each number stored. Multiply this figure by the total number of scans+3 to find the final size of the data file.

Suppose the largest group in the setup stores 15 channels of readings. This works out to 18 numbers per record, or a record size of 1+18*8 or 145 bytes. If there are 5 groups in the setup, and each group takes 33 scans, the final size of the file is 145*(5*33+3) or 24,360 bytes.

If the data file is to be stored on the disc, it is possible to compute the number of scans that will be taken before the internal file BUFFER must be flushed to the disc. To compute this figure, subtract 3500+(270**number-of-groups*) from available memory in the HP-71, divide that figure by the record size, and round down.

Some analysis of the order of group execution may be required to estimate the actual time between disc writes. In a simple situation with just one group which is scanned every minute, and the record size is 145, an available memory size of 8526 bytes would yield a disc write about every 32 minutes. If the disc is connected to an a.c. charger, this would provide a reasonable recharge interval between disc writes. In the same example, a second group which is scanned every two minutes storing one reading would reduce the disc write interval to about 21 minutes.

It is also important to consider the effect of available memory size on the schedule of events. A very large BUFFER file might require several minutes to be flushed to the disc. If the interval between group scans is larger than the time to write the flush the buffer, no problem will be observed. If the interval between group scans is shorter than the "flush time", the group scans will be delayed (with no effect on the order of execution).

8.5 DATA LOGGING EXAMPLE

Now let's look at an application of the LOG program. In the darkroom problem of section 7 the MONITOR program was used to monitor the temperature of a darkroom and control a constant-temperature bath within the darkroom. Let's continue with this application, this time using the data logging program. In this section the system will be described. Subsection 9.14, "Setup Example," will describe the use of the SETUP program to create the setup file for the system. Subsection 10.2, "Log Example," will continue the example by showing how the LOG program is used to run the system.

The LOG program allows you to log the status of a system, and to *control* the system using limit tests. Consider a production darkroom with a controlled-temperature bath that must be maintained within one degree of 25°C. As in the example of section 7, two type T thermocouples are used to monitor the temperatures. The room-temperature thermocouple is connected to channel 3 of the HP 3421A Data Acquisition/Control Unit, and the bath-temperature thermocouple is connected to channel 4. In addition, the bath heater is controlled by a relay, which in turn is controlled by actuator channel 0 of the HP 3421A. Two HP 82401A HP-IL Interfaces are connected to the HP-71 using an HP 82402A Dual

HP-IL Adapter. The HP 3421A is located on loop 1, and a disc drive on loop 2, as shown in figure 8-1. Keeping the disc on loop 2 will keep the disc drive batteries from being discharged during the frequent access to the HP 3421A.

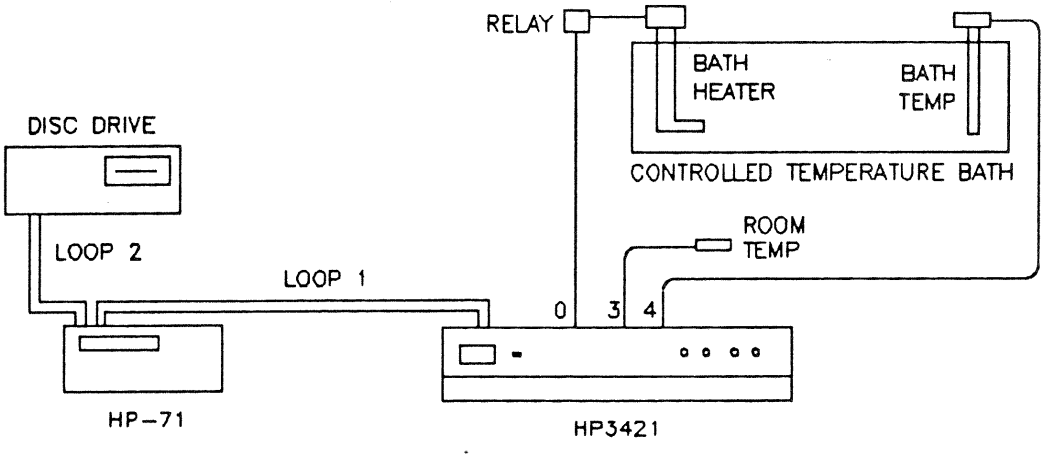


Figure 8-1. Temperature Logging System With Actuator Control

In our example the log setup will consist of two groups: the first will will record the the room temperature and bath temperature on the disc drive every 15 minutes; the second group will monitor and control the bath temperature every 30 seconds. Two limit tests are specified: the lower and upper *control* limits, and the lower and upper *alarm* limits. The lower and upper control limits are set at 24.5 and 25.5 °C. When the temperature falls below 24.5 °C, the actuator channel is closed, turning on the heater by means of a relay. When the temperature rises above 25.5 °C, the actuator channel is opened, turning the heater off. The lower and upper alarm limits are set at 24 and 26 °C. If the control system fails, one of the alarm limits will be reached and the HP-71 will beep.

The setup is designed to begin logging data an hour before a production shift starts (to bring the bath to temperature), and to continue logging throughout the shift. This means that group one will begin to record data at 8:00 a.m., but group two will begin to monitor and control the bath temperature at 7:00 a.m. Group one will execute 33 times - once every 15 minutes from 8:00 am to 4:00 p.m. Group two will execute 1081 times - once every 30 seconds from 7:00 am to 4:00 p.m.

THE SETUP PROGRAM

SECTION 9

The setup program is used to create and manage *setup files*. These files are used by the LOG program to guide the data acquisition and control procedure. A setup file consists of one or more *channel groups*. (Refer to section 8, "Defining a Data Logging Problem" for further information about channel groups.) The data logger package can support up to 20 groups with up to 5 limit tests per group. The scheduler can support 1 second resolution for group execution appointments.

9.1 MEASUREMENT CHOICES

Each group can measure one or more channels or control a single channel in the HP 3421A Data Acquisition/Control Unit. There are 22 measurement or control functions available:

SIGNALS	TEMPERATURE	DIGITAL
DC Volts	T,E,J,K,R,S Thermocouples	Digital Bit
AC Volts	2252 Ohm Thermistor (2WΩ)	Digital Byte
4-20mA Current	2252 Ohm Thermistor (4WΩ)	
2-Wire Ohms	5000 Ohm Thermistor (2WΩ)	CONTROL
4-Wire Ohms	5000 Ohm Thermistor (4WΩ)	
Frequency	European RTD (α=.00385) (2WΩ)	Open Act/Bit
	European RTD (α=.00385) (4WΩ)	Close Act/Bit

Most functions can call a user-written *conversion program* which may be used to perform additional processing on each reading, such as a unit conversion.

As an alternative to these functions, a channel group may call a *custom program*. The LOG program expects up to thirty numbers in return, and stores the readings in the same fashion as other channel groups. This allows the user to include measurements from a sensor or instrument that is not directly supported by the data logger package, or create custom limit action capabilities.

9.2 LIMIT TESTS

You can specify up to five *limit tests* for each group. For each limit test a *limit point* and a *limit action* are specified. The current value for *each* channel in a group is compared with the limit point, and the limit action is taken if the value goes *past* the limit point. That is, for a lower limit, the limit action is taken if the current value goes below the limit point; for an upper limit, the limit action is taken if the value goes above the limit point. The available limit actions are:

- **BEEP** - Sound a beep on the HP-71.
- **PRINT** - Print a message on the system printer.
- **OPEN / CLOSE ACT/BIT** - Open or close an actuator or bit on a digital output card.
- **GROUP ON/OFF** - Enable or disable a channel group.
- **LIMIT PROGRAM** - Call a user-written program which takes specific actions.

9.3 SETUP PROGRAM OPERATION

RUN SETUP [ENDLINE] — Run the SETUP program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Verify Quit?
```

The main menu.

The program has 9 commands which are selected from three menus as follows:

Main Menu

```
Edit File Verify Quit?
```

Edit - Select the *edit* menu (press [E]).

File - Select the *file* menu (press [F]).

Verify - Verify a setup file (press [U]).

Quit - End the program (press [Q]).

Edit Menu

```
Add Del Rpl Prt Main?
```

Add - Add a group to the setup (press ([A]).

Del - Delete a group from the setup (press [D]).

Rpl - Replace a group or its limits (press [R]).

Prt - Print the setup file (press [P]).

Main - Return to the main menu (press [M]).

File Menu

```
Get New Save Main?
```

Get - Get an existing setup file (press [G]).

New - Create a new setup file (press [N]).

Save - Save the current setup file (press [S]).

Main - Return to the main menu (press [M]).

To select a command, press the key corresponding to the first letter of the command. For instance, to select the New command, press [N].

The FLAG 0 annunciator in the display reminds you that the current setup has not been saved to a file. The annunciator will go on when a setup is created or edited, and will go off when the setup is saved.

9.4 CREATING A NEW SETUP

Use the New command to create a new list of groups. Each group requires one or more of the following specifications:

- The function to be measured (refer to subsection 9.1, "Measurement Choices").
- The channel(s) to be scanned.
- The number of digits of resolution to be used by the HP 3421A.
- The temperature units (C, F, K, or R).
- The conversion subprogram to be called, if needed.
- Up to five limit tests.

When New is selected the program prompts for the number of groups in the new setup. If a setup is currently defined, the program asks if it may be destroyed in favor of a new setup.

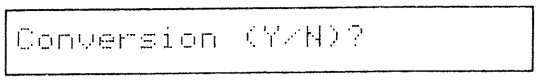
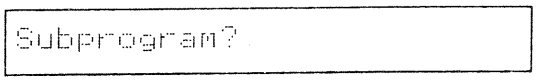
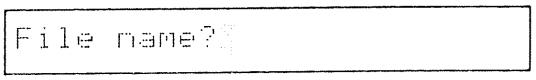
`Get New Save Main?`	The file menu.
N	Press N to select the New command.
`Destroy setup (Y/N)?`	If a setup is currently defined, the program asks if it may be destroyed.
Y or N	Press Y to proceed with the new setup, or N to escape back to the file menu.
`Number of groups?`	The program prompts for the number of groups to be in the setup.
number of groups ENDLINE	Enter the number of groups, up to 20.
`* * Group 1 * *`	The program displays the number of the group being entered.
`Label?`	The program prompts for the group label.
group label ENDLINE	Enter the group label, up to 20 characters, and press ENDLINE.

`Start time? HH:MM:SS`	The program prompts for the time to begin scanning this group.
start time [ENDLINE]	Enter the time in HH:MM:SS format, and press [ENDLINE]. The start time is in 24-hour format. Enter −1 for groups that should begin as soon as the LOG program starts.
`Active at start (Y/N)`	The program asks if the group is initially active.
[Y] or [N]	If the group is to unconditionally begin scanning at the *start time*, press [Y]. If the group is to begin scanning *only if activated by another group*, press [N].
`Interval: HH:MM:SS`	The program prompts for the interval between *start times* of each scan.
interval [ENDLINE]	Enter the interval in HH:MM:SS format press [ENDLINE]. The interval must be five seconds or greater.
`No. of scans?`	The program prompts for the number of times the group should be scanned.
number of scans [ENDLINE]	Enter the number of scans, and press [ENDLINE]. You may specify from 1 to 99999 scans.
`FN: DC Volts`	The function menu.
[v], [^], or [ENDLINE]	Press the arrow keys to choose the function to be measured, then press [ENDLINE] to select that function.

What you do next depends on the function that you have selected. Refer to the appropriate subsection: 9.4.1, "Signals"; 9.4.2, "Digital Functions"; 9.4.3, "Control"; or 9.4.4, "Custom Program"; then follow the instructions in subsection 9.5, "Limits." When you have entered all of the specifications for one group, you will be prompted to begin entering the information for the next group. When all groups have been entered, the main menu will reappear.

9.4.1 Signals

`# Digits (3, 4, or 5)?`	The program prompts for the number of digits of resolution. This prompt does not appear if the function is *frequency* or *temperature*. (Frequency measurements are made with 5.5-digit resolution and a 1-second gate time.)
[3], [4], or [5]	Press [3], [4], or [5] to use 3.5, 4.5, or 5.5 digits in the HP 3421A.
`Degrees: (C F K or R)?`	If the function is *temperature*, the program prompts for the desired temperature unit. Temperature measurements are made with 5.5-digit resolution.
[C], [F], [K], or [R]	Press [C] to select Celsius units, [F] to select Fahrenheit units, [K] to select Kelvin units, or [R] to select Rankine units.
`First channel?`	The program prompts for the first channel in the HP 3421A which should be measured.
channel number [ENDLINE]	Enter the channel number, then press [ENDLINE].
`Last channel?`	The program prompts for the last channel to be scanned.
last channel [ENDLINE]	Enter the last channel of the range to be scanned.
`No. burst readings?`	If the first and last channels are identical, the program asks how many readings should be taken on that channel in a single burst.
number of burst readings [ENDLINE]	Enter the number of burst readings (up to 30), and press [ENDLINE].
`Average (Y/N)?`	If a series of burst measurements are to be taken on a single channel, the program gives you two options. The program can retain the numerical average of the burst, or all of the readings in the burst.
[Y] or [N]	Press [Y] to retain the average of the burst readings, or [N] to retain all the burst readings.

	The program asks if a *conversion subprogram* should be called.
Y or N	Press Y if a conversion subprogram is needed.
	If a conversion is requested, the program prompts for the name of the subprogram.
subprogram name ENDLINE	Enter the name of the subprogram and press ENDLINE.
	If a conversion is requested, the program prompts for the name of the file containing the subprogram.
file name ENDLINE	Enter the name of the file and press ENDLINE.

When these specifications for the function have been entered, proceed to subsection 9. 5, "Limits."

9.4.2 Digital Functions

Two digital input functions are available: digital *bit*, and digital *byte*:

Digital Bit

`First channel?`	The program prompts for the first input bit to be scanned.
first bit address [ENDLINE]	Enter the address of the first bit, and press [ENDLINE].
`Last channel?`	The program prompts for the last bit to be scanned.
last bit address [ENDLINE]	Enter the address of the last bit, and press [ENDLINE].

When these specifications have been entered, proceed to subsection 9. 5, "Limits."

Digital Byte

`Slot?`	The program asks which slot to read a byte from. The readings from the digital card are returned as a decimal value in the range 0 - 255.
slot number [ENDLINE]	Enter the slot number for a digital card and press [ENDLINE].
`Conversion (Y/N)?`	The program asks if a *conversion subprogram* should be called (for example, to decode readings from a BCD device).
[Y] or [N]	Press [Y] if a conversion subprogram is needed.
`Subprogram?`	If a conversion is requested, the program prompts for the name of the subprogram.
subprogram name [ENDLINE]	Enter the name of the subprogram and press [ENDLINE].
`File name?`	If a conversion is requested, the program prompts for the name of the file containing the subprogram.
file name [ENDLINE]	Enter the name of the file and press [ENDLINE].

When these specifications have been entered, proceed to subsection 9. 5, "Limits."

9.4.3 Control

Control functions are used only to turn on or off an actuator, or set or clear a digital output bit. Like data acquisition functions, these functions can only take place at the start time for the group *if the group is active.*

Control functions include the two selections OPEN ACT/BIT and CLOSE ACT/BIT in the function menu.

Channel?	The program prompts for the number of the actuator or digital output bit to control.
channel number [ENDLINE]	Enter the channel number, and press [ENDLINE].

When this information has been entered, the program will prompt for the information about the next group. *No limit tests are available for control functions.*

9.4.4 Custom Program

A custom program may be called which takes a reading from another instrument, or uses a custom sequence with the HP 3421A. The program may return up to 30 values for logging purposes. *Note that no limit actions are available for custom program calls.* Refer to appendix C, "Custom Programs," for further details about custom programs.

Subprogram?	The program prompts for the subprogram name.
subprogram name [ENDLINE]	Enter the name of the subprogram and press [ENDLINE].
File name?	The program prompts for the file containing the subprogram.
file name [ENDLINE]	Enter the file name and press [ENDLINE].

9.5 LIMITS

Each group can have up to five limit tests. The following series of prompts appears for each limit test. When the current limit action is declined or five limit tests have been requested, the program returns to the beginning of the group entry procedure. If all of the groups have been specified, the program returns to the main menu.

`Limit test 1 (Y/N)?`	The program asks if a limit test is required.
Y or N	Press Y to request a limit test, or N to begin entering the next group.

The prompt for the *limit type* depends upon the function being measured by the current group. For all functions except "Digital Bit," look under the heading "Analog."

After the limit type has been specified, proceed to subsection 9.5.3, "Limit Actions."

9.5.1 Analog

`Limit type: Low High?`	The program asks you to specify either a lower limit (Low) or an upper limit (High). The limit action will be triggered when *any measurement in the channel range being scanned* goes past the specified limit point. (The action is triggered when a measurement falls below a lower limit, or when a measurement rises above an upper limit.)
L or H	Press L to select a *low* limit or H to select a *high* limit. If *average* has been specified, the limit test is done on the average, not the individual readings.
`Limit point?`	The program prompts for the value to be compared with each reading.
limit point ENDLINE	Enter the limit point, and press ENDLINE.

9.5.2 Digital Bit

`Limit type: Set Clear?`	The program asks if the limit should be triggered when *any bit in the channel range* is `Set` or `Clear`.
S or C	Press S to select a *set* limit, or press C to select a *clear* limit.

9.5.3 Limit Actions

The available limit actions are:

- **BEEP** - Sound a beep on the HP-71.
- **PRINT** - Print a message on the system printer.
- **OPEN / CLOSE ACT/BIT** - Open or close an actuator, or a bit on a digital output card.
- **GROUP ON** - Enable a group to begin scanning if its start time has arrived.
- **GROUP OFF** - Prevent a group from scanning even if its start time has arrived.
- **LIMIT PROGRAM** - Call a user-written program which takes specific actions.

`Action: BEEP`	The program presents the limit action menu.
↓, ↑, or ENDLINE	Press the arrow keys to choose the desired limit action, then press ENDLINE to select that action.

Depending upon the limit action selected, the program may present one of the following prompts:

`Message?`	If the limit action selected is `PRINT`, the program prompts for the message to appear on the system printer.
message ENDLINE	Enter the message, up to 32 characters, and press ENDLINE.
`Channel?`	If the limit action selected is `OPEN ACT/BIT` or `CLOSE ACT/BIT`, the program prompts for the number of the channel to open or close.
actuator or bit ENDLINE	Enter the channel number, and press ENDLINE. The channel must be either an actuator channel or an output bit on a digital card.

`Group number?`	If the limit action selected is GROUP ON or GROUP OFF, the program prompts for the number of the group to turn on or off.
group number [ENDLINE]	Enter the group number, and press [ENDLINE].
`Limit subprogram?`	If the limit action selected is LIMIT PROGRAM, the program prompts for the name of the subprogram to call. Refer to appendix E for details about limit subprograms.
subprogram name [ENDLINE]	Enter the subprogram name and press [ENDLINE].
`File name?`	The program prompts for file containing the limit subprogram.
file name [ENDLINE]	Enter the file name, and press [ENDLINE].

When all the limit actions have been specified, the program asks if the data collected is to be stored:

`Store readings (Y/N)?`	If the function selected is a measurement function, the program asks if the data acquired should be stored in a data file.
[Y] or [N]	Press [Y] to store the data, or [N] to throw away the data after the limit checks have been performed.

After the data storage option has been specified, the program returns to prompt for the next group or, if all of the groups have been specified, to the main menu.

9.6 STORING GROUP SETUPS

Use the Save command to save the current group setup to a file, either in RAM or on a mass storage device.

To use this command, press [S] from the file menu:

`Get New Save Main?`	The file menu.
[S]	Press [S] to select the Save command.
`File name?`	The program prompts for the file in which to store the group setup.
file name [ENDLINE]	Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].
`Overwrite file (Y/N)?`	If the file already exists, the program asks if the file should be overwritten.
[Y] or [N]	Press [Y] to overwrite the file with the current group setup, or press [N] to escape back to the file menu.
`Saving...`	The program displays a status message while the group setup is being stored in the file.
`Edit File Verify Quit?`	The program returns to the main menu.

9.7 RETRIEVING GROUP SETUPS

Use the Get command to retrieve a setup file from mass storage. *Note that when this command is invoked, any currently-active setup information will be lost!*

To use this command, press [G] from the file menu:

`Get New Save Main?`	The file menu.
[G]	Press [G] to select the Get command.
`Destroy setup (Y/N)?`	If a group setup currently exists, the program reminds you that it will be destroyed.
[Y] or [N]	Press [Y] to proceed, or [N] to escape back to the main menu.
`File name?`	The program prompts for the name of the file to read.
file name [ENDLINE]	Enter the file name and, if needed, the optional mass storage specifier, then press [ENDLINE].
`Reading...`	The program displays a status message while the file is being read.
`Edit File Verify Quit?`	The program returns to the main menu.

9.8 VERIFYING THE SETUP FILE

Use the Verify command to verify that the group setups correctly match the hardware configuration of the HP 3421A Data Acquisition/Control Unit connected to the HP-71. This command should be used when an existing setup file has been retrieved from storage, prior to running the LOG program.

If errors are encountered in the group setups, the commands in the edit menu may be used to adjust the group specifications.

To use the Verify command, press [V] from the main menu:

```
Edit File Verify Quit?
```

The main menu.

[V]

Press [V] to select the Verify command.

```
Group 1 ...
```

As each group is examined, the program displays a status message. If an error is encountered, it will be printed, then the program will proceed to the next group.

```
Edit File Verify Quit?
```

When all of the groups have been examined, the program returns to the main menu.

9.9 ADDING A GROUP

The Add command is used to add a new group to the setup file. The data logger package can accommodate up to 20 groups in one setup file.

To use the Add command, press [A] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[A]	Press [A] to select the Add command.
`* * Group 9 * *`	The program displays the number of the group being added. This will always be at the end of the setup file. If there are 8 groups in the current setup, the display will read "Group 9".
`Label?`	The program begins to prompt for the specifications for the new group. Follow the same procedure for group entry as described under the New command.
`Add Del Rpl Prt Main?`	When the new group has been specified, the program returns to the edit menu.

9.10 DELETING A GROUP

The Delete command is used to delete a group from the current setup file.

NOTE

You may not delete a group that is referenced by the limit actions of another group. If the group is referenced, the program will return an error message and the delete request will be canceled.

To use the Delete command, press [D] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[D]	Press [D] to select the Delete command.
`Group number?`	The program prompts for the number of the group to be deleted.
group number [ENDLINE]	Enter the group number, and press [ENDLINE].
`Delete group n (Y/N)?`	The program confirms that you wish to delete the group.
[Y] or [N]	Press [Y] to delete the group, or [N] to cancel the request and return to the edit menu.
`Working...`	The program displays a status message while the group is being deleted. The setup file will be renumbered to reflect the change. All intra-group references will be preserved.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

9.11 REPLACING A GROUP

The Replace command is used to alter the function or limit specifications for a group in the current setup.

To use the Replace command, press [R] from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[R]	Press [R] to select the Replace command.
`Replace group?`	The program prompts for the group to be replaced.
group number [ENDLINE]	Enter the group number, and press [ENDLINE].
`Replace group n(Y/N)?`	The program asks if you wish to replace the entire group specification.
[Y], or [N]	Press [Y] to replace the entire group specification, or [N] to replace just the limits.
`* * Group n * *`	If the entire group is to be replaced, the program begins to prompt for the new setup information. Follow the same procedure for group entry as described under the New command.
`Replace limits (Y/N)?`	If the entire group is not to be replaced, the program asks if the limit tests should be replaced.
[Y] or [N]	Press [Y] to replace the limit tests, or [N] to return to the edit menu.
`Limit test 1 (Y/N)?`	The program begins to prompt for the limit test information. Follow the instructions in subsection 9.5, "Limits."

9.12 PRINTING THE SETUP FILE

The Print command is used to print the specifications for each group in the current setup.

To use the Print command, press the [P] key from the edit menu:

`Add Del Rpl Prt Main?`	The edit menu.
[P]	Press the [P] key to select the Print command.
`Printing...`	The program displays a status message while the setup file is being printed.
`Add Del Rpl Prt Main?`	The program returns to the edit menu.

A sample printout of one group looks like this:

```
Group 1: Furnace Temperatures
     Start: 14:30:00    Interval: 00:05:00   Scans: 20
     Group is active
     Function: J Thermocouple
     First channel: 3   Last channel: 7
     Readings are not stored
     Temperature in degrees C
     Digits of resolution: 5.5
     Limit 1: LOW 700 PRINT: Low temperature!
     Limit 2: HIGH 800 OPEN ACT/BIT: 4
     Limit 3: HIGH 800 PRINT: High temperature!
```

9.13 ENDING THE SETUP PROGRAM

The Quit command is used to end the program. If you haven't yet saved the current group setup, you will be asked whether you want to do so.

To end the program, press [Q] from the main menu:

Edit File Verify Quit?	The main menu.
[Q]	Press [Q] to end the program.
Save setup (Y/N)?	If the current setup has not been saved in a file, the program asks if you wish to save your setup.
[Y] or [N]	Press [Y] to save the setup, or [N] to end the program and loose the current setup.
Done	The program is finished.

9.14 SETUP EXAMPLE

Now let's use the SETUP program to create the setup file for the darkroom temperature logging problem described in section 8 (see figure 8-1).

RUN SETUP [ENDLINE]

Run the SETUP program.

```
Reading the HP3421...
```

The program reads the internal configuration of the HP 3421A.

```
Edit File Verify Quit?
```

[F]

The main menu appears. Press [F] to select the file menu.

```
Get New Save Main?
```

[N]

Press [N] to start a new setup.

```
Number of groups?
```

2 [ENDLINE]

The program prompts for the number of groups in the setup.

```
* * Group 1 * *
```

Now the program prompts you to begin entering specifications for group 1.

```
Label?
```

Room/bath temps. [ENDLINE]

The program prompts you for a label for group number 1.

```
Start time? HH:MM:SS
```

08 [ENDLINE]

The program asks for the time that group 1 will begin to execute.

```
Active at start (Y/N)?
```

[Y]

The program asks if the group will be active at the start.

```
Interval: HH:MM:SS
```

0015 [ENDLINE]

The program asks for the execution interval.

```
Number of scans?
```

33 [ENDLINE]

Enter the scans for group one.

```
FN~ DC  Volts
```

[v], [v], [v], [v], [v], [v]

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
```

[ENDLINE]

```
Degrees: (C F K or R)?
```

[C]

You are prompted for the temperature units for trace 1. Press [C] to select Celsius.

```
First channel?
```

3 [ENDLINE]

You are prompted for the number of the first HP 3421A channel to be measured for group 1. Channel 3 is the room-temperature thermocouple.

```
Last channel?
```

4 [ENDLINE]

You are prompted for the number of the last HP 3421A channel to be measured for group 1. Channel 4 is the bath-temperature thermocouple.

```
Conversion (Y/N)?
```

[N]

No conversion subprogram is needed.

```
Limit test 1 (Y/N)?
```

[N]

The program gives you the option of setting limit tests. Press [N] to set no limit tests for group 1.

```
Store readings (Y/N)?
```

[Y]

The program asks if the data acquired for group 1 should be stored.

```
* * Group 2 * *
```

Now the program prompts you to begin entering specifications for group 2.

```
Label?
```

Bath temp. [ENDLINE]

The program prompts you for a label for group number 2.

```
Start time? HH:MM:SS
```

07 [ENDLINE]

The program asks for the time that group 2 will begin to execute.

```
Active at start (Y/N)?
```

[Y]

The program asks if the group will be active at the start.

```
Interval: HH:MM:SS
```

000030 [ENDLINE]

The program asks for the execution interval.

```
Number of scans?
```

1081 [ENDLINE]

Enter the number of scans for group two.

```
FN~ DC Volts
```

[v], [v], [v], [v], [v], [v]

The function menu appears. Use the [v] key to select T Thermocouple.

```
FN~ T Thermocouple
```

[ENDLINE]

```
Degrees: (C F K or R)?
```

[C]

You are prompted for the temperature units for trace 2. Press [C] to select Celsius.

```
First channel?
```

4 [ENDLINE]

You are prompted for the number of the first HP 3421A channel to be measured for group 2. Channel 4 is the bath-temperature thermocouple.

```
Last channel?
```

4 [ENDLINE]

You are prompted for the number of the last HP 3421A channel to be measured for group 2.

```
No. burst readings?
```

1 [ENDLINE]

Since the first and last channel numbers for this group are the same, the program asks if more than one reading should be taken.

```
Conversion (Y/N)?
```

N

No conversion subprogram is needed.

```
Limit test 1 (Y/N)?
```

Y

Although no limit tests were set for group 1, you are given the option of setting limit tests for group 2. Two sets of upper and lower limits are to be set for group 2; first the alarm (beep) limits, then the control (actuator) limits. Press Y to request the first limit test.

```
Limit type: Low High?
```

L

To set a lower limit, press L.

```
Limit point?
```

24 ENDLINE

Set the lower alarm limit to 24°C. The program will compare each reading with this limit.

```
Action~ BEEP
```

ENDLINE

The limit action menu appears. Just press ENDLINE to select BEEP as the action.

```
Limit test 2 (Y/N)?
```

Y

Now you can set a second limit test. Press Y.

```
Limit type: Low High?
```

H

To set an upper limit, press H.

```
Limit point?
```

26 ENDLINE

Set the upper limit to 26°C.

```
Action~ BEEP
```

ENDLINE

The limit action menu appears. Just press ENDLINE to select BEEP as the action. The HP-71 will beep if the temperature either rises above 26°C or falls below 24°C. Note that if the beep is not a satisfactory alarm, you could use an actuator channel to trigger an external alarm bell or other signal.

```
Limit test 3 (Y/N)?
```

Y

Now you can set the control (actuator) limits.

```
Limit type: Low High?
```

L

To set a lower limit, press L.

```
Limit point?
```

24.5 ENDLINE

Set the lower limit to 24.5 °C. The program will compare each reading with this limit.

```
Action: BEEP
```

↓, ↓, ↓, ↓

The limit action menu appears. Use the ↓ key to select CLOSE ACT/BIT as the action.

```
Action: CLOSE ACT/BIT
```

ENDLINE

```
Channel?
```

0 ENDLINE

Select channel 0 as the actuator channel. Whenever the temperature of the bath drops below 24.5 °C, the HP-71 will close actuator channel 0 on the HP 3421A, which actuates the heater relay.

```
Limit test 4 (Y/N)?
```

Y

Now you can set the upper control limit.

```
Limit type: Low High?
```

H

To set an upper limit, press H.

```
Limit point?
```

25.5 ENDLINE

Set the upper limit to 25.5 °C.

```
Action: BEEP
```

↓, ↓, ↓

The limit action menu appears. Use the ↓ key to select OPEN ACT/BIT as the action.

```
Action~  OPEN ACT/BIT
```

ENDLINE

```
Channel?
```

0 ENDLINE

Select channel 0 as the actuator channel. Whenever the temperature of the bath rises above 25.5 °C, the HP-71 will open actuator channel 0 on the HP 3421A, which turns off the heater relay. Thus, the bath temperature is maintained between the control limits of 24.5 and 25.5 °C. If the control system fails, the HP-71 will beep when the temperature goes outside the range 24 to 26 °C.

```
Limit test 5 (Y/N)?
```

N

The program gives you the option of another limit test. Press N.

```
Edit File Verify Quit?
```

F

Once the setup is completed, the main menu reappears. So far the monitor setup has not been saved to a file. To save the example setup, press F.

```
Add Del Rpl Prt Main?
```

S

The file menu appears. Press S to save the setup.

```
File name?
```

LOGSET ENDLINE

Enter a name for a file to store the setup.

```
Saving...
```

The program saves the setup in the LOGSET file in RAM.

```
Edit File Verify Quit?
```

Q

The program again prompts for the desired action. Press Q to quit.

```
Done
```

The program is finished.

The LOG program can now be used to execute the setup. Subsection 10.2, "Log Example," illustrates the use of the LOG program.

THE LOG PROGRAM

SECTION 10

You can use the LOG program to log data continuously under the control of a setup file. The setup file must be created using the SETUP program (refer to section 9) *before* the LOG program is run.

The LOG program, driven by the setup file, builds an interrupt-driven event scheduler using the system timers in the HP-71. One timer is used for a "midnight correction"; a second timer is used to count down to the next event. A "pending event list" indicates which groups need to be serviced at any given time. The order for execution for the LOG program is as follows:

- Prompts for the setup file to be used.
- Finds and reads the instrument specified by the setup file.
- Creates RAM files as needed to buffer readings going to mass storage.
- Builds the "pending event list" from all groups which start immediately.
- Starts the midnight correction timer.
- Starts the countdown duration for the next non-immediate scheduled event.
- Begins servicing pending events.

When a pending event comes due, the following actions occur:

- Completes the scan as specified.
- Decrements the scan counter for the group.
- Calls conversion routines as needed.
- Performs limit tests and actions as needed.
- Stores the data as specified.

The program will run as long as there is at least one active group with at least one scan remaining to execute. If all groups become inactive, the program will end regardless of the number of scans remaining.

10.1 LOG PROGRAM OPERATION

To run the program, connect the HP-71 to the HP 3421A, mass storage device, and any other peripherals that are required.* If external power supplies are required, be sure that they are connected and working properly. If necessary, make sure flag -3 is clear so that the HP-71 will go to sleep after the log program has finished. You may wish to use the Verify command in the SETUP program to check the setup file before starting a long, unattended experiment.

RUN LOG [ENDLINE]	Run the LOG program.
Reading the HP3421...	The program reads the HP 3421A internal configuration.
LOG: Setup file?	The program prompts for the setup file.
setup file [ENDLINE]	Enter the name of the setup file (including the device specifier if the file is on a disc), and press [ENDLINE].
Reading...	The program displays a status message while the setup file is read.
Data file?	If the setup file specifies that data is to be stored, the program prompts for the name of the data file to be created.
file name [ENDLINE]	Enter the name of the data file, and press [ENDLINE]. Be sure to include the device specifier if the file is to reside on a mass storage device. To test out a LOG setup, you can enter a blank filename (just press [ENDLINE]). The LOG program will still execute the setup, but will not store any data.
Buffer readings (Y/N)?	If the data file resides on a mass storage device, the program asks if the readings should be buffered in memory.
[Y] or [N]	Press [Y] to buffer the readings, or [N] to store the readings on the mass storage device as they are taken.

*By using a substitute CHANLIST subprogram in main memory, you can use an HP 3421A that is either a) not the first HP 3421A on the loop or b) on the second loop. Refer to appendix F, "Alternative Peripheral Options" for further details.

`Creating...`	The program displays a status message while the data file is being created.
`Power down loop (Y/N)?` [Y] or [N]	The program asks if the HP-IL loop should be powered down between readings. Press [Y] to power down loop 1 between groups, or [N] to keep the loop alive. *Note that the digital output channels on the option 050 digital cards are not latched. They will clear when the HP 3421A receives a loop power down command.*
`Press [fQ] to abort...`	The program begins to log data. Pressing [f][Q] at any time will cause the program to close the data files and end immediately When the program is between clusters of activity, the loop is powered down and the HP-71 is placed in a low power state. The LCD remains on to indicate program status, and the keyboard is alive to receive a keystroke if the program is to be aborted. Flags 0 to 4 will come on from time to time as the event scheduler executes.
`Done`	The program is finished. If flag -3 is not set, the HP-71 will go to sleep after the timeout period, powering down the loop.

While the LOG program is running, an error check is enabled to provide protection against HP-IL errors, such as invalid frames being received due to power fluctuations, etc. If an HP-IL error is encountered, the program calls the subprogram RECOVER which will attempt to restore the loop. Refer to appendix G for details about the RECOVER subprogram. If the error encountered is not an HP-IL error, the program will end with the error message in the display.

10.2 LOG EXAMPLE

Let's continue with the example begun in section 8, "Defining A Data Logging Problem," and set up in section 9, "The SETUP Program." Let's now use the LOG program to execute the group setup stored in the file LOGSET.

`RUN LOG` [ENDLINE]	Run the LOG program.

```
Reading the HP3421...
```

The program reads the HP 3421A internal configuration.

```
LOG: Setup file?
LOGSET [ENDLINE]
```

Enter the name of the example setup file.

```
Data file?
LOGDATA:HP9114:2 [ENDLINE]
```

Use the name LOGDATA for the data file. Since the disc is on loop two in the example, the file name must include the disc specifier, followed by the loop specifier.

```
Buffer readings (Y/N)?
[N]
```

For frequent file updates, buffered readings would reduce power consumption in the disc drive. In this example, with one file access every 15 minutes, the buffering is not required.

```
Creating...
```

The program creates the data file.

```
Power down loop (Y/N)?
[N]
```

Since group two (controlling the bath temperature) will execute every 30 seconds, not much will be gained by powering down the loop between groups. In fixed site installations such as the one illustrated, the HP 3421A can be powered from an a.c. outlet.

```
Press [f0] to abort...
```

The program begins to run. When 7:00 a.m. comes next, group 2 will begin to execute. An hour later, group 2 will begin to log temperatures.

```
Done
```

Shortly after 4:00 p.m., the program will finish.

Once the LOG program has created the data file, you can analyze the data using the REPORT program, or you can transmit the data to another computer. Use the TRANSFER program (refer to section 12) if you want to send the data to the HP 44456 System Software package on an HP Series 200 computer. Use the MSDOSXFR program (refer to section 13) if you want to send the data to an MS-DOS based computer such as the HP 150, The Portable, or The Portable Plus.

The example setup, LOGSET, can be used over and over again. In our example, the setup could be used in daily production for the darkroom, with the data file names changing to reflect the calendar days.

THE REPORT PROGRAM

SECTION 11

The REPORT program reads files generated by the STRIP, MONITOR, and LOG programs and prepares printed reports. The options for report generation are:

- List the contents of the file.
- Print the data in the file.
- Print strip chart from data in specific channel(s).
- Generate summary statistics from the data.

The list option indicates what program generated the file, the number of groups in the file, the channels scanned, and the time period covered during the experiment.

Each print option allows data to be printed from the entire file or from a particular time period during the experiment.

The print and statistics options will work with any 80-column output device, such as a video monitor or a ThinkJet printer. The strip chart option assumes the printer is a ThinkJet. (If an alternate printer is to be used for printing strip charts refer to appendix F, "Alternative Peripheral Options".)

To generate printed reports, set the PRINTER IS setting in the HP-71 to the desired output device,* and run the REPORT program.

RUN REPORT [ENDLINE]

Run the REPORT program.

```
File name?
```

The program asks for the name of the data file to read.

file name [ENDLINE]

Enter the file name, including the device specifier if needed, and press [ENDLINE]. Entering a null file name will end the program.

```
Chrt Lst Prt Stat End?
```

This is the main menu.

[C], [L], [P], [S], or [E]

Press [C] to print a strip chart, [L] to list the contents of the file, [P] to print the data, [S] to generate summary statistics, or [E] to end the program.

---

*If the printer is in a nonstandard print mode the PWIDTH setting may have to be adjusted to match.

11.1 LISTING FILE CONTENTS

The List command is used to list the contents of a data file. The program will list the origin of the file, the number of data records, and the times of the first and last data records. If the file was generated by STRIP or MONITOR, the program will indicate how many traces or channels are represented in each record. If the file was generated by LOG, the program will print a chart listing the group numbers, first and last channels of the scans for each group, and the number of readings collected for each scan. Although it shows the total number of records in the file, it does not show the number of scans (records) per group.

To use the List command, press [L] from the main menu:

`Chrt Lst Prt Stat End?`	The main menu.
[L]	Press [L] to select the List command.
`Printing...`	The program displays a status message while the file contents are listed.
`Chrt Lst Prt Stat End?`	The program returns to the main menu.

Three sample listings follow:

```
STRIP file STRIPDAT:TAPE contains 9 records:
5 traces recorded
First reading:  16:15:00 85/11/13
Last reading:   18:30:00 85/11/13


MONITOR file MONDAT3:MAIN contains 15 records:
8 channels recorded
First reading:  13:22:35 85/11/22
Last reading:   13:23:34 85/11/22


LOG file LOGDATA:TAPE contains 31 records:

       1st   Last   Rdgs/
Grp   Chnl   Chnl   Scan
  1      3      3     30
  2      2      2      1
  3  Custom Prog      3

First reading:  15:09:18 85/11/04
Last reading:   15:20:51 85/11/04
```

11.2 PRINTING THE DATA

You can use the Print command to print some or all of the data in a file. If the data file has been generated by the STRIP or MONITOR programs, the program will print all readings for each data record in the specified time period. If the data file has been generated by the LOG program, the program will request the group number and time interval for the printout.

To use the Print command, press [P] from the main menu:

```
Chrt Lst Prt Stat End?
```

[P]

The main menu.

Press [P] to select the Print command.

```
Group?
```

group number [ENDLINE]

If the data file has been generated by the LOG program, the program asks for the group number to be printed. (If there is only one group, this prompt will not appear.)

Enter the group number, or 0 to escape back to the main menu, and press [ENDLINE].

```
Select scans (Y/N)?
```

[Y] or [N]

The program asks if you wish to print only data from a given time period.

Press [Y] to specify the time and date of the beginning and end of the time period to print, or press [N] to print all records in the file (or group) and skip the next four steps.

```
Start date: YY/MM/DD
```

start date [ENDLINE]

The program asks for the starting day of the time period.

Enter the date in YY:MM:DD form and press [ENDLINE].

```
Start time: HH:MM:SS
```

start time [ENDLINE]

The program asks for the starting time in the first day of the time period.

Enter the starting time in HH:MM:SS form (24hr clock) and press [ENDLINE].

```
End date: YY/MM/DD
```

end date [ENDLINE]

The program asks for the ending date of the time period.

Enter the ending date in YY:MM:DD form and press [ENDLINE].

End time: HH:MM:SS *end time* [ENDLINE]	The program asks for the ending time in the last day of the time period. Enter the ending time in HH:MM:SS form (24hr clock), and press [ENDLINE].
Printing...	The program displays a status message while the data is being printed.
Chrt Lst Prt Stat End?	The program returns to the main menu.

11.3 PRINTING SUMMARY STATISTICS

The Stat command is used to generate summary statistics from selected data in a file. If the data file has been generated by the STRIP or MONITOR programs, the program will summarize readings for an individual trace. If the data file has been generated by the LOG program, the program will request the group number and the channel channel number to be summarized. The results may be presented one at a time in the display, or printed on the current PRINTER IS device.

The statistics calculated from the data are:

- Number of data points (records)
- Minimum and maximum values
- Sum of values
- Mean and standard deviation of values
- Variance
- Standard error of the mean

The standard deviation, variance, and standard error of the mean are calculated using *n-1* as the degrees of freedom - that is, *sample* statistics are calculated. Refer to the *HP-71 Reference Manual* for additional information on how the statistics are calculated.

To use the Stat command, press [S] from the main menu:

Chrt Lst Prt Stat End?	The main menu.
[S]	Press [S] to select the Stat command.

```
Group?
```

group number [ENDLINE]

If the data file has been generated by the LOG program and contains more than one group, the program asks for the number of the group to read. (If there is only one group, this prompt will not appear).

Enter the group number (or 0 to escape back to the main menu) and press [ENDLINE].

```
Trace?
```

trace number [ENDLINE]

If a STRIP or MONITOR file contains more than one trace, the program asks for the trace to analyze.

Enter the trace number and press [ENDLINE].

```
Channel?
```

channel number [ENDLINE]

If the data file has been generated by LOG and the specified group scanned more than one channel in the HP 3421A, the program asks for the channel number to examine.

Enter the channel number to analyze and press [ENDLINE].

```
All readings (Y/N)?
```

[Y] or [N]

If a group from LOG contains multiple readings from a burst measurement, or multiple readings from a custom program, the program asks if statistics should be calculated from all readings in the scans.

If so, press [Y] and skip the next step. If you want statistics from only one reading in each scan, press [N].

```
Reading?
```

reading number [ENDLINE]

Now select which of the multiple readings will be used to calculate statistics. For example, if a custom program stored 26 values in each scan, and you are analyzing the 14th reading from each scan, enter 14.

```
Select scans (Y/N)?
```

[Y] or [N]

The program asks if you wish to generate statistics only from a given time period.

Press [Y] to specify the time and date of the beginning and end of the time period to print, or press [N] to print all records in the file and skip the next four steps.

```
Start date: YY/MM/DD
```

start date [ENDLINE]

The program asks for the starting date of the time period.

Enter the starting date in YY:MM:DD form, and press [ENDLINE].

Start time: HH:MM:SS *start time* [ENDLINE]	The program asks for the starting time in the first day of the time period. Enter the starting time in HH:MM:SS form (24hr clock), and press [ENDLINE].
End date: YY/MM/DD *end date* [ENDLINE]	The program asks for the ending date of the time period. Enter the ending date in YY:MM:DD form and press [ENDLINE].
End time: HH:MM:SS *end time* [ENDLINE]	The program asks for the ending time in the last day of the time period. Enter the ending time in HH:MM:SS form (24hr clock), and press [ENDLINE].
Display or Print(D/P)? [D] or [P]	The program asks whether the results should be printed or displayed in the LCD. Press [P] to print the results on the current printer device, or [D] to display the results in the LCD.
Working...	The program displays a status message while the data is being scanned. *Note that at least two records must be found to compute statistics. The program will alert you if less than two records are found.*

If the statistics are to be printed, the message Printing... will appear in the display until the program returns to the main menu.

If the statistics are to be displayed, the first result will appear in the display:

n Records selected [^], [v], [ENDLINE], or [Q]	The program displays the first result. To view the next result, press [v] or [ENDLINE]. Press [^] to view the previous result, or [Q] to escape to the main menu.
Chrt Lst Prt Stat End?	The program returns to the main menu after the last result has been displayed.

11.4 PRINTING A STRIP CHART

The Chart command is used to print a strip chart from selected data in a file. If the data file has been generated by the STRIP or MONITOR programs, the program will ask for the channel to be used for each trace. If the data file has been generated by the LOG program, the program will request the group number to scan and channel number for each trace (all traces must come from the same group). In the case of a LOG file, the program also allows you to trace the *average* of all the readings in a group.

The strip chart generated is in the same format as that provided by the STRIP program, execpt that the chart header indicates that the data was derived from a data file rather than from HP 3421A readings. If you are using a printer other than a ThinkJet, or wish to change the format of the printed charts, refer to appendix F, "Alternative Peripheral Options," for details on the PRINTSET subprogram.

To use the Chart command, press [C] from the main menu:

`Chrt Lst Prt Stat End?`	The main menu.
[C]	Press [C] to select the Chart command.
`Group?`	If the data file has been generated by the LOG program and more than one group has been recorded, the program asks for the group number to read. (If there is only one group, this prompt will not appear).
group number [ENDLINE]	Enter the group number (or 0 to escape back to the main menu), and press [ENDLINE].
`Number of traces?`	If data from more than one channel in the HP 3421A has been recorded, the program asks for the number of traces.
number of traces [ENDLINE]	Enter the number of traces to be printed, up to 9, and press [ENDLINE].
`* * Trace 1 * *`	The program displays the number of the trace being entered.
`Trace?`	If more than one trace was recorded in a data file from STRIP or MONITOR, the program asks for the *original* trace number to use.
trace number [ENDLINE]	Enter the original trace number, press [ENDLINE], and skip the next three steps.

```
Average (Y/N)?
```

[Y] or [N]

This option applies if the data file has been generated by the LOG program and the group contains multiple readings (several burst measurements, or the group scanned a series of channels, or a custom program stored multiple readings). If you select the "Average" option, the readings in the group are averaged and presented as a single number. This allows the average of a series of readings to be plotted against the data from one or more individual channels.

If there is only one reading per scan, this prompt will not appear, and the program will skip to the scaling prompts.

Press [Y] to use the average of the group's readings, or [N] to use an individual reading for the trace.

```
Channel?
```

If more than one channel has been recorded in a LOG group, the program asks for the channel number to use for the trace.

channel number [ENDLINE]

Enter the number of the HP 3421A channel that was measured.

```
Reading?
```

If burst readings were stored for a single channel or a custom program was used, the program asks for the reading to use.

reading number [ENDLINE]

Enter the number of the reading to use, and press [ENDLINE].

```
Scale minimum?
```

The program prompts for the scaling values for the strip chart.

scale minimum [ENDLINE]

Enter the value which represents the *lower bound* of the scale for this trace.

```
Scale maximum?
```

scale maximum [ENDLINE]

Enter the the value which represents the *upper bound* of the scale for this trace.

Repeat the previous steps for each trace in the chart.

```
Select scans (Y/N)?
```

The program asks if you wish to print a strip chart only from scans taken in a given time period.

Y or N

Press Y to specify the time and date of the beginning and end of the time period to print, or press N to print all records in the file and skip the next four steps.

```
Start date: YY/MM/DD
```

The program asks for the starting date of the time period.

start date ENDLINE

Enter the starting date in YY:MM:DD form and press ENDLINE.

```
Start time: HH:MM:SS
```

The program asks for the starting time in the first day of the time period.

start time ENDLINE

Enter the starting time in HH:MM:SS form (24hr clock) and press ENDLINE.

```
End date: YY/MM/DD
```

The program asks for the ending date of the time period.

end date ENDLINE

Enter the ending date in YY:MM:DD form and press ENDLINE.

```
End time: HH:MM:SS
```

The program asks for the ending time in the last day of the time period.

end time ENDLINE

Enter the ending time in HH:MM:SS form (24hr clock), and press ENDLINE.

```
Printing...
```

The program displays a status message while the chart is being printed.

```
Chrt Lst Prt Stat End?
```

The program returns to the main menu.

11.5 ENDING THE REPORT PROGRAM

The End command is used to end the program.

To end the program, press [E] from the main menu:

Chrt Lst Prt Stat End?	The main menu.
[E]	Press [E] to end the program.
Done	The program is finished.

THE TRANSFER PROGRAM

SECTION 12

12.1 DATA TRANSFER OPTIONS

The TRANSFER program is used to transfer data from LOG, STRIP, and MONITOR data files to the HP 44456 System Software package running on an HP Series 200 computer. HP 44456 is a Series 200-based software package for the HP 3852A Data Acquisition/Control Unit. However, the numerous HP 44456 data analysis tools can be applied to HP-71 Data Acquisition Pac data once the data is transferred with the TRANSFER program. TRANSFER offers two options for moving the data:

- **One scan/vector:** A single scan of a trace or channel group in the HP-71 corresponds to a *vector* in the HP 44456 package. Data transfer consists of transmitting single scans, each of which becomes a *vector*.

- **One reading/vector:** The set of data for a particular reading within each scan corresponds to a *vector* in the HP 44456 package. Data transfer consists of transmitting data for each reading, each of which becomes a *vector*.

For example, if a strip chart data file contains 20 scans, and each scan contains three readings:

- Transferring the data one scan/vector will produce 20 vectors, each containing three values.

- Transferring the data one reading/vector will produce three vectors, each containing 20 values.

The choice of which method to use depends on the application and how the data is to be used by the HP 44456 package.

NOTE

Because of the structure of the data files in the HP-71 (refer to appendix H), transferring the data one reading/vector requires significantly more file I/O, resulting in increased execution time. If the file is on a mass storage device, more physical I/O is required, resulting in increased execution time and media wear.

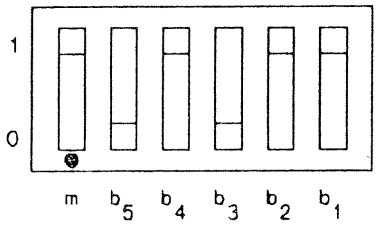
There are three steps to transferring data between the HP-71 and an HP Series 200 computer:

- Establish a hardware link between the two computers for data transfer.

- Run the program XFER200 on the HP Series 200 computer. This program prompts for the address of the HP-IL/HP-IB interface and the name of the vector to be stored.

- Run the program TRANSFER in the HP-71 Data Acquisition Pac. This program prompts for name of the data file to be transferred.

To establish the link between the HP-71 and the HP 44456 package, configure an HP 82169A HP-IL/HP-IB Interface in mailbox mode and connect it to both the HP-71 and the Series 200 computer. Mailbox mode is established by setting bit *m* to 1 and setting the address switches b_1 to b_5 to the desired HP-IB address.



The HP-IL/HP-IB interface switches configured for *mailbox* mode at HP-IB address 11.

For further details about the configuration of the mailbox, refer to section 4 of the *HP 82169A HP-IL/HP-IB Interface Owner's Manual.*

NOTE

TRANSFER on the HP-71 will always use the *first* HP-IL/HP-IB interface found on the primary HP-IL loop (loop 1).

12.2 STARTING THE SERIES 200 PROGRAM

The program for the HP Series 200 computer is provided on the supplemental disc, and should be started *before* starting the TRANSFER program on the HP-71. Like the rest of the HP 44456 package, it runs under the HP Series 200 BASIC 3.0 (or greater) operating system. The program is provided in two forms:

- As a subprogram for use with the rest of the HP 44456 package. See "Using The FROM71 Subprogram" later in this section.
- As a ready-to-use program, with necessary subprograms from the HP 44456 package. Instructions follow.

To run the ready-to-use program on the Series 200 computer, load XFER200 from the disc and RUN it. The program will prompt for the address of the HP-IL/HP-IB interface. If the interface is configured as shown above, and if the HP-IB interface on the Series 200 computer is at select code 7, the proper response would be 711. The program will then prompt for the name of the vector set. This name, suffixed by successive digits, will be the name of the vectors transferred from the HP-71. For example, responding MYDATA:MEMORY,0,15 to the prompts for the vector set name will result in vectors named MYDATA1, MYDATA2, and so on in the internal memory volume (:MEMORY,0,15).

At this point, the program will be ready to receive data from the mailbox.

During execution, the Series 200 transfer program displays status messages describing the state of the transfer:

- Before the HP-71 begins transmitting the data, the Series 200 computer will display "Waiting For Data".
- After data transmission starts, the Series 200 computer will display the vector name, followed by a running count of the number of items transferred.
- When the Series 200 computer is waiting for another vector to be sent, it displays "Awaiting Another Vector". This means that the HP-71 is between vectors or is awaiting entry of another group number.

12.3 STARTING THE TRANSFER PROGRAM

Once the program on the Series 200 computer is ready to receive data from the mailbox, run the transfer program in the HP-71 Data Acquisition Pac:

RUN TRANSFER [ENDLINE]

Run the TRANSFER program.

```
File name?
```

file name [ENDLINE]

The program prompts for the name of the data file to be read.

Enter the name of a **LOG**, **STRIP**, or **MONITOR** data file and press [ENDLINE]. If the file resides on a mass storage device, be sure to include the device specifier, eg: LOGFILE:HP9114.

```
Reading...
```

The program displays a status message while the file header is read.

```
One scan/vector (Y/N)?
```

[Y] or [N]

The program asks if you wish to transfer data in one scan/vector order.

Press [N] to transfer data in one reading/vector order, or [Y] to transfer data in one scan/vector order.

```
Group # (0 to end)?
```

group number [ENDLINE]

If the data file has been created by the LOG program, the program prompts for the number of the channel group to be transferred.

Enter the group number and press [ENDLINE].

```
Select scans (Y/N)?
```

[Y] or [N]

The program asks if you wish to transfer only scans taken in a given time period.

Press [N] to transfer all scans in the data file for the specified group, or [Y] to specify a time interval.

If all the scans for the group are to be transferred, skip the next four steps.

```
Start date: YY/MM/DD
```

start date [ENDLINE]

The program asks for the starting date of the time period.

Enter the starting date in YY/MM/DD form, and press [ENDLINE].

```
Start time: HH:MM:SS
```

start time [ENDLINE]

The program asks for the starting time in the first day of the time period.

Enter the starting time in HH:MM:SS form (24hr clock) and press [ENDLINE].

```
End date: YY/MM/DD
```

end date [ENDLINE]

The program asks for the ending date of the time period.

Enter the ending date in YY/MM/DD form and press [ENDLINE].

```
End time: HH:MM:SS
```

end time [ENDLINE]

The program asks for the ending time in the last day of the time period.

Enter the ending time in HH:MM:SS form (24hr clock), and press [ENDLINE].

```
Working...
```

The program displays a status message while the data file is read and data is transferred.

Note that if the data is being transferred in one reading/vector order, TRANSFER must first scan the entire file before actually transferring any data. Depending on file size, this can result in a significant delay before data transfer actually begins.

```
Done
```

When all the scans in the data file have been processed, the program ends.

When the program ends, an ending command is sent to the HP 44456 package, which causes that program to terminate.

12.4 IF SOMETHING GOES WRONG

Ordinarily, TRANSFER and XFER200 should be able to stop in an orderly manner if data transfer cannot proceed normally. Specifically, if TRANSFER cannot read the data file, it will send a signal terminating XFER200. Likewise, if XFER200 receives invalid data, it will send a signal terminating TRANSFER.

Sometimes one of the programs may terminate without being able to send a signal to the other, leaving the other program hanging. For example, if XFER200 cannot create a vector, it will stop without sending any signal to TRANSFER. If one program terminates without stopping the other, the following procedures can be used to regain control of the hung program:

- If XFER200 stops without terminating TRANSFER, halt TRANSFER by pressing ATTN twice and restore the loop by performing RESET HPIL and RESTORE IO on the HP-71.
- If TRANSFER stops without terminating XFER200, try halting XFER200 by pressing **PAUSE**. Failing that, use **CLR I/O**. Failing that, the program can be stopped with **RESET** (shift **PAUSE**).

12.5 HANDLING OF NUMERIC EXCEPTIONS

Normally, extremely large numbers, extremely small numbers, and NaNs* will not occur when using the HP 3421A Data Acquisition/Control Unit. It is possible, however, for a custom conversion program to generate numbers out of the normal range of the HP 3421A. Under these circumstances, TRANSFER will make the following conversions for compatibility with the Series 200 computers:

- If a value being transferred has an absolute value greater than 1.0E+308, TRANSFER will replace it with ±1.0E+308. This will also occur for a value of Inf.
- If a value being transferred has an absolute value less than 1.0E-307, TRANSFER will replace it with 0.
- If a value being transferred is NaN, TRANSFER will replace it with the value 9999999999. This is in keeping with the HP 3421A method of representing out-of-range readings. (Note that, except in the case of unusual activity in a custom conversion program, a value of NaN will never occur.)

---

*A NaN (Not-a-Number) is a special value generated to conform to the IEEE proposal for floating-point arithmetic. It is explained more fully in the *HP-71 Owner's Manual*.

12.6 USING THE FROM71 SUBPROGRAM

The Series 200 BASIC From71 subprogram is contained in FROM71 on the supplemental disc. A familiarity with the HP 44456 package is assumed.

To load the From71 subprogram, perform a LOADSUB FROM71 FROM "FROM71" or LOADSUB ALL FROM "FROM71". Additional subprograms needed to use From71 are:

1) Hpnav_prterror (from SYSTEM)

2) Hpnav_disperror (from SYSTEM)

3) Save_rvect (from DATA_STORE)

Entry and exit conditions for the subprogram are as follows:

INVOCATION:

From71(Vectname$, INTEGER Mailbox, Errorflag)

ENTRY:

Vectname$	Name of the vector series. This must be short enough to accommodate a 4 digit numeric postfix for the file names (e.g.: VOLTSdddd).
Mailbox	HP-IB address of the HP 82169A HP-IL/HP-IB Interface. The interface must be set in "mailbox" mode.

EXIT:

ERRORFLAG	0	No errors.
	1	Transfer is aborted by the HP-71.
	2	Data received is not recognized as IEEE real.
	3	The HP-71 sends an unrecognized command.
	4	Other abnormal termination.

THE MSDOSXFR PROGRAM

SECTION 13

13.1 INTRODUCTION

The MSDOSXFR program provides a method to transfer data from STRIP, MONITOR, and LOG data files to MS-DOS® machines such as the HP 150, The Portable, The Portable Plus, and the IBM PC family. It does this by creating files on an MS-DOS-format disc either directly (through an HP 9114A Disc Drive) or through the HPLINK program on a host computer.

13.2 HARDWARE AND SOFTWARE REQUIREMENTS

Hardware and software requirements are as follows:

HP 9114A	No additional hardware or software is required to transfer data to a 3-1/2 inch micro-floppy disc in an HP 9114 Disc Drive.
Portable	No additional hardware is required to transfer data into The Portable and The Portable Plus. The built-in ROM disc contains the necessary HPLINK software for comunications.
HP 150	Requires the Extended I/O Accessory (part number 45643A) and HPLINK software (included with 45463A).
IBM PC/AT/XT	Requires the HP-IL Interface (part number 82973A) and the HPLINK software (included with the 82973A).

The remainder of this section will refer to the disc drive or whatever device is receiving the data as the "target device".

MS-DOS is a registered trademark of Microsoft, Inc.

Note For Advanced Users:

In addition to the above products, the MSDOSXFR program may transfer data to other target devices. The requirements for performing data transfer from MSDOSXFR are a follows:

- HP-71 can communicate with target device via HP-IL.
- Target device has an accessory ID indicating that it is a mass storage device (between 16 and 31, inclusive).
- Target device uses Subset/80 command protocol.
- Target device contains an MS-DOS-format disc (or disc image).

13.3 FORMAT OF TARGET FILE

The MS-DOS file created is a PRN format file, much like that created by a /PF command in Lotus 1-2-3®. The file is directly compatible with the /FI command in 1-2-3, and can be easily read into 1-2-3 for further analysis. Lotus 1-2-3 expects a file read in this way to have the .PRN extension. For this reason, it is recommended that files created by MSDOSXFR be named with the .PRN extension, although MSDOSXFR does not force you to do this.

13.4 COMMUNICATIONS BETWEEN HP-71 AND TARGET DEVICE

Before MSDOSXFR is run, it is important to understand some of the details of communicating with the target device:

- It is necessary in MSDOSXFR for you to specify the HP-IL address of the target device. While the HP 9114A Disc Drive can be referenced by its device ID(HP9114), a host computer running HPLINK does not have a device ID. It must be referenced by its loop address or by its accessory ID.
- Many target devices support more than one disc drive. In this case, MSDOSXFR will ask which "unit" is to receive the data. For an MS-DOS machine running HPLINK, unit 0 corresponds to disc "A:", unit 1 corresponds to disc "B:", etc. For a multiple-unit disc drive, refer to the owner's manual.
- When running MSDOSXFR, the HP-71 is the loop controller. A host computer running HPLINK is *not* loop controller, and *cannot* access other devices (such as disc drives) on the loop.

1-2-3 is a registered trademark of Lotus Development Corporation.

13.5 SAMPLE DESTINATION NAMES

The name of the file which will be created in MS-DOS must include the address of the target device. The format for this name is:

<device>:[<path>]<filename>[.<extension>]

The optional <path> allows you to specify a subdirectory path to the file. For example, a path and filename of "A\B\C.PRN" specifies file C.PRN in subdirectory B within subdirectory A.*

The optional <extension>, if not specified, will be blank.

Examples:

HP9114A:MYFILE.PRN	Indicates MYFILE.PRN on the HP 9114A Disc Drive.
3:DATA.PRN	Indicates DATA.PRN on a target device at loop address 3 (third device on the loop).
%17:junk.prn	Indicates JUNK.PRN on the first device on the loop with an accessory ID of 17 (usually, this will be a host computer running HPLINK).
5:dir\newdata.prn	Indicates NEWDATA.PRN in directory DIR on a target device at loop address 5.

If the target device supports multiple units, the program will prompt for the unit number.

NOTE

If you are using the HP 82402A Dual HP-IL Adapter, the target device must be on loop 1.

13.6 RUNNING MSDOSXFR

The MSDOSXFR program consists of two parts: the BASIC program MSDOSXFR and the LEXfile FATLEX. Both files must be present in the HP-71 for the program to run. In addition, the HP-71 must have the HP-IL module and the HP-71 Data Acquisition Pac installed.

Once MSDOSXFR and FATLEX have been copied into the HP-71, be sure that the loop is set up for the desired data transfer. If the target device is a disc drive, it should be in the loop and should contain an

---

*The MS-DOS path separation character, "\", is not a standard key on the HP-71. If you wish to use <path>, you should redefine a rarely-used key to "\", and enter USER mode. For example, executing DEF KEY "}",CHR$(92); will redefine the "}" key to "\" whenever the HP-71 is in USER mode.

MS-DOS-format disc (MSDOSXFR will *not* format an unformatted disc). If the target device is a computer, it should be running **HPLINK** *before* being added to the loop. If the loop has been disrupted, it may be necessary to perform a RESET HPIL and RESTORE IO before continuing.

Once the loop has been properly configured, run the MSDOSXFR program:

RUN MSDOSXFR [ENDLINE]

Run the program.

```
HP-71 file name?
```

file name [ENDLINE]

The program prompts for the name of the data file to transfer.

Enter the name of the STRIP, MONITOR or LOG data file that you wish to transfer.

```
Reading...
```

The HP-71 examines the file to be transmitted.

```
<dev>:<file>[.ext]?
```

destination filename [ENDLINE]

The program prompts for the name of the MS-DOS file to be created.

Enter the file name in the form indicated, and press [ENDLINE].

```
Unit number?
```

unit number [ENDLINE]

If the target device supports multiple units, the program prompts for the unit number.

Enter the unit number corresponding to the desired target disc.

The program will now take a few moments to examine the MS-DOS disc. The amount of time is variable; just a few seconds for a floppy disc to over a minute for a large hard disc.

```
Group #?
```

group number [ENDLINE]

If the data being transferred is from a LOG experiment, the program asks for the group number to transfer.

Enter the group number, and press [ENDLINE].

```
Select scans (Y/N)?
```

[Y] or [N]

The program asks if you wish to selectively transfer scans.

Press [N] to transfer all scans in the group. Press [Y] to specify a time and date window within the file from which to transfer data, and answer the following four questions:

```
Start date: YY/MM/DD
```

start date [ENDLINE]

The program asks for the starting date of the time period.

Enter the starting date in YY/MM/DD form, and press [ENDLINE].

```
Start time: HH:MM:SS
```

start time [ENDLINE]

The program asks for the starting time in the first day of the time period.

Enter the starting time in HH:MM:SS form (24hr clock) and press [ENDLINE].

```
End date: YY/MM/DD
```

end date [ENDLINE]

The program asks for the ending date of the time period.

Enter the ending date in YY/MM/DD form and press [ENDLINE].

```
End time: HH:MM:SS
```

end time [ENDLINE]

The program asks for the ending time in the last day of the time period.

Enter the ending time in HH:MM:SS form (24hr clock), and press [ENDLINE].

```
Working...
```

The program displays a status message while the data file is read and data is recorded on the target device.

```
Done
```

When all the scans in the data file have been processed, the program ends.

13.7 READING DATA INTO LOTUS 1-2-3

The data written to the target device can be read into Lotus 1-2-3 for further analysis with the powerful tools in 1-2-3. To read the data, use the /FI (File Import) command with the N (Numbers) option. The position of the worksheet cell pointer will be the upper left corner of the region occupied by the imported data.

Lotus 1-2-3 expects files read in this way to conform to a certain format (which is used by MSDOSXFR) and to have the filename extension ".PRN". A file created by MSDOSXFR under the name MYFILE.PRN can be read into 1-2-3 with the key sequence /FINMYFILE followed by a <return>.

Every row in the Import file will correspond to one scan. The first column will contain the date of the scan (in text form YY/MM/DD). The second column will contain the time of the scan (in text form HH:MM:SS). The remaining columns will contain the actual data collected with each scan: from 1 to 30 columns of numeric data.

NOTE

Lotus 1-2-3 cannot import files with a record length greater than 240 characters (a record corresponds to one row in import files). While this limitation is usually not a problem, there are rare cases where groups with very wide scans (such as a 30-scan burst) may not be readable by 1-2-3.

The exact record width in the MS-DOS import file is dependent on how many readings comprise the scan and the number of characters needed to represent those readings. Each record in the MS-DOS import file uses a fixed overhead of 21 characters, plus one character per reading plus the number of characters needed to represent the readings in the HP-71 STD format. (For example, a reading of "1" requires one character; a reading of "12345000" requires 8 characters.)

13.8 HANDLING OF NUMERIC EXCEPTIONS

Normally, extremely large numbers, extremely small numbers, and NaNs* will not occur when using the HP 3421A Data Acquisition/Control Unit. It is possible, however, for a custom conversion program to generate numbers out of the normal range of the HP 3421A. Under these circumstances, MSDOSXFR will make the following conversions for compatibility with Lotus 1-2-3:

- If a value being transferred has an absolute value greater than 9.9999999E+99, MSDOSXFR will replace it with ±9.9999999E+99. This will also occur for a value of Inf.
- If a value being transferred has an absolute value less than 1.0E-99, MSDOSXFR will replace it with 0.
- If a value being transferred is NaN, MSDOSXFR will replace it with the text value "NaN". As with all text cells, 1-2-3 will interpret such a cell as containing 0. (Note that, except in the case of unusual activity in a custom conversion program, a value of NaN will never occur.)

13.9 MEMORY REQUIREMENTS OF MSDOSXFR

The memory requirements of MSDOSXFR are variable, and depend on the disc size of the target device. A 14 Mbyte hard disc, for example, might easily require 10 to 12K-bytes of HP-71 memory for storage and manipulation of the File Allocation Table; a micro-floppy may require only 1500 bytes. Because of this, it is impossible to determine program memory requirements until the target device and unit number have actually been identified. At that time, the program may terminate for lack of memory.

---

*A NaN (Not-a-Number) is a special value generated to conform to the IEEE proposal for floating-point arithmetic. It is explained more fully in the *HP-71 Owner's Manual*.

OPERATIONAL VERIFICATION

SECTION 14

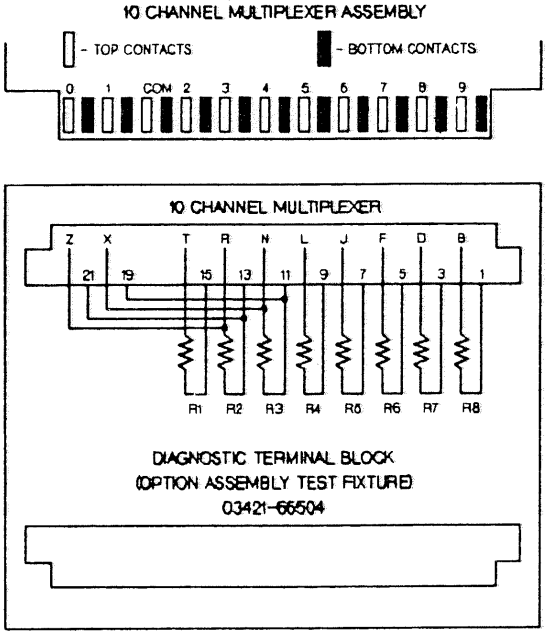
The VERIFY program may be used to verify the proper operation of the HP 3421A Data Acquisition/Control Unit and the optional multiplexer or digital I/O cards. Note that the verification procedure just verifies that the equipment is functional. The procedure does not verify that the equipment is operating within specification tolerances.

The VERIFY program uses the Diagnostic Terminal Block (or DTB), also called the Option Assembly Test Fixture (03421-66504) to test the option cards. The verification procedure performs the following steps:

- Verifies proper communication with the HP 3421A.
- Reads the status registers to determine the configuration.
- For each option card, prompts for the installation of the DTB, and checks the operation of each channel on that card.

14.1 RELAY CARD TEST

The 10-channel multiplexer assembly test measures the total resistance between the high and low terminals for each relay acquisition channel, using a known resistance of 100Ω +/- 0.1% (part of the DTB) placed across the input terminals. This checks the resistance of the relay contacts and will indicate either a bad relay, or PC board leakage due to corrosion, contaminants, etc.



The resistance of each channel (0-9) on the card is checked sequentially, using the 2-wire ohms function. Channels 0 and 1 are first checked to see if they are actuators. If they are actuators, the actuator channel

is closed simultaneously with another channel, shorting out the 100Ω resistor on the other channel. The sum resistance should now only include two sets of relay contacts and the fuse in the actuator channel. The program checks for a value of <3.1Ω.

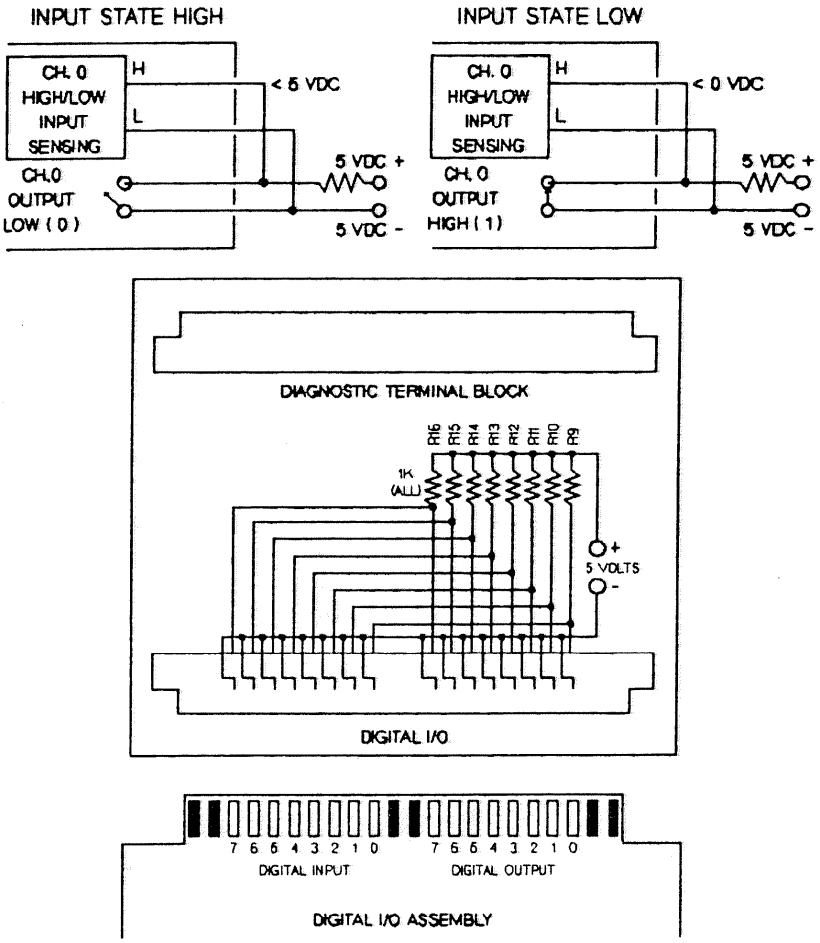
Channel 2 on the relay card may have a 900KΩ resistor in series, and a 101.5KΩ resistor in parallel, with the channel as part of a "divide-by-10" network. When the 100Ω load from the DTB is added to this circuit, the theoretical total load resistance for channel 2 is 91216Ω to 91307Ω. If it is in this range, the "divide-by-10" circuit is in use and the test passes. If it is outside of this range, channel 2 is assumed to be the same as a standard acquisition channel.

Standard acquisition channels (3-9, and 0 through 2, depending upon the configuration) are checked for a resistance in the range of 99.9Ω to 101.65Ω.

If the relay card being tested has been modified with additional "divide-by-10" networks (part of accessory package 44469A), those channels will fail the test.

14.2 DIGITAL CARD TEST

The digital card test requires that you connect 5 Vdc (24 Vdc maximum) to the DTB at the time the DTB is installed. The program runs a high/low test on each channel (0-7) for this card, utilizing both the input and output sides of the channel.



When the test begins, the program opens all channels in the instrument. With all of the channel outputs on the card open (set to the low state), the 5 Vdc supply, sensed through the DTB pull-up resistor for each channel, should set a high state on each channel input.

If the channel input is low, the problem could be either that the output will not go to a low state, or that the input is incapable of sensing a high state.

If the first test passes, the program closes the channel output, and checks the channel input for a low state. The input should be low because with the channel output closed, the bottom side of the DTB pull-up resistor for that channel should be connected to the minus side of the 5 Vdc supply.

If the channel input tests high, the problem could be either that the output will not go to a high state, or that the input is incapable of sensing a low state.

14.3 RUNNING THE TEST

To prepare the HP 3421A Data Acquisition/Control Unit for the test, remove any test assemblies connected to the option cards, and install the instrument as the first device on the (first) interface loop. If any relay card is configured for 4-wire Ω, connect the 4-wire Ω terminals to the 2 wire Ω/volts terminals on the front panel. Otherwise leave the front panel terminals disconnected.

`RUN VERIFY [ENDLINE]` — Run the verification program.

`Reading 3421...` — The program finds and resets the first HP 3421A on the loop, and reads the status registers to determine the configuration.

`Prepare Mux Slot 0?`

[Y], [N], or [Q] — If the first slot has a multiplexer card installed, the program waits for you to install the DTB. Press [Y] when the DTB is ready. Press [N] to advance to the test for the next slot. Press [Q] to end the program.

`Prepare Dig Slot 0?`

[Y], [N], [Q] — If the first slot has a digital I/O assembly installed, the program waits for you to install the DTB and connect the 5V supply. Press [Y] when the DTB is ready. Press [N] to advance to the test for the next slot. Press [Q] to end the program.

`Testing Channel 0` — As each channel is tested, the program displays a message indicating the progress of the test.

`Channel nn Fails` — If a channel fails, the program will sound a beep on the HP-71 and display this message.

`nn Errors Found` — After all slots have been tested, the program indicates the number of errors found.

CARE, WARRANTY, AND SERVICE INFORMATION

APPENDIX
A

A.1 CARE OF THE MODULE

The HP 82479A Data Acquisition Pac ROM module does not require maintenance. However, there are several precautions, listed below, that you should observe.

CAUTION

- Do not place fingers, tools, or other objects into the plug-in ports. Damage to plug-in module contacts and the computer's internal circuitry may result. Such actions could result in minor electrical shock hazard and interference with pacemaker devices worn by some persons.
- Turn off the computer (press [f][OFF]) before installing or removing a plug-in module.
- If a module jams when inserted into a port, it may be upside down. Attempting to force it further may result in damage to the computer or the module.
- Handle the plug-in modules very carefully while they are out of the computer. Do not insert any objects in the module connector socket. Always keep a blank module in the computer port when a module is not installed. Failure to observe these cautions may result in damage to the module or the computer.

A.2 LIMITED ONE-YEAR WARRANTY

What We Will Do

The HP 82479A Data Acquisition Pac ROM module is warranted by Hewlett-Packard against defects in materials and workmanship affecting electronic and mechanical performance, but not software content, for one year from the date of original purchase. If you sell your unit or give it as a gift, the warranty is transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair, or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to a Hewlett-Packard service center.

What Is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than an authorized Hewlett-Packard service center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY.** Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **IN NO EVENT SHALL HEWLETT-PACKARD BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country.

Warranty for Consumer Transactions in the United Kingdom

This warranty shall not apply to consumer transactions and shall not affect the statutory rights of a consumer. In relation to such transactions, the rights and obligations of Seller and Buyer shall be determined by statute.

Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of manufacture. Hewlett-Packard shall have no obligation to modify or update products once sold.

Warranty Information

If you have any questions concerning this warranty, please contact an authorized Hewlett-Packard dealer or a Hewlett-Packard sales and service office. Should you be unable to contact them, please contact:

- In the United States:

Hewlett-Packard
Personal Computer Group
Customer Support
11000 Wolfe Road
Cupertino, CA 95014

Toll-Free Number: (800) FOR-HPPC (800 367-4772)

• In Europe:

Hewlett-Packard S.A.
150, route du Nant-d'Avril
P.O. Box CH-1217 Meyrin 2
Geneva
Switzerland
Telephone: (022) 83 81 11

Note: Do *not* send units to this address for repair.

• In other countries:

Hewlett-Packard Intercontinental
3495 Deer Creek Rd.
Palo Alto, California 94304
U.S.A.
Telephone: (415) 857-1501

Note: Do *not* send units to this address for repair.

A.3 SERVICE

Hewlett-Packard maintains service centers in most major countries throughout the world. You may have your unit repaired at a Hewlett-Packard service center any time it needs service, whether the unit is under warranty or not. There is a charge for repairs after the one-year warranty period.

Hewlett-Packard products are normally repaired and reshipped within five (5) working days of receipt at any service center. This is an average time and could vary depending upon the time of year and the work load at the service center. The total time you are without your unit will depend largely on the shipping time.

Obtaining Repair Service in the United States

The Hewlett-Packard United States Service Center for battery-powered computational products is located in Corvallis, Oregon:

Hewlett-Packard Company
Service Department

P.O. Box 999
Corvallis, Oregon 97339, U.S.A.
or
1030 N.E. Circle Blvd.
Corvallis, Oregon 97330, U.S.A.

Telephone: (503) 757-2000

Obtaining Repair Service in Europe

Service centers are maintained at the following locations. For countries not listed, contact the dealer or sales office where you purchased your unit.

AUSTRIA
HEWLETT-PACKARD Ges. m. b. H.
Kleinrechner-Service
Wagramerstrasse-Lieblgasse 1
A-1220 Wien (Vienna)
Telephone: (0222) 23 65 11

BELGIUM
HEWLETT-PACKARD BELGIUM SA/NV
Woluwedal 100
B-1200 Brussels
Telephone: (02) 762 32 00

DENMARK
HEWLETT-PACKARD A/S
Datavej 52
DK-3460 Birkerod (Copenhagen)
Telephone: (02) 81 66 40

EASTERN EUROPE
Refer to the address listed under Austria.

FINLAND
HEWLETT-PACKARD OY
Revontulentie 7
SF-02100 Espoo 10 (Helsinki)
Telephone: (90) 455 02 11

FRANCE
HEWLETT-PACKARD FRANCE
Division Informatique Personnelle
S.A.V. Calculateurs de Poche
F-91947 Les Ulis Cedex
Telephone: (6) 907 78 25

GERMANY
HEWLETT-PACKARD GmbH
Kleinrechner-Service
Vertriebszentrale
Berner Strasse 117
Postfach 560 140
D-6000 Frankfurt 56
Telephone: (611) 50041

ITALY
HEWLETT-PACKARD ITALIANA S.P.A.
Casella postale 3645 (Milano)
Via G. Di Vittorio, 9
I-20063 Cernusco Sul Naviglio (Milan)
Telephone: (2) 90 36 91

NETHERLANDS
HEWLETT-PACKARD NEDERLAND B.V.
Van Heuven Goedhartiaan 121
NL-1181 KK Amstelveen (Amsterdam)
P.O. Box 667
Telephone: (020) 472021

NORWAY
HEWLETT-PACKARD NORGE A/S
P.O. Box 34
Oesterndalen 18
N-1345 Oesteras (Oslo)
Telephone: (2) 17 11 80

SPAIN
HEWLETT-PACKARD ESPANOLA S.A.
Calle Jerez 3
E-Madrid 16
Telephone: (1) 458 2600

SWEDEN
HEWLETT-PACKARD SVERIGE AB
Skalholtsgatan 9, Kista
Box 19
S-163 93 Spanga (Stockholm)
Telephone: (08) 750 2000

SWITZERLAND
HEWLETT-PACKARD (SCHWEIZ) AG
Kleinrechner-Service
Allmend 2
CH-8967 Widen
Telephone: (057) 31 21 11

UNITED KINGDOM
HEWLETT-PACKARD Ltd
King Street Lane
GB-Winnersh, Wokingham
Berkshire RG11 5AR
Telephone: (0734) 784 774

International Service Information

Not all Hewlett-Packard service centers offer service for all models of HP products. However, if you bought your product from an authorized Hewlett-Packard dealer, you can be sure that service is available in the country where you bought it.

If you happen to be outside the country where you bought your unit, you can contact the local Hewlett-Packard service center to see if service is available for it. If service is unavailable, please ship the unit to the address listed above under Obtaining Repair Service in the United States. A list of service centers for other countries can be obtained by writing to that address. All shipping, reimportation arrangements, and customs costs are your responsibility.

Service Repair Charge

There is a standard repair charge for out-of-warranty repairs. The repair charges include all labor and materials. In the United states, the full charge is subject to the customer's local sales tax. In European countries, the full charge is subject to Value Added Tax (VAT) and similar taxes wherever applicable. All such taxes will appear as separate items on invoiced amounts.

Computer products damaged by accident or misuse are not covered by the fixed repair charges. In these situations, repair charges will be individually determined based on time and materials.

Service Warranty

Any out-of-warranty repairs are warranted against defects in materials and workmanship for a period of 90 days from date of service.

Shipping Instructions

Should your unit require service, return it with the following items:

- A completed Service Card, including a description of the problem.
- A sales receipt or other proof of purchase date if the one-year warranty has not expired.

The product, the Service Card, a brief description of the problem, and (if required) the proof of purchase date should be packaged in adequate protective packaging to prevent in-transit damage. Such damage is not covered by the one-year limited warranty; Hewlett-Packard suggests that you insure the shipment to the service center. The packaged unit should be shipped to the nearest Hewlett-Packard designated collection point or service center. Contact your dealer for assistance. (If you are not in the country where you originally purchased the unit, refer to "International Service Information" above.)

Whether the unit is under warranty or not, it is your responsibility to pay shipping charges for delivery to the Hewlett-Packard service center.

After warranty repairs are completed, the service center returns the unit with postage prepaid. On out-of-warranty repairs in the United States and some other countries, the unit is returned C.O.D. (covering shipping costs and the service charge).

Further Information

Circuitry and designs are proprietary to Hewlett-Packard, and service manuals are not available to customers.

Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard service center.

A.4 WHEN YOU NEED HELP

Hewlett-Packard is committed to providing after-sale support to its customers. To this end, our customer support department has established phone numbers that you can call if you have questions about this product.

Product Information. For information about Hewlett-Packard dealers, products, and prices, call the toll-free number below:

(800) FOR-HPPC
(800) 367-4772

Technical Assistance. For technical assistance with your product, call the number below:

(503) 757-2004

For either product information or technical assistance, you can also write to:

Hewlett-Packard
Portable Computer Division
Customer Technical Support
1000 N.E. Circle Blvd.
Corvallis, OR 97330

HP 3421A COMMAND REFERENCE

APPENDIX B

The keywords CMD3421, SEND3421, and the subprogram SCAN in the Data Management Pac send *command strings* to the HP 3421A Data Acquisition/Control Unit to select measurement and control options. The HP 3421A command set consists of *standard commands* and *advanced commands*. Each standard command performs a complete measurement or control function. Two or more advanced commands are generally required to perform a single measurement. Refer to the *HP 3421A Data Acquisition/Control Unit Operating, Programming, and Configuration Manual* for detailed information on each command.

Syntax:

[] means optional channel or bit list
<> means mandatory channel or bit list

Standard Commands

DCV [x,y,...z]

DC Volts. Sets the voltmeter to DCV (F1), Autorange (RA1), Autozero on (Z1), 5 1/2-digit resolution (N5). If no channel list is sent, the channel list is not changed but software single trigger is executed (T2). If a channel list is sent, the channels are measured in the order received (T3). DCV always opens the last channel before closing the next channel in the list. It exits with the last channel in the list closed. If no channel list was received, the channels remain in the same state they were in prior to the command. When the HP 3421A is addressed to talk, the readings are sent in the sequence of the channel list.

ACV [x,y,...z]

Same as for DCV but for AC Volts (F2) and 4 1/2 digit resolution (N4).

TWO [x,y,...z]

Same as for DCV but for 2-wire ohm (F3) measurements.

FWO [x,y,...z]

Same as for DCV but for 4-wire ohm (F4) measurements. Channels are automatically paired with x+10 MOD 30. Pairs are closed simultaneously.

TEM [x,y,...z]

Same as for DCV, but for temperature measurements (F6). A software-compensated T-type thermocouple converision is done, and the result is returned in Degrees C. TEM will take a REF temperature measurement on the HP 44462A Multiplexer assembly in the lowest numbered slot if no channel numbers are sent.

REF [x,y,...z]

Measures the temperature of the REFerence junction (F5) on the HP 44462A Multiplexer assembly where channel 'x' is. If 'x' is not sent, the assembly with a closed multiplexer channel is measured. If all channels are open, the HP 44462A assembly in the lowest numbered slot is measured. The result is returned in Degrees C.

FRQ [x,y,...z] — Measures frequency (F7) with a one-second gate time (G0) and 5 1/2-digit resolution. If no channel numbers are sent, the channel list is not changed, no channels are opened or closed, and a software single trigger (T2) is executed. If a channel list is sent, they are loaded, executed, and sent in the order given.

TOT [x] — Totalizes events (F7) up to a maximum count of 65,535. If channel 'x' is sent, all channels are opened before closing channel 'x'. The counter is zeroed, then starts totalizing. When the HP 3421A is addressed to talk it will send out the current subtotal without disrupting the counter. Note that if a TRIGGER command is received, the TOT is aborted and a frequency reading is taken.

CLS <x> — Close single channel 'x'. The HP 3421A first identifies the type of channel at 'x'. If the channel is an actuator (00, 01, 10, 11, 20, or 21 are possible actuator numbers), the actuator is closed. If the channel is a digital output, the output bit will be set. If the channel is a multiplexer, all other multiplexer channels will be opened before closing channel 'x'.

CLP <x> — Close a pair of channels. The HP 3421A opens all multiplexer channels, then closes channels x and x+10 MOD 30.

OPN [x] — Open channel(s). If channel 'x' is not sent, the OPN command will open all channels: digital outputs, actuators, and multiplexers. If 'x' is sent, that channel is opened.

REDi — Reads the digital input byte from slot i and replies with a decimal number from 0 to 255. This decimal number represents the values of the bits that were set.

WRTi, *value* — Write the decimal value [ab]c to slot i. The value must be in the range 0 to 255.

BIT<x>[,y,...z] — Reads the digital input bits (up to 30 in the bit list) and sends 0 if the bit is low or 1 if the bit is high.

Advanced Commands

Range Codes (RA1 = Autorange on, RA0 = off)

Function, Command	R-1	R0	R1	R2	R3	R4	R5	R6	R7
All functions off, F0	*	*	*	*	*	*	*	*	*
DC Volts, F1	.3V	3V	30V	300V	*	*	*	*	*
AC Volts, F2	*	3V	30V	*	*	*	*	*	*
Two Wire Ohms, F3	*	*	*	300	3K	30K	300K	3M	30M
Four Wire Ohms, F4	*	*	*	300	3K	30K	300K	3M	30M
Reference, F5	The range is automatically set by the REF command								
Temperature, F6	The range is automatically set by the TEM command								
Frequency, F7	Gate times: G-1 = .1 sec., G0 = 1 sec., G1 = 10 sec.								

* indicates an invalid combination of function and range.

Z0 Z1	Autozero off (Z0) or on (Z1).
N3 N4 N5	Number of digits of resolution: N3 = 3 1/2, N4 = 4 1/2, N5 = 5 1/2.
T0 T1 T2 T3 DTa	Trigger: T0 = hold trigger and enable channel list scan; T1 = internal trigger; T2 = software single trigger; T3 = triggers measurements from channel list and stores readings; DTa = digital trigger, triggers when digital input bit 'a' goes low.
AN *value*	AND mask, used with the MN command.
C [*cal value*]	Calibrate, refer to the *HP 3421A Data Acquisition/Control Unit Service Manual.*
DC [*slot, value*]	Digital clear specified output bits.
DS [*slot, value*]	Digital set specified output bits.
DN [*number 0-29*]	Display number. Note: send DN alone to turn off display number mode.
LS<*channel list*>	Load single channels into channel list.
LP<*channel list*>	Load channel pairs into channel list.
M [*value*]	Set SRQ mask.
MH<*bit*>	Monitor digital input bit and SRQ interrupt when the bit goes high.
ML<*bit*>	Monitor digital input bit and SRQ interrupt when the bit goes low.
MN<*slot*>	Monitor slot and compare to AN mask and XR mask. SRQ interrupt when result is zero.
RA0 RA1	Autorange off (RA0) and Autorange on (RA1).
RL	Read channel list.
RS	Reset the HP 3421A to power on state.
SI0	Initialize channel list pointer to beginning of list.
SI1	Opens channel and closes next channel in list.
SR	Read status registers.
UC<*channel*>	Unconditionally close specified channel.
XR [*value*]	Exclusive OR mask, used with the MN command.

CUSTOM PROGRAMS

APPENDIX C

The STRIP, MONITOR and LOG programs can call a user-written subprogram to obtain a measurement. This section gives information about the required syntax and structure for these subprograms.

C.1 STRIP AND MONITOR SUBPROGRAMS

The STRIP and MONITOR programs can call a subprogram for each channel in the display, and expects a single real number in return. The syntax for the subprogram header is:

SUB *subprogram-name*(*numeric variable*)

Program example:

```
10 SUB STRAIN(S)
20 V=DCVOLTS(14)
30 S=(V/.1738-1.003238)/2
40 END SUB
```

The strain gauge example is a simple one. A more sophisticated program could take measurements from other instruments, or use the monitor high/low capabilities of the HP 44465A Digital I/O Assembly to wait for the right time to take a measurement. Custom programs can also be used to perform specialized limit tests/actions (refer to appendix E).

C.2 LOG SUBPROGRAMS

The LOG program can call a subprogram for either data acquisition or control functions. The subprogram can return up to 30 readings for storage in the data file. The subprogram is called at the beginning of the data logging session to verify its existence, indicate how many readings will be returned for storage, and indicate memory requirements.

The syntax for the subprogram header is:

SUB *name* (*control, vector, count, group list, memory, errorflag*)

The parameters are:

- *control* - (input): The value is either 0 (if data is being taken) or 1 (if the call is for verification).
- *vector* - (output): A vector of 30 real numbers which is used to hold the data to be stored.
- *count* - (output): A number, returned to the LOG program, that indicates the number of readings that should be stored in the data file. The LOG program reads this value only once, and assumes thereafter that the number of readings to be stored will be constant.

- *group list* - (input/output): A string that contains one character for each group in the setup. Each character is a 'Y' if the group is currently active, or an N if the group is not active. For instance, if group 5 is active, the fifth character will be 'Y'. The subprogram can modify the contents of this string to activate or deactivate individual groups.

- *memory* - (output): A number which indicates the amount of memory required by the subprogram. This defaults to 500 bytes, enough for many applications, and may be ignored if 500 bytes is sufficient. **If the subprogram uses many variables or large arrays, the memory requirements must be specified, otherwise LOG may abort with a low memory error.** For instance, if the subprogram dimensions a real array of 100 elements and uses 19 variables, the memory requirements will be *at least* 990 bytes. For details on memory requirements of variables, refer to "System Characteristics" in the *HP-71 Reference Manual.*

- *errorflag* - (output): A number which indicates an error resulting from some problem in the subprogram. This number should be 0 if there are no errors, or 1 if an error is encountered. If an error is reported, the LOG program will end immediately.

CAUTION

There are five things that a custom program should *never* do:

- The custom programs should not alter HP-71 system flags or use flags 0 through 10. These flags are used for monitoring the status of the event scheduler in the LOG program, as well as other functions. Flags 11 through 63 are available for use.

- The custom programs should not corrupt the instrument buffer. If a second HP 3421A is used by a custom program, the instrument buffer should be restored.

- The custom programs should not use system timers #1 and #2. Timer #3 is available for use.

- The custom programs should not alter setup or data files being used by the calling program.

- Custom programs for LOG should *never* alter the number of characters in the grouplist, or set the characters in the string to other than 'Y' or N.

In the following program example, a device connected to an RS-232 interface is used in a data logging application. The device returns a reading in response to the command F1. Note that line 20 is used to tell the LOG program that 5 readings are to be stored. In the event of an error, the device is cleared, and the error flag 2 is set before returning to LOG.

Program example:

```
10 SUB STRAIN(C,V(),N,G$,M,Z)
20 IF C THEN Z=0 @ N=5 @ GOTO 120
30 R=DEVADDR(":RS232")
40 ON ERROR GOTO 110
50 FOR I=1 TO 5
60 OUTPUT :R;"F1"
70 ENTER :R;A
80 V(I)=(A/.1738-1.0003873)*PI
90 NEXT I
100 OFF ERROR @ Z=0 @ GOTO 120
110 Z=1 @ CLEAR R
120 END SUB
```

C.3 USING MULTIPLE HP 3421A INSTRUMENTS

If more than one HP 3421A is in the system, a custom program may use the keywords to control the second instrument *as long as the instrument buffer is restored to the original instrument.* This can be done by preserving the location of the currently active instrument, assigning the second instrument to take the measurements, and re-assigning the original instrument.

The following example, suitable for use by either STRIP or MONITOR, preserves the current HP 3421A assignment and measures DC Volts on channel 5 of the second HP 3421A on the loop:

```
10 SUB CUSTOM(V)          Custom program header
20 A$=ADR3421$            Preserve current address
30 USE3421 :HP3421(2)     Use the second HP 3421A on the loop
40 V=DCVOLTS(5)           Measure DC Volts on channel 5
50 USE3421 A$             Restore the original instrument
60 END SUB                End
```

CONVERSION PROGRAMS

APPENDIX D

The programs STRIP, MONITOR, and LOG give you the option to call a user-written *conversion program.* You can use a conversion program to change a measurement obtained from the HP 3421A Data Acquisition/Control Unit into more useful units. Conversion programs are written as BASIC subprograms which are called after a measurement has been taken, but before any limit tests are taken (if applicable).

D.1 STRIP AND MONITOR CONVERSIONS

The STRIP and MONITOR programs call the conversion program passing a single measurement. The syntax for a conversion program header is:

SUB *subprogram-name*(*numeric variable*)

Program example:

```
10 SUB STRAIN(S)
20 S=(S/.1738-1.003238)/2
30 END SUB
```

This is the simplest form of a conversion program. A number is received, altered through an equation, and returned to the calling program. More complex conversion programs might evaluate a polynomial solution, do a table look-up, etc.

D.2 LOG CONVERSIONS

The LOG program calls the conversion program passing a vector of raw measurements and the number of measurements to be converted. The syntax for the conversion program header is:

SUB *subprogram-name*(*vector*, *numeric variable*)

Program example:

```
10 SUB STRAINL(R(),C)
20 FOR I=1 TO C
30 R(I)=R(I)/13.283+3
40 NEXT I
50 END SUB
```

This is the simplest form of a conversion program for the LOG program. As in the example above, the conversion might be more complex.

CAUTION

There are three things that a conversion program should *never* do:

- The conversion programs should not alter HP-71 system flags or use flags 0 through 10. These flags are used for monitoring the status of the event scheduler in the MONITOR and LOG programs, as well as other functions. Flags 11 through 63 are available for use.

- The conversion programs should not use system timers #1 and #2. Timer #3 is available for use.

- The conversion programs should not alter setup or data files being used by the calling program.

LIMIT PROGRAMS

APPENDIX E

The programs MONITOR and LOG give you the option to call a user-written *limit program* as one of the available limit actions. Limit programs may be used to perform specific actions that are not offered by the main program, such as controlling another instrument, or switching several actuators. Limit programs are written as BASIC subprograms.

There are two classes of limit activities: *transition events*, and *continuous events*. A transition event occurs only when a measurement crosses a pre-defined threshold. A continuous event occurs whenever a measurement is out of its normal range. The limit test system for the MONITOR and LOG programs uses *continuous* limits.

For example, suppose a limit test is applied to a level gauge, and the setup file specifies that a message is to be printed when the level rises above a certain level. If the measurement remains above the critical point for a large number of measurements, the printout might be rather long and redundant if the PRINT action is specified. A limit program could be used to build a *transition* action.

What follows is the syntax for the limit action program, and two examples.

E.1 SYNTAX

The MONITOR and LOG programs call the limit program passing the value of the measurement that triggered the limit action. The value passed to the limit program has already been processed by a conversion program, if any. The syntax for a limit program header is:

SUB *subprogram-name*(*measurement*)

The measurement is passed to the program as a real number which should not be altered by the limit program.

E.2 CONTINUOUS EVENTS

Continuous events occur each time a measurement is found to be out of its specified bounds by the MONITOR or LOG program.

Program example:

```
10 SUB ALARM(R)
20 IF R>=20 THEN 50
30 CLOSE 10 @ CLOSE 11
40 GOTO 130
50 IF R>45.66 THEN 90
60 OPEN 10 @ OPEN 11
70 PRINT "Heaters off at ";TIME$
80 GOTO 130
90 OPEN 21 @ FOR I=1 TO 5
```

```
100 CLOSE 1 @ WAIT .3 @ OPEN 1
110 IF I<5 THEN WAIT .3
120 NEXT I @ PRINT "ALARM ";TIME$
130 END SUB
```

This limit program examines the measurement to decide which action to take. If the measurement is less than 20, two actuators are closed. If the measurement is greater than 45.66, the program switches an alarm horn on and off five times by controlling an actuator, then prints a message. If the measurement is between 20 and 45.66 the program opens two actuators.

E.3 TRANSITION EVENTS

Transition events occur only when a measurement crosses a specified boundary. Some history must be available in order to determine that a measurement is out of bounds for the first time, defining the point at which the transition occurs.

To build this history, a limit program can use a data file to store the last reading that triggered a limit action. Suppose a limit action is desired which prints a message when a measurement rises above a *critical point* of 10 volts. In this example the limit program is part of a data logging application which scans a group every two minutes.

```
10 SUB TRANSLIM(R)
20 ON ERROR GOTO 90
30 ASSIGN #1 TO HISTORY:MAIN
40 READ #1;H
50 RESTORE #1
60 IF R>10 AND H>10 THEN 120
70 PRINT "Transition occured: ";TIME$
80 GOTO 120
90 OFF ERROR
100 CREATE DATA HISTORY,1,8
110 ASSIGN #1 TO HISTORY
120 PRINT #1;R
130 ASSIGN #1 TO *
140 END SUB
```

Lines 20 and 100 to 110 are used to create the file HISTORY if it is missing. Line 60 determines if the transition has occurred, and line 70 performs the limit action if the transition has occurred. Line 120 stores the current reading.

Notice that this system does not work very well unless the limit test is set up correctly in the setup file. For a transition to be observed, the history file must contain a reading *below* the critical point. This suggests that a "high" limit test should call the limit program for values that occur prior to the critical point. In the example above, the limit test should be at nine volts. This would permit values between nine volts and the critical point (10 volts) to be stored in the history file. As the voltage rises, the history file begins to record voltages until the transition is seen.

Another issue of concern with transition limits is the effect of spikes in the signal data. Using our example again, suppose the system is yielding readings of about five volts. A spike going directly to 12

volts could fail to trigger a limit action if no history file has been established, or if the history file contains a reading greater than or equal to the critical point. Two traps may be used to prevent these problems. If no history file is present *and* the measurement is above the critical point, the limit action could be executed anyway. Another test of R> 10 at line 95 would do this. The second solution is to use the history file technique in a custom program that acquires the data originally, and perform limit actions there.

CAUTION

There are three things that a limit program should *never* do:

- The limit program should not alter HP-71 system flags or use flags 0 through 10. These flags are used for monitoring the status of the event scheduler in the MONITOR and LOG programs, as well as other functions. Flags 11 through 63 are available for use.
- The limit programs should not use system timers #1 and #2. Timer #3 is available for use.
- The limit programs should not alter setup or data files being used by the calling program.

ALTERNATIVE PERIPHERAL OPTIONS

APPENDIX F

This appendix describes the use of user-written subprograms to control alternate output devices for strip chart and system monitor applications. Subprograms are also described for STRIP, MONITOR, or LOG setups without an HP 3421A Data Acquisition/Control Unit connected to the HP-71, or with the HP 3421A on the second or third loop.

The STRIP, REPORT and MONITOR programs were written primarily for use with the ThinkJet printer and the HP 92198A Mountain Computer HP-IL 80-Column Video Interface. There is a provision in each program which allows the use of a different device for output. An alternate output device may be specified by intercepting calls to either the PRINTSET or MONSET subprograms in the UTILITY file. These subprograms return the location and/or operating characteristics of the ThinkJet printer or the video interface.

The HP-71 scans user memory *before* looking in plug-in ROM modules when scanning for the PRINTSET or MONSET subprograms. This gives a "hook" to create a custom display monitor interface. If no subprograms are found with these names, the file UTILITY in the Data Acquisition Pac contains subprograms which will be executed to prepare the peripherals.

F.1 SPECIFYING ALTERNATE PRINTERS

The STRIP program assumes that the printer device is the HP 2225B ThinkJet printer. A provision in the software allows the use of alternate printers such as the HP 2631 for strip chart output.

When STRIP begins to run, the subprogram PRINTSET is called which returns the escape sequences for the various print options that are used.

The syntax for the subprogram is as follows:

SUB PRINTSET(*escapes array*)

The *escapes array* is a string array that contains the *escape sequences* which control the print options such as print size, lines per inch, etc. The array contains seven elements, numbered 0 to 6. The contents of each element as defined by PRINTSET in the file UTILITY are set as specified below for the ThinkJet printer. A \E indicates the Escape character (ASCII 27).

Element	Description	ThinkJet
0	Start STRIP/REPORT chart	\EE
1	Normal print mode	\E&k0S
2	Compressed print mode	\E&k2S
3	Enhanced print mode	\E&k3S
4	Enable perf skip, 8 lines/inch	\E&l1l8D
5	Form feed character*	
6	Exit STRIP/REPORT chart	\EE

* This should be used *only* if perf skip is not enabled (don't do both).

The supplemental disc provided with the Data Acquisition Pac contains a PRINTSET subprogram for the HP 82905B printer.

F.2 SPECIFYING ALTERNATE VIDEO DISPLAYS

The MONITOR program uses as the default display device the HP 92198A Mountain Computer HP-IL 80-Column Video Interface. A provision in the software allows the use of alternate devices such as the HP 150 or an 80-column display terminal to act as the video interface.

When MONITOR begins to run, the subprogram MONSET is called. This subprogram returns the address and operating commands for the current display device.

The syntax for the subprogram is as follows:

SUB MONSET(*device specifier string* , *escapes array* , *error*)

The *device specifier* is a string which contains the address of the video interface (refer to section 2.5, "Specifying HP-IL Devices" for more about device specifiers). The device specifier is returned as a null string (" ") if the device is not found.

The *escapes array* is a string array that contains the *escape sequences* which control the operation of the video interface. The contents of this array are described below.

The *error* variable is a number which is returned that indicates whether an error was encountered while configuring the display. This number is returned as 0 if no error was encountered. A non-zero number indicates that an error was detected.

The escapes array contains seven elements, numbered 0 to 6. In the following table, the contents of each element as defined by MONSET in the UTILITY are listed. A \E indicates the Escape character (ASCII 27); \X indicates ASCII 0; \Y indicates ASCII 22.

Element	Description	HP 92198A
0	Enter MONITOR (cursor off)	\E<
1	Home cursor	\EH
2	Clear to end of screen	\EJ
3	Clear to end of line	\EK
4	Enable display enhancement*	
5	Disable display enhancement	
6	Exit MONITOR	\E%\X\Y

* If this element is a null string, MONITOR assumes that setting the high bit in a character will enable the inverse video display enhancement.

F.2.1 Subprogram For the HP 2392 Terminal

The supplemental disc contains a MONSET subprogram for using a HP 2392 or HP 2393 terminal as the display device. The subprogram must reside in a file in main memory before running MONITOR. The subprogram uses the first HP-IL/RS-232 interface (on the lowest-numbered loop containing the interface) as the output device.

If you wish to designate an interface instead of allowing the subprogram to select one, EDIT the file and replace lines 20-60 with:

```
20 E=0 @ H$="<your interface name>"
```

F.2.2 Subprogram For the HP 2648 Terminal

The following subprogram contains the necessary escape sequences for using a HP 2648 terminal as the display device. The subprogram must reside in a file in main memory before running MONITOR.

```
10 SUB MONSET(H$,P$(),E)
20 H$="" @ E=0 @ ON ERROR GOTO 110
30 FOR I=1 TO 3 @ IF STATUS(I)<0 THEN END ELSE
   IF NOT BIT(STATUS(I),5) THEN 50
40 H=DEVADDR("RS232:"&STD$(I)) @ IF H=-1 THEN 50
   ELSE H$=STD$(H)&":"&STD$(I) @ GOTO 70
50 NEXT I
60 IF NOT LEN(H$) THEN END
70 E$=CHR$(27)
80 P$(0)="" @ P$(1)=E$&"H" @ P$(2)=E$&"J"
   @ P$(3)=E$&"K" @ P$(4)=E$&"&dB"
90 P$(5)=E$&"&d@" @ P$(6)=E$&"&a0c22Y"
100 END
110 E=ERRN
120 END SUB
```

F.3 WORKING WITHOUT an HP 3421A

The programs STRIP, MONITOR, and SETUP require that the HP 3421A be connected to the HP-71 in order to run. These programs call the subprogram CHANLIST (in the UTILITY file) to determine which options are present in the HP 3421A (and thus the type of each channel). If the HP 3421A is not available when a new setup is to be entered, such as in a production environment, the call to CHANLIST may be intercepted by placing a temporary CHANLIST substitute in main memory. The substitute will describe the instrument to be used (although the Run modules will not work).

The syntax for the subprogram is as follows:

CALL CHANLIST(*digital cards, mux cards, channel array, errorcode*)

The *digital cards* variable returns the number of digital cards installed in the HP 3421A.

The *mux cards* variable returns the number of multiplexer cards installed in the HP 3421A.

The *channel array* is a numeric array which indicate the type of each channel in the HP 3421A. The contents of this array are described below.

The *errorcode* is a number which is returned that indicates whether an error was encountered. This number is returned as 0 if no error was found.

The channel array contains 30 elements, numbered 0 to 29. Each element in the array contains the type of its corresponding channel in the HP 3421A. The types are:

Type	Description
0	The channel is empty.
1	The channel is an acquisition channel.
2	The channel is a digital channel.
3	The channel is an actuator channel.

The following example subprogram could be used to simulate a HP 3421A with the following options installed:

- Option 020 8 Channel Multiplexer/2 Channel Actuator Assembly in slot 0.
- Option 022 10 Channel Multiplexer Assembly in slot 1.
- Option 050 Digital I/O Assembly in slot 2.

```
10 SUB CHANLIST(B1,B2,C(),E)
20 DATA 3,3,1,1,1,1,1,1,1,1 ! Slot 0
30 DATA 1,1,1,1,1,1,1,1,1,1 ! Slot 1
40 DATA 2,2,2,2,2,2,2,2,0,0 ! Slot 2
50 FOR I=0 TO 29
60 READ C(I)
70 NEXT I
80 B1=2 @ B2=1 @ E=0
90 END SUB
```

F.4 WORKING WITH SEVERAL HP 3421A INSTRUMENTS

The application programs in the Data Acquisition Pac (execpt STATUS and VERIFY) call CHANLIST to set up the instrument buffer and read the channel types. The CHANLIST subprogram as supplied in UTILITY looks for the first HP 3421A on the first loop. Supplying the CHANLIST subprogram main memory allows the use of an HP 3421A in other locations. The following example illustrates a CHANLIST subprogram which will allow the application programs to use the third HP 3421A found on the second loop as the primary instrument.

```
10 SUB CHANLIST(B1,B2,C(),E)
20 ON ERROR GOTO 70 @ USE3421 :HP3421(3):2
30 FOR I=0 TO 29 @ C(I)=CHANTYPE(I) @ NEXT I
40 B1=(C(3)=1)+(C(13)=1)+(C(23)=1)
50 B2=(C(3)=2)+(C(13)=2)+(C(23)=2)
60 E=0 @ END
70 E=1 @ END SUB
```

If more than one HP 3421A is in the system, a custom program may use the keywords to control the second instrument *as long as the instrument buffer is restored to the original instrument.* This can be done by preserving the location of the currently active instrument, assigning the second instrument to take the measurements, and re-assigning the original instrument.

The following example, suitable for use by either STRIP or MONITOR, preserves the current HP 3421A assignment and measures DC Volts on channel 5 of the second HP3421 on the loop:

```
10 SUB CUSTOM(V)              Custom program header
20 A$=ADR3421$                Preserve current address
30 USE3421 :HP3421(2)         Use the second HP3421 on the loop
40 V=DCVOLTS(5)               Measure DC Volts on channel 5
50 USE3421$ A$                Restore the original instrument
60 END SUB                    End
```

ERROR RECOVERY

APPENDIX G

The programs in the Data Acquisition Pac perform many tests to verify that the setup information and data file operations for the STRIP, MONITOR, and LOG programs are proper. Under normal conditions, it should be impossible to configure a setup that cannot be executed correctly with the HP 3421A Data Acquisition/Control Unit, *as long as the* VERIFY *routines accept the setup information.* There are several instances where normal operation of these programs could encounter errors:

- **Low Memory:** Large setups may require a great deal of memory. Such setups, combined with calls to custom, conversion, or limit subprograms, can in some cases overflow available memory.
- **Corrupt Setup:** A setup which has not been validated by the VERIFY routine could still request an impossible function from the HP 3421A, such as DCVOLTS(24) when slot 2 contains a digital card.
- **Broken Loop:** During execution, a power "glitch" or operator error might cause a device to reset or lockup, the loop to break physically, or an invalid frame to return to the HP-71.

The STRIP, MONITOR, and LOG programs utilize error traps in an attempt to protect against the majority of problems that occur. When data is being collected, an error such as LOOP BROKEN causes a call to a subprogram RECOVER.

The HP-71 scans user memory *before* looking in plug-in ROM modules when scanning for the RECOVER subprogram. This gives a "hook" to create a custom error handling routine. If no subprograms called RECOVER are found in user memory, the file UTILITY in the Data Acquisition Pac module contains a subprogram called RECOVER, which will be executed.

G.1 LOW MEMORY CONDITIONS

A low memory error can occur under a variety of conditions, such as when very large setups are being executed, when large data files are being created in memory, or when user subprograms are being called. If a low memory condition occurs within the calling program, a message is displayed, and depending upon the module being executed, a branch to a menu usually occurs. The LOG program will end if a low memory condition occurs during execution. LOG will preserve the data that has been collected and display a message. The STRIP and MONITOR programs will return to the main menus with the ER: prefix if a low memory condition occurs while data is being collected.

The calling programs cannot protect against low memory conditions in user-written subprograms other than to ensure that sufficient memory exists to set up the call. If there is doubt about the memory available, the subprograms should employ some form of test to ensure that sufficient memory exists to execute properly. For example, if a custom program is written for LOG which requires an array of 100 real numbers, a test should be made to ensure that there is room for the array.

To minimize memory usage, save unneeded files to mass storage and load the setup information from a mass storage file, rather than keeping a copy in memory.

G.2 CORRUPT SETUP INFORMATION

If an impossible measurement request is sent to the HP 3421A, the RECOVER subprogram will be called. Since the error relates to instrument configuration, the programs will return to the main menu with the ER: prefix, or in the case of LOG, the program will end. A corrupt setup may be detected by using the Verify routine prior to running the setup.

G.3 LOOP AND DEVICE ERRORS

If a power fluctuation or device failure causes the loop to break or an invalid message to return to the HP-71, the RECOVER subprogram is called in an attempt to handle the error. In many cases this will be sufficient to keep the system running. If the loop cannot be restored by the RECOVER subprogram, the STRIP and MONITOR programs will return to the main menu with the ER: prefix. The LOG program will end with the error message in the display.

If the LOG program ends abnormally *and* data is being buffered, the file BUFFER may be present in main memory, containing data that should have been written to the file on the mass storage device. The program MERGEBUF (described later in this appendix) may be used to recover the data in the buffer file.

G.4 THE RECOVER SUBPROGRAM

The RECOVER subprogram in the UTILITY file is used to attempt recovery from common interface problems such as power fluctuations. It may also be used by new programs that use devices on HP-IL.

The call to the RECOVER subprogram is as follows:

```
CALL RECOVER(E)
```

The RECOVER subprogram in the Data Acquisition Pac takes the following steps:

1) Beeps and displays the error message eg: LOOP BROKEN.

2) Returns with E=1 if the error is not HP-IL related.

3) Attempts a RESTOREIO, returning with E=0 if successful.

4) Beeps and attempts a RESET HPIL @ RESTOREIO ten more times.

5) Returns with the parameter E set to "1" if unsuccessful.

Notice that the recovery subprogram provided works only with the *primary* interface loop. If more than one HP-IL interface is in the system, only loop 1 will be restored. A recovery program for more complex systems should account for the various kinds of errors that can arise *on each loop.*

WARNING

Some applications may require the system to go to a known-safe state in case of an equipment or power failure. For example, if a furnace heater is being controlled, it should go to the off state in case of failure. Note the following:

The HP 3421A Data Acquisition/Control Unit and the Option 020, 021, and 022 Multiplexer Assemblies use latching relays. The state of these relays can only be altered under program control. Under most conditions of failure, the relays will remain in whatever state the program last set them.

The HP 3421A Option 050 Digital I/O Assembly output switches are not latched. Under most conditions of failure the switches will go to the open state.

It is up to the programmer to provide the appropriate circuitry and recovery programs to ensure that the system under control goes to a known-safe state in case of an equipment or power failure. In some applications serious damage or injury may otherwise occur.

G.5 WRITING YOUR OWN RECOVER PROGRAM

System configurations which must be tolerant of unusual device failure possibilities or multiple loops (using the HP 82402A Dual HP-IL Adapter) may need specialized error recovery routines that are beyond the scope of the RECOVER program provided in the UTILITY file. The file search order of the HP-71 provides a "hook" that allows a subprogram RECOVER found in main memory to be executed in place of the subprogram provided in UTILITY. (Refer to section 12, "Subprograms and User-Defined Functions" in the *HP-71 Owner's Manual* for more about subprograms.)

Several tools are available to the programmer who must build a specialized RECOVER subprogram. They take the form of diagnostic keywords provided in the HP-71, the HP-IL module, and the Data Acquisition Pac. These keywords can be used to narrow down and repair the error that led to RECOVER.

The keywords are:

- ADR3421$ - Returns the device specifier of the current HP 3421A.
- BUF3421$ - Returns the contents of the instrument status buffer.
- ERRL - Returns line number of most recent error or warning.
- ERRM$ - Returns message text of most recent error or warning.
- ERRN - Returns error number of most recent error or warning.
- ON ERROR - Executes a branch when an error occurs.

- **RESET HPIL** - Resets the HP-IL interface to a known condition.
- **RESTORE IO** - Enables I/O operations to occur on HP-IL.
- **STANDBY** - Sets the HP-IL timeout period and verify interval.
- **STATUS** - Returns the HP-IL interface status.

The general form of a recovery subprogram is as follows:

```
10 SUB RECOVER(E)
    error recovery procedure
9999 END SUB
```

The parameter E is a real number that is used to inform the calling program (STRIP, MONITOR, or LOG) of the results. If RECOVER exits with E=0, the calling program will assume that normal execution may continue. Setting E=1 will result in the termination of the calling program.

If the calling program is your own, and not in the Data Acquisition Pac, further information could be passed back from a custom recovery program, such as the nature of the error and the recovery attempt. This may be done by assigning meanings to different values of E or adding additional parameters.

The following is an example of a recovery program for a system that uses two interface loops. The program calls the RECOVER program in UTILITY to attempt a restoration of the first loop. If the restoration fails, the program attempts to send a message to a host computer on the second loop (using RS-232), and the program exits with E not equal to zero, which will notify the system of the problem.

```
File:   FIXLOOP:MAIN

10 SUB RECOVER(E)
20 CALL RECOVER(E) IN UTILITY
30 IF NOT E THEN END
40 ON ERROR GOTO 60
50 OUTPUT :RS232:2 ; "LOOP 1 BROKEN" @ GOTO 70
60 BEEP @ DISP "Host Not Notified"
70 END SUB
```

G.6 RECOVERING BUFFERED DATA

If LOG terminates abnormally while data is being buffered to the mass storage device, the file BUFFER in memory will contain the readings that have not been stored in the final data file. These readings are not in a form that may be read by REPORT, and must be moved to the data file once the system is working again. The process of moving the data consists of the following steps:

- Identify the data file on the mass storage device.
- Determine the data file's size, structure, and amount of room remaining.
- Ensure that the data records in the file BUFFER match the structure of the destination data file, and that there is sufficient room in the data file to hold the buffered data.
- Move the buffered records to the destination file and update the data record count.

The program MERGEBUF in the Data Acquisition Pac may be used to recover the data in BUFFER. To use the program, restore the HP-71 system to working order and run MERGEBUF:

Input/Result

RUN MERGEBUF [ENDLINE]	Run the MERGEBUF program.
Data file?	The program asks for the name of the destination data file.
file name [ENDLINE]	Enter the file name, including the device specifier eg: MYFILE:TAPE.
Reading...	The program reads the data file and the file BUFFER to determine if the structure of the two files match.
Working...	The program displays a status message while the data file is updated.
Done	The program is finished.

HPAF FILE STANDARD

APPENDIX H

The Applications File Format (HPAF) is intended to allow exchange of data between various programs. The HP-71 Data Acquisition Pac reads and writes files that correspond to this format. Several existing software packages use this format, such as the HP-71 Data Management Pac, the HPAF File Utilities Pac, the AMPI Statistics Pac, and the HP-71 Curve Fitting Pac. The format provides room for the data and information that describes the structure of the data, so that various programs may make use of and exchange the data.

HPAF files are of type DATA, and may be stored in either the HP-71 or a mass storage device, such as the HP 82161A Digital Cassette Drive or the HP 9114A Disc Drive.

The HPAF files are composed of three major sections: a *header*, the *data records*, and an optional *descriptor block*. An example of a file with three fields (two numbers and a string) looks like this:

Rec #	Contents	Description
0	"HPAFNNS"	There are two numbers and one string in each data record.
1	4	There are four data records.
2	12	The descriptor block starts at 12.
3	13,61.44,"CLUTCH"	First data record
4	10,2.77,"FUSE KIT"	..
5	21,3.99,"LUBRICANT"	..
6	42,22.81,"TONER"	..
..		More data records
12	"FIELDS",3,"NUMBER", "PRICE","NAME", "LENGTHS",3,"8","8", "15"	The descriptor block contains the names and lengths of the fields.

The following sections describe the header, the data records, and the descriptor block.

H.1 Header Information

The header must contain the following items:

1) Record zero contains a type string. The type string serves two purposes. The first four characters indicate the file is an HPAF file. The remaining characters describe the number of data items in each record, and their type. For example, HPAFNNS: the characters NNS indicate that there are three items in each record: the first two are numbers, and the third is a string.

2) Record 1 contains the number of data records that contain information. This number may be less than the total number of available records, allowing room for additional records to be added later, or for the optional descriptor block.

3) Record 2 contains the address of the optional descriptor block. If no descriptor block is present, this number should be zero.

H.2 Data Records

The data records begin in record 3, and must end before the descriptor block. Note that all data items for each record must fit within each logical record, so that any record may be accessed randomly. To compute the optimal logical record length for the file, remember that each number written in the record occupies eight bytes, and each string occupies three bytes plus the number of bytes in the string. In addition, there must be one byte for the end of record mark. For example, if each record is going to hold two numbers and a ten character string, the record length must be at least 2*8+3+10+1, or 30 bytes. For more information about creating DATA files, refer to the *HP-71 Owner's Manual*, section 14.

H.3 Descriptor Block

The descriptor block is optional in the HPAF definition. Record 2 of the file contains the starting address of the descriptor block. An address of zero indicates that no descriptor block is present.

Information in the descriptor block consists of *tags* which identify the type of information that follows, followed by the *number of items* associated with the tag, followed by the *items* themselves. The *tag* must be a string, the *number of items* must be a number, and the *items* must be strings. If numeric values are to be in the *items*, they should be string representations (STR$).

The information in the descriptor block may be written serially, or, if the logical record size is sufficiently large, written one tag to a record. In either case, the descriptor block must be able to be read serially.

For example, to describe the names of the columns, a temperature offset, and the fact that the temperature units are degrees Kelvin, the descriptor block for a hypothetical file might look like this:

Rec	File contents	Comments
67	"COLNAMS",3,"TEMP","VISCOSITY","DENSITY"	Column names
	"OFFSET",1,"2.172"	Offset
	"DEGREES",1,"KELVIN"	Units information
	{EOF}	

H.4 Tag Examples

The HP-71 Data Management Pac uses two tags to describe the fields in a file. The first tag, FIELDS, indicates that the following data will contain the names of the fields in the file. The second tag, LENGTHS, indicates that the following data will contain the lengths of the fields in the file. Numeric fields always default to a length of 8, the number of bytes taken in the file by a number.

For example, a file DATADEMO has four fields: two of string type, and two of numeric type. The type string is HPAFSSNN. The contents of the descriptor block are as follows:

```
"FIELDS",4,"Part #","Name","No.","Price"
```

The tag FIELDS is followed by the number of fields, followed by the names.

```
"LENGTHS",4,"6","15","8","8"
```

The tag LENGTHS is followed by the number of fields followed by the lengths.

The data files generated by the Data Acquisition Pac programs STRIP, MONITOR, and LOG each write to the descriptor block. Appendix I, "File Structures", contains a description of the information written to the descriptor block.

When writing programs that work with the descriptor block, it is essential to be able to find a specific tag *regardless of position within the descriptor block.* A program that looks for tags either at the beginning of, or at a specific place in, the descriptor block may have trouble with files from other application programs. For instance, a program looking for the FIELDS tag should be able to recognize that tag anywhere in the descriptor block, and not just at the beginning as illustrated above.

FILE STRUCTURES

APPENDIX
I

The files created by the HP-71 Data Acquisition Pac are all of type DATA, and correspond to the HPAF file format. The data files are used to store either setup information or data that has been collected. The programs that create data files are STRIP, MONITOR, and LOG. The REPORT program can read data files from any of the three programs, but does not use the setup files.

Each program that can create a setup file (STRIP, MONITOR, and SETUP) has unique requirements, and thus the setup files are different for each program. The first three headings in this appendix discuss the setup files. The last heading describes the format for data files, which are organized the same way by each application.

I.1 STRIP CHART SETUP FILES

A strip chart setup may contain the specifications for up to nine traces. Each trace needs information about the nature of the measurement being taken, and scaling information for the printout. The file contains a header block, and one data record for each trace. No descriptor block is used, so record two of the file contains a zero.

The type string is HPAFNNNNSSS. The strip chart program reads the setup records with the following statement:

```
READ #1,I+2;F(I),C1(I),L(I),H(I),A1$(I),A2$(I),D$(I)
```

The subscript I refers to the *trace number*. The variables are used as follows:

F(*) This variable stores the number of the function being measured. The function numbers are:

```
 1: DC Volts
 2: AC Volts
 3: 4-20ma Current
 4: Two Wire Ohms
 5: Four Wire Ohms
 6: Frequency
 7: T Thermocouple
 8: E Thermocouple
 9: J Thermocouple
10: K Thermocouple
11: R Thermocouple
12: S Thermocouple
13: 2K Thermistor (2WΩ)
14: 5K Thermistor (2WΩ)
15: RTD (2WΩ)
16: 2K Thermistor (4WΩ)
17: 5K Thermistor (4WΩ)
18: RTD (4WΩ)
19: Digital Bit
```

```
20: Digital Byte
21: Custom Program
```

C1(*) This variable contains the channel number in the HP 3421A to be measured.

L(*) This variable stores the lower (left) value for the scale in the printout.

H(*) This variable stores the upper (right) value for the scale in the printout.

A1$(*) This variable stores the name of the conversion subprogram to be called if unit conversions are being used, or the name of the custom subprogram to be called if the measurement selection is *custom program*. The name may be from 1 to 8 characters long.

A2$(*) This variable stores the name of the file containing the subprogram referenced by A1$(*). The name may be from 1 to 20 characters long.

D$(*) This variable stores control information which specifies how each measurement is to be conducted. Each character contains meaning for a different parameter. The character positions are listed in order:

```
1: Conversion function (Y or N)
2: Temperature units (C F K or R)
3: Number of digits (3, 4, or 5)
```

I.2 MONITOR SETUP FILES

A monitor setup may contain the specifications for up to 18 traces. Each trace needs information about the nature of the measurement being taken, scaling information for the screen, and limit tests. The file contains a header block, and one data record for each channel. The descriptor block contains one tag, TITLE, followed by one item, which is the screen title.

The type string is HPAFSSNNSSNNNNNSSSSSNN. The monitor program reads the setup records with the following code:

```
READ #1,I+2;A1$(I),A2$(I),C1(I),F(I),F$(I),L$(I)
FOR J=1 TO 5 @ READ #1;L1(I,J) @ NEXT J
FOR J=I TO I+72 STEP 18 @ READ #1;M$(J) @ NEXT J
READ #1;S1(I),S2(I)
```

The subscript I refers to the *trace number*. The variables are used as follows:

A1$(*) This variable stores the name of the conversion subprogram to be called if unit conversions are being used, or the name of the custom subprogram to be called if the measurement selection is *custom program*. The name may be from 1 to 8 characters long.

A2$(*) This variable stores the name of the file containing the subprogram referenced by A1$(*). The name may be from 1 to 20 characters long.

C1(*) This variable contains the channel number in the HP 3421A to be measured.

F(*) This variable stores the number of the function being measured. The function numbers are:

```
 1: DC Volts
 2: AC Volts
 3: 4-20mA Current
 4: Two Wire Ohms
 5: Four Wire Ohms
 6: Frequency
 7: T Thermocouple
 8: E Thermocouple
 9: J Thermocouple
10: K Thermocouple
11: R Thermocouple
12: S Thermocouple
13: 2K Thermistor (2WΩ)
14: 5K Thermistor (2WΩ)
15: RTD (2WΩ)
16: 2K Thermistor (4WΩ)
17: 5K Thermistor (4WΩ)
18: RTD (4WΩ)
19: Digital Bit
20: Digital Byte
21: Custom Program
```

F$(*) This variable stores control information which specifies how each measurement is to be conducted. Each character contains meaning for a different parameter. The character positions are listed in order:

```
 1: <reserved>
 2: Conversion (Y or N)
 3: Number of limit tests
 4: Limit type 1 (L, H, S, C)
 5: Limit type 2 (L, H, S, C)
 6: Limit type 3 (L, H, S, C)
 7: Limit type 4 (L, H, S, C)
 8: Limit type 5 (L, H, S, C)
 9: Limit action 1 (1 to 6)
10: Limit action 2 (1 to 6)
11: Limit action 3 (1 to 6)
12: Limit action 4 (1 to 6)
13: Limit action 5 (1 to 6)
14: Number of digits (3, 4, or 5)
15: Temperature units (C F K or R)
```

Limit types are L (low), H (high), C (clear), or S (set). There are 6 available limit actions. They are: 1) Beep, 2) Highlight, 3) Print message, 4) Open actuator, 5) Close actuator, or 6) Call a limit program.

L$(*) This variable stores the label for the trace, up to 20 characters.

L1(I,1)
...
L1(I,5)

These elements store the limit points for limit tests 1 through 5, respectively.

M$(*)

These strings store text associated with the limit actions, if needed. The strings may be up to 32 characters long. The variable M$(I+(J-1)*18) holds the text for the Jth limit action in group I. The text in the string can be a message, or the string representation of the channel number which should be opened or closed. If the limit action is a call to a custom limit program, the first 8 characters contain the name of the subprogram, and the next 20 characters contain the name of the file containing the subprogram.

S1(*)

This variable stores the lower (left) value for the scale in the video display.

S2(*)

This variable stores the upper (right) value for the scale in the video display.

I.3 LOGGER SETUP FILES

A log setup may contain the specifications for up to 20 groups. Each group needs information about the nature of the measurement being taken or channel being controlled and limit tests. The file contains a header block and one data record for each channel. There is no descriptor block, so record two contains a zero.

The type string is HPAFSSNNNSSNNNNNNSSSSSNSS. The programs SETUP and LOG read the setup records with the following code:

```
READ #1,I+2;A1$(I),A2$(I),C1(I),C2(I),F(I),F$(I),L$(I)
FOR J=1 TO 6 @ READ #1;L(I,J) @ NEXT J
For J=I TO I+80 STEP 20 @ READ #1;M$(J) @ NEXT J
READ #1;S(I),T$(I),W$(I)
```

The subscript I refers to the *group number*. The variables are used as follows:

A1$(*) This variable stores the name of the conversion subprogram to be called if unit conversions are being used, or the name of the custom subprogram to be called if the measurement selection is *custom program*. The name may be from one to eight characters long.

A2$(*) This variable stores the name of the file containing the subprogram referenced by A1$(*). The name may be from 1 to 20 characters long.

C1(*) This variable contains the first channel number in the HP 3421A to be measured. If the function is *digital byte*, this variable contains the number of the slot being read.

C2(*) This variable contains the last channel number in the HP 3421A to be measured.

F(*) This variable stores the number of the function being measured. The function numbers are:

```
 1: DC Volts
 2: AC Volts
 3: 4-20mA Current
 4: Two Wire Ohms
 5: Four Wire Ohms
 6: Frequency
 7: T Thermocouple
 8: E Thermocouple
 9: J Thermocouple
10: K Thermocouple
11: R Thermocouple
12: S Thermocouple
13: 2K Thermistor (2WΩ)
14: 5K Thermistor (2WΩ)
15: RTD (2WΩ)
16: 2K Thermistor (4WΩ)
17: 5K Thermistor (4WΩ)
18: RTD (4WΩ)
19: Digital Bit
20: Digital Byte
```

```
21: Custom Program
22: Open Act/Bit
23: Close Act/Bit
```

F$(*) This variable stores control information which specifies how each measurement is to be conducted. Each character contains meaning for a different parameter. The character positions are listed in order:

```
 1: Group active (Y or N)
 2: Conversion (Y or N)
 3: Number of limit tests
 4: Limit type 1 (L, H, S, C)
 5: Limit type 2 (L, H, S, C)
 6: Limit type 3 (L, H, S, C)
 7: Limit type 4 (L, H, S, C)
 8: Limit type 5 (L, H, S, C)
 9: Limit action 1 (1 to 7)
10: Limit action 2 (1 to 7)
11: Limit action 3 (1 to 7)
12: Limit action 4 (1 to 7)
13: Limit action 5 (1 to 7)
14: Number of digits (3, 4, 5)
15: Temperature units (C F K or R)
16: Average of burst (Y or N)
17: Store data (Y or N)
```

Limit types are L (low), H (high), S (set), or C (clear). There are seven available limit actions. They are: 1) Beep, 2) Print message, 3) Activate group, 4) Deactivate group, 5) Open actuator, 6) Close actuator, or 7) Call a limit program.

L$(*) This variable stores the label for the group, up to 20 characters.

L(I,1) These elements store the limit points for limit tests 1 through 5, respectively.
...
L(I,5)

L(I,6) This variable stores the number of burst readings to be taken, if needed.

M$(*) These strings store text associated with the limit actions, if needed. The strings may be up to 32 characters long. The variable M$(I+(J-1)*20) holds the text for the Jth limit action in group I. The text in the string can be a message, or the string representation of the channel number which should be opened or closed or the group which is activated or deactivated. If the limit action is a call to a custom limit program, the first 8 characters contain the name of the subprogram, and the next 20 characters contain the name of the file containing the subprogram.

S(*) This variable stores the number of scans to be taken for each group.

T$(I) This variables stores the string representation of the start time for each group (-1:00:00 means start immediately).

W$(I) This variables stores the string representation of the interval between group execution times.

I.4 DATA FILES

The programs STRIP, MONITOR and LOG store data in an identical fashion, allowing the REPORT program to work with each. The data files conform to the HPAF format, and are organized as follows:

Header

The header contains the type string in record zero, the number of records of actual data in the file in record one, and the address of the descriptor block in record two. The type string consists of the string HPAF followed by a series of one or more Ns. The number of N characters defines the *worst case* number of items in each record. This number corresponds to the number of traces or channels in the case of a STRIP or MONITOR file, or to the largest number of readings stored by a group in a file generated by the LOG program.

The number of records indicated in record one does not represent the total number of available data records in the file - it shows the number of records that were actually recorded. If the data logging sequence was aborted before all data had been collected, the file will still be valid.

Data Records

The data records contain, in order, the time of acquisition, date of acquisition, and group number, followed by the actual data. The time is a real number representing the number of seconds since midnight. The date is in YYDDD form, indicating the year and the day number in the year. The group number indicates which group collected the data which follows. The group number will always be 1 for files generated by STRIP and MONITOR.

Descriptor Block

The descriptor block contains a tag which identifies which program generated the data file, followed by one item for each group which contains information about the amount and origins of the data for that group.

Files generated by STRIP have a tag STRIP, followed by one item. The item is a six-character string. The first two characters contain the string representation of the number of traces in the setup, which should be equal to the number of Ns in the type string. The third and fourth characters should read 01, and the fifth and sixth characters are the same as the first two.

Files generated by MONITOR have a tag MONITOR, followed by one item. The item is organized the same way as for the STRIP file.

Files generated by LOG have a tag LOG, followed by one item for each group in the setup. The first two characters in the item contain the string representation of the number of values stored by the group. The third and fourth characters contain the string representation of the first channel in the HP 3421A used in the scan, or the slot number in the case of a digital byte. The fifth and sixth characters contain the string representation of the last channel in the HP 3421A used in the scan. The channel numbers will be -1 in the case of a custom program call.

FILE NAMES USED IN THIS PAC

APPENDIX J

This appendix lists the file names used by this pac. The file listed with a * is temporary, present only when LOG is running. Be sure that you don't have a file with this name, as it will be purged when you run LOG. Files listed with a + are supplied on the disc.

File	Type	Description
BIN3421	BIN	Contains the subprogram SCAN.
*BUFFER	DATA	Temporary file for data logging.
+FATLEX	LEX	File allocation table keywords for MSDOSXFR
FMTLEX	LEX	Contains formatting keywords.
+FROM71	BASIC	Series 200 BASIC 3.0 data transfer subprogram.
FRONT	BASIC	The front panel program.
KEYSLEEP	LEX	The KEYSLP$ keyword.
LEX3421	LEX	Contains the instrument control keywords.
LOG	BASIC	The data logging program.
MERGEBUF	BASIC	The program for recovering BUFFER data.
+MON2392	BASIC	MONSET subprogram for 2392 terminal.
MONITOR	BASIC	The system monitor program.
+MSDOSXFR	BASIC	Program for data transfer to MS-DOS computers.
+PRT82905	BASIC	PRINTSET subprogram for strip charts.
REPORT	BASIC	The report program.
SETUP	BASIC	The setup program.
STATUS	BASIC	The status program.
STRIP	BASIC	The strip chart program.
TCONV	LEX	Time and date conversions.
TRANSFER	BASIC	The program for data transfer to the HP44456A.
UTILITY	BASIC	Some common subprograms.
VERIFY	BASIC	The operational verification program.
+XFER200	BASIC	Series 200 BASIC 3.0 program for data transfer.

ERROR AND WARNING MESSAGES

APPENDIX K

The following messages may be displayed or printed by the programs in the Data Acquisition Pac during execution:

Aborted by From71	The Series 200 computer receiving data from the TRANSFER program sent an abort message.
Ascending Order Only	The channels for a multi-channel scan in LOG must be listed in ascending order.
Average Not Specified	The setup file does not indicate whether a burst reading should be averaged.
Bad Channel In Series	A channel series contains a channel of inappropriate type for the measurement specified, such as a voltage measurement on channels 3 through 25 when a digital card is in slot 1.
Channel Not Act/Bit	The specified channel for a limit control action is not an actuator channel or a digital output bit.
Conversion Subprogram Missing	A conversion program specified by a setup is not in memory.
Corrupt Data	The data in the HP-71 file is unreadable.
Descending Channels	A series of channels specified for a channel group is in descending order.
Device Not Found	The device specified for HP-71 file or MS-DOS file does not exist on the loop.
Dev Not Mass Storage	The target device is not a mass storage device.
Device Not SS80	The target device does not respond to Subset/80 command protocol.
Directory Not Found	A directory specified in <path> does not exist.
Disk Error:...	An error has been detected in accessing the disc. Normally, an explanation will follow the ":". If not, the error might be in specifying a unit number for which there is no physical disc (e.g., specifying unit 2 while talking to HPLINK on the HP 150, when there is no disk assigned to "C:").
Disk Too Big	Disc is too big to be handled by MSDOSXFR program.
ERROR: Calling *filename*	A problem occured while trying to call a custom program. This may be because the custom program is not in memory or the parameters are mismatched.
File Exists	The MS-DOS file already exists on the target device.

File Mismatch — The data file and the buffer file do not have the same structure.

File *filename* Missing — A custom program, conversion, or limit file is not in memory.

Illegal Field Type — The HP-71 file to be transferred is not of the expected format.

Invalid # Digits — The number of digits of resolution specified by the setup file is not 3, 4, or 5.

Invalid Date Window
Invalid Time Window — The time period specified for time/date search in the data file is invalid.

Invalid Buffer File — The buffer file in memory is either nonexistent or contains invalid data.

Insufficient Memory — The memory of the HP-71 is too full to continue. Usually, extra files may be removed to provide enough room to continue.

Invalid Channel — The HP 3421A channel specified is of the wrong type, such as a digital channel specified for a resistance measurement.

Invalid Function — The function number specified for a trace/group in a setup file is out of range.

Invalid Group Number — A group number has been specified which is less than 1 or greater than 20.

Invalid Input — This message indicates that the response to a prompt is not correct. Usually the message occurs when letters or non-integer numbers are entered when an integer is required, such as for a channel number.

In the MSDOSXFR program,the message may also mean the MS-DOS file specifier is invalid. The format *must* be the following: 1) Device specifier followed by ":"; 2) Optional path specifier; 3) Filename, 1-8 legal MS-DOS file-naming characters; 3) Optional "." followed by filename extension, 0-3 legal MS-DOS file-naming characters.

Invalid Limit Action — The limit action number specified in the setup file is out of range.

Invalid Limit Channel — The channel number specified for a limit action is either out of range or specifies a nonexistent channel.

Invalid Limit Type — The limit type specified is not L, H, S, or C or is inappropriate for the measurement.

Invalid # Scans — A group may specify from 1 to 99999 scans for each group.

Invalid Setup — The setup file does not have the correct field structure to be a setup for this program. The setup files for STRIP, MONITOR, and LOG have different structures.

Invalid Setup Size — The setup file specified is of the correct structure, but contains either less than one or more than the maximim allowable number of traces/groups.

Invalid Slot	The slot specified for a digital byte function does not contain a digital I/O card.
Invalid Temp Units	The valid temperature units are C, F, K, and R.
Max Unit Number <x>	Highest legal unit number for "Unit number?" prompt is <x>.
Missing Data Tag	The HP-71 file to be transferred is not a STRIP, MONITOR, or LOG data file.
Must Be On Same Card	A series of four wire ohms measurements can only span one card, for instance from channels 3-8.
No Digital Card	The HP 3421A does not contain a digital I/O assembly.
No Mux Card	The HP 3421A does not contain a multiplexer assembly.
No Room in Directory	There is no space in the MS-DOS directory to add another file.
No Room on Disk	There is insufficient space on the target device to hold the file.
No Setup	There is no current setup to edit or run.
No Video Monitor	The MONSET subprogram could not find a video interface.
Nonexistent Group	The group number specified for editing does not exist in the current setup.
Nonexistent Trace	The trace number specified for editing does not exist in the current setup.
Not A 4WO Pair	The specified channel in the HP 3421A does not have a paired channel for four wire ohms measurements.
Not A Digital Card	The specified slot in the HP 3421A does not contain a digital I/O card.
Not A Monitor File	The data file specified does not have the correct structure to be a strip chart setup file.
Not A Setup File	The data file specified does not have the correct structure to be a setup file for data logging.
Not A Strip Chart File	The data file specified does not have the correct structure to be a strip chart setup file
Not Acquisition Chnl	The specified channel is either non-existent or is a digital I/O channel.
Not Enough Memory	There is not enough available HP-71 memory to run the program.
Not HPAF File	The HP-71 file to be transferred is not an HPAF-format file.
Not MSDOS Disk	The target device contains a non-MS-DOS disc.
Referenced By *nn*	The specified group cannot be deleted because it is referenced by a limit action in another group.

Scale Error	The scale specified for a strip chart must have the minimum less than the maximum.
SETUNIT Error:...	Disc reported an error during the low-level SETUNIT operation.
Setup Full	The current setup has the maximum allowable number of traces/groups.
Unexpected Fault Error: <x> **Unexpected Information Field-Error: <x>** **Unexpected Reject Error: <x>**	The target device reported an unexpected error in disc access. The <x> encodes a Subset/80 error condition.
Value Out Of Range	The value specified to be written to a digital output port is not in the range 0-255.

Subject Index

A

ACVOLTS, 3-2
ADD command, 6-13, 7-20, 9-16
Address
  channel, 2-8
  HP-IL, 2-6
ADR3421$, 3-2
Alternative peripheral options, F-1
  printers, F-1
  video displays, F-2
Applications format, 2-7, H-1
Application notes, 2-20
AUTOIDY, 3-2
AUTORANGE, 3-3
AUTOZERO, 3-3

B

Bar graph format, 7-1
Broken loop, G-1
BUF3421$, 3-3
BUFFER file, 8-4, G-5
Buffered data readings, 10-2, G-5
BYTEREAD, 3-3
BYTEWRITE, 3-4

C

CHANLIST subprogram, 5-2, 6-8, 7-14, 10-2, F-4, F-5
Channel
  array, F-4
  groups, 8-2, 9-1
  lists, 8-2
Channel numbers, 2-8, F-4
Channel types, 3-4, F-4
CHANTYPE, 3-4
CHART command, 11-7
CLOSE, 3-4
CMD3421, 3-5
Column format, 7-2
Command keys, 5-1
Continuous event limits, E-1
Control functions, 9-9
Conversion program, 6-1, 7-2, 8-2, 9-1, D-1
Custom programs, C-1
  data logging, 9-1, 9-9, C-1
  monitoring, 7-2, 7-10, C-1
  strip chart, 6-1, 6-7, C-1

D

Data files, 2-7
Data logging
  log program, 8-1
  monitor program, 7-2
  procedure, 8-1
  storage requirements, 8-4
  strip chart program, 6-1, 6-8
Data transfer options, 12-1
Date setting, 2-4
DCNV, 3-5
DCNV$, 3-5
DCVOLTS, 3-5
DELETE command, 6-14, 7-21, 9-17
Descriptor block, H-1
Diagnostic terminal block, 14-1
Digital functions, 6-5, 7-9, 9-8
  bit, 6-5, 7-9, 9-8
  byte, 6-5, 7-9, 9-8
Digital card test, 14-3
Digital I/O assembly, 2-8
DIGITS, 3-6

E

Edit menu
  monitoring, 7-4
  setup, 9-3
  strip chart, 6-2
Ending the report program, 11-10
Error messages, K-1
Error recovery, 7-16, 12-6, G-1
Equipment needed, 2-3

F

FATLEX lexfile, 2-2, 13-3
File menu
  monitoring, 7-4
  setup, 9-3
  strip chart, 6-2
File names used, J-1
File structures, I-1
  data files, I-7
  log setups, I-5
  monitor setups, I-2
  strip chart setups, I-1
Flags, 6-2, 7-4, 9-3, 10-2, 10-3, C-2, D-2, E-3

FREQ, 3-6
FROM71 subprogram, 2-2, 12-7
Front panel program, 5-1
  functions, 5-3
  operation, 5-2

G

GATE, 3-6
GET3421, 3-6
GET command, 6-11, 7-18, 9-14
Group, 8-2
  adding, 9-16
  deleting, 9-17
  list, C-2
  replacing, 9-18

H

Header, H-1
HP 44456, 12-1
HGL$, 3-7
HPAF, 2-7, H-1
HP 3421, 1-3, 2-8, 2-11, 2-19, B-1,
  C-3, F-4, F-5
HP-IL, 1-1
  accessory ID, 2-6
  address, 2-6
  assign code, 2-6
  connecting, 2-5
  device id, 2-6
  device specifiers, 2-5
  device word, 2-6
  volume label, 2-6

I

IMAGE$, 3-7
INIT3421, 3-7
Instrument commands, 2-11, B-1
  advanced commands, B-2
  standart commands, B-1
Interrupt
  programming, 2-12, 2-14
  subprograms, 2-13

K

Keyboard overlay, 5-1
KEYSLP$, 3-8
KEYWAIT$, 3-8
Keywords
  syntax, 3-2
  using, 2-9

L

Limit
  actions, 7-2, 7-12, 9-2, 9-11
  analog, 7-11, 9-10
  digital, 7-11
  tests, 7-2, 7-3, 7-11, 8-2, 9-2, 9-10, 9-18
  programs, E-1
LIST command, 11-2
LOG program, 8-1, 10-1, 10-2
LOTUS 1-2-3, 13-5
Loop power down, 8-3
LTRIM$, 3-8

M

Main menu
  monitoring, 7-4
  report, 11-1
  setup, 9-3
  strip chart, 6-2
Measurement choices
  data logging, 9-1
  monitoring, 7-2
  strip chart, 6-1
Measurement interval, 8-2
Memory requirements, 13-6, C-2, G-1
Menus
  choices, 2-16, 2-17
  keystroke, 2-16
  monitoring, 7-4
  revolving, 2-16, 2-17
  setup, 9-3
  strip chart, 6-2
MERGEBUF program, G-5
Module, 2-1
  installation, 2-1
  removal, 2-1
MON2392 subprogram, 2-2
MONHIGH subprogram, 3-19
MONLOW subprogram, 3-19
MONITOR program, 7-1
MONITOR SLOT, 3-9
MONSET subprogram, 2-2, F-2
MONSLOT subprogram, 3-20
MS-DOS, 1-3, 13-1
MSDOSXFR program, 2-2, 8-1, 13-1
Multiple instruments, C-3, F-5
Multiplexer assembly, 2-8

N-O

NEW command, 6-3, 7-5, 9-4
Numeric Execptions, 12-6, 13-6
OHMS2, 3-9
OHMS4, 3-10
OPEN, 3-10
OPTION DEGREES, 3-10
Overlay, keyboard, 5-1

P-Q

Power consumption, 8-2
PRINT command, 6-16, 7-23, 9-19, 11-2
PRINT TO, 3-11
PRINTSET subprogram, 2-2, F-1
Product information, A-6
Programming
  keywords, 2-10
Prompts
  date, 2-18
  time, 2-18
PRT82905, 2-2
QUIT command, 6-17, 7-24, 9-20

R

RANGE, 3-11
READBIT, 3-11
RECOVER subprogram, G-1 thru G-4
Recovering buffered data, G-5
Relay card test, 14-1
REFTEMP, 3-12
Repair services, A-3 thru A-5
REPLACE command, 6-15, 7-22, 9-18
REPORT program, 8-1, 11-1
  limits, 7-22
  scale, 7-22
  screen title, 7-22
RPT$, 3-12
RTD
  keyword, 3-12
  sensor, 2-19
RTNERR, 3-13
RTRIM$, 3-13
RUN command, 6-8, 7-14, 9-3

S

SAVE command, 6-10, 7-17, 9-13
Scale
  report program, 11-7
  strip chart, 6-1,
  system monitor, 7-1
SCAN subprogram, 2-11
Scans, 8-2, 10-1
SEND3421, 3-13
Series 200 program, 12-3
Service, A-3 thru A-5
SET3421, 3-14
SETDATE, 2-4
SETSRQ, 3-14
SETTIME, 2-4
Setup files, 6-1, 8-1, 9-1
  corrupt, G-1, G-2
  creating, 6-3,7-5, 9-4
  printing, 6-16, 7-23, 9-19
  retrieving, 6-11, 7-18, 9-14
  saving, 6-10, 7-17, 9-13
  verifying, 6-12, 7-19, 9-15
SETUP program, 8-1
Signals, 6-4, 7-7, 9-6
Slots, 2-8
Start time, 8-2
STAT command, 11-4
STATUS program, 4-1
STD$, 3-14
Strip chart report, 11-7
Strip chart program, 6-1
Supplemental disc, 2-2
System settings, 2-4
System timers, 7-15, 10-1, C-2, D-2, E-3

T

Tags, H-2, H-3
Target device, 13-1, 13-2
Target file format, 13-2
TCNV, 3-15
TCNV$, 3-15
TCOUPLE, 3-15
Thermistors, 2-19
Thermocouples, 2-19
ThinkJet printer, 2-3, 6-1, 8-3, 11-1, F-1
THMST2, 3-16
THMST5, 3-16
Time setting, 2-4
Traces, 6-1, 7-1
  adding, 6-13, 7-20
  deleting, 6-14, 7-21
  listing, 6-16
  replacing, 6-15, 7-22
TRANSFER program, 8-1, 12-1, 12-4
Transition event limits, E-1, E-2
TRIM$, 3-16

U–V

USE3421, 3-17
Vector, 12-1
VERIFY command, 6-12, 7-19, 9-15
VERIFY program, 14-1
Video interface, 7-1, 7-16
Volume label, 2-6

W–X

Warranty, A-1 thru A-3
WRITEBYTE, 3-17
XFER200 program, 2-2, 12-1, 12-3

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