DP-MS-80-87
CONF-810329--3

A VERSATILE MULTICOMPUTER DATA SYSTEM

by

R. F. Overman and R. J. Sand

E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808

A Paper Prepared for Presentation to the
Pittsburgh Conference of Analytical Chemistry
and Applied Spectroscopy to be held in
Atlantic City, NJ
March 9-13, 1981

DP-MS-80-87

A VERSATILE MULTICOMPUTER DATA SYSTEM

R. F. Overman and R. J. Sand

E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808

ABSTRACT

A multicomputer system was designed and built to provide a means of transferring data from analytical instruments to a PDP-15 (Digital Equipment Corp., Maynard, MA) minicomputer. A model 6800 microcomputer (Motorola, Inc, Phoenix, AZ) was designed to accept data from instruments with diverse data formats and data collection times on a time-sharing basis. Once in the computer memory, the data are sent via a modified serial communications port to a PDP-15 minicomputer. The analytical instruments include an infrared spectrometer, two pulse height analyzers, an atomic absorption spectrophotometer, and a desk-top computer.

This paper describes the versatility of the system, the microcomputer handling of the instrument I/O requirements, the changes in the PDP-15 to accept data at a 2400 baud rate, and changes in the TTY handler in the monitor to accommodate binary data and nonstandard byte configurations.

INTRODUCTION

The Analytical Chemistry Division was using a PDP-15 minicomputer (Digital Equipment Corp.) for data calculations and a very limited amount of data acquisition. Data were entered into the PDP-15 manually or by punched paper tape. About five years ago, we decided to investigate ways of transferring the data directly from various instruments to the PDP-15.

The PDP-15 (Figure 1) is an 18-bit word machine, which was designed for data manipulation. It does not have the PDP-11 (Digital Equipment Corp.) Unibus and is not easily modified for servicing nonstandard I/O devices. While the PDP-15 is not in widespread use, the approach we took to solve our problem is a viable approach for other brands of computers. A computer with versatile input ports, a memory for temporary storage of data, and inputs to the PDP-15 that look like a signal from a standard terminal were needed for the job.

COMPUTER HARDWARE

A modular microcomputer was designed around the 6800 microprocessor. The four basic modules are the microcomputer, a 4K EPROM, a 1K RAM, and a serial interface. Additional modules used for this application include a parallel interface, I/O pulse interface, status indicator, four time clocks, eight pairs of serial I/O ports, and a 64K RAM. Programs for each of the terminal and instrument ports are in the firmware. The microcomputer is shown in Figure 2. It does not look like a computer because it doesn't

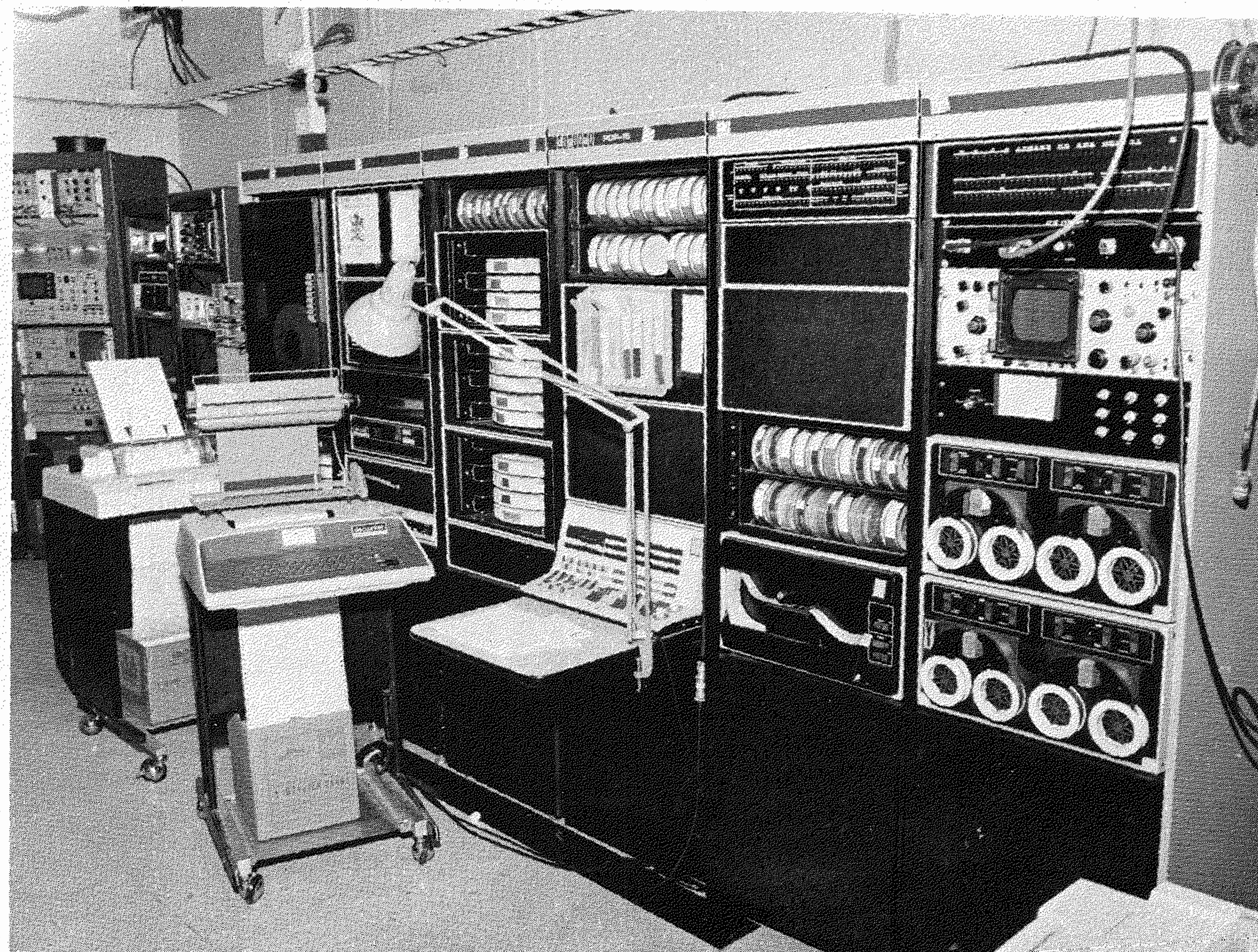

FIGURE 1. PDP-15 Minicomputer

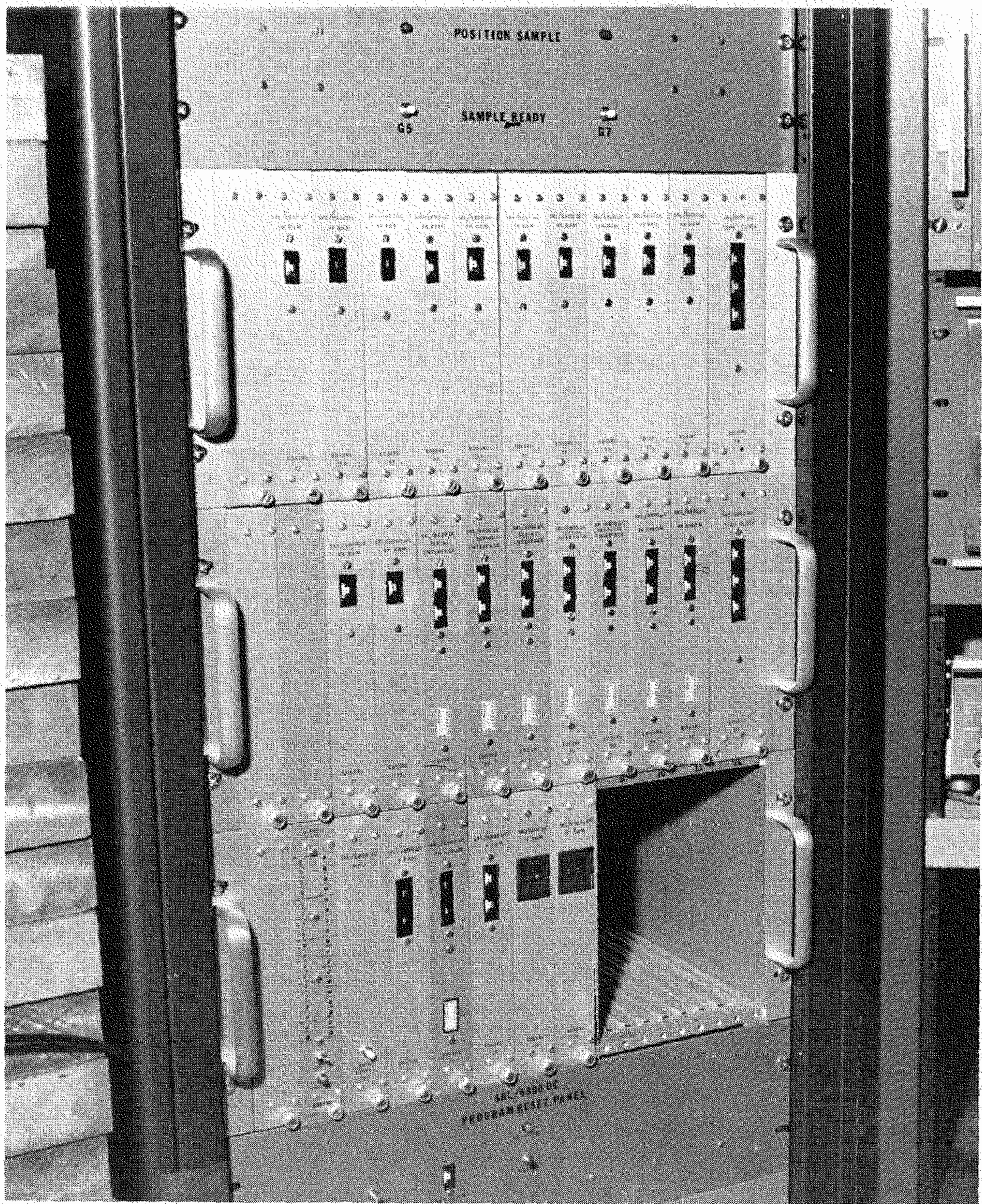

FIGURE 2. SRL 6800 Microcomputer

have a keyboard and it has very few flashing lights. Figure 3 shows the signal panel at the computer. Terminal boxes were installed in each lab. Each box contained one cable for voice communication, three cables for terminals (three twisted pairs of wire in each cable), coaxial cables for analog signal transmission, and one 110V AC power line. The cables were grounded only at the computer to avoid ground loops.

Each instrument interfaced to the microcomputer is accompanied by a serial I/O terminal (TTY). The TTY is used to sign the instrument ON and OFF and to enter information about the sample being analyzed by the instrument.

MICROCOMPUTER SOFTWARE REQUIREMENTS

The information protocol is highly structured to save memory space in the microcomputer, and the microcomputer sends prompting codes to the terminal to ensure conformity with the protocol.

Some of the analytical instruments have internal microprocessors and data storage. These instruments send all of their data to the microcomputer in one package. The microcomputer in turn sends the package of data to the PDP-15, which permits these instruments to share memory in the microcomputer. Other instruments do not have internal data storage. They send their data as they are generated to the microcomputer, and the microcomputer stores the data in a portion of its memory dedicated to that instrument. After the data have been accumulated by the microcomputer, they are sent in a package to the PDP-15. The two types of instruments are exemplified by a pulse height analyzer (PHA) and an infrared (IR) spectrometer.

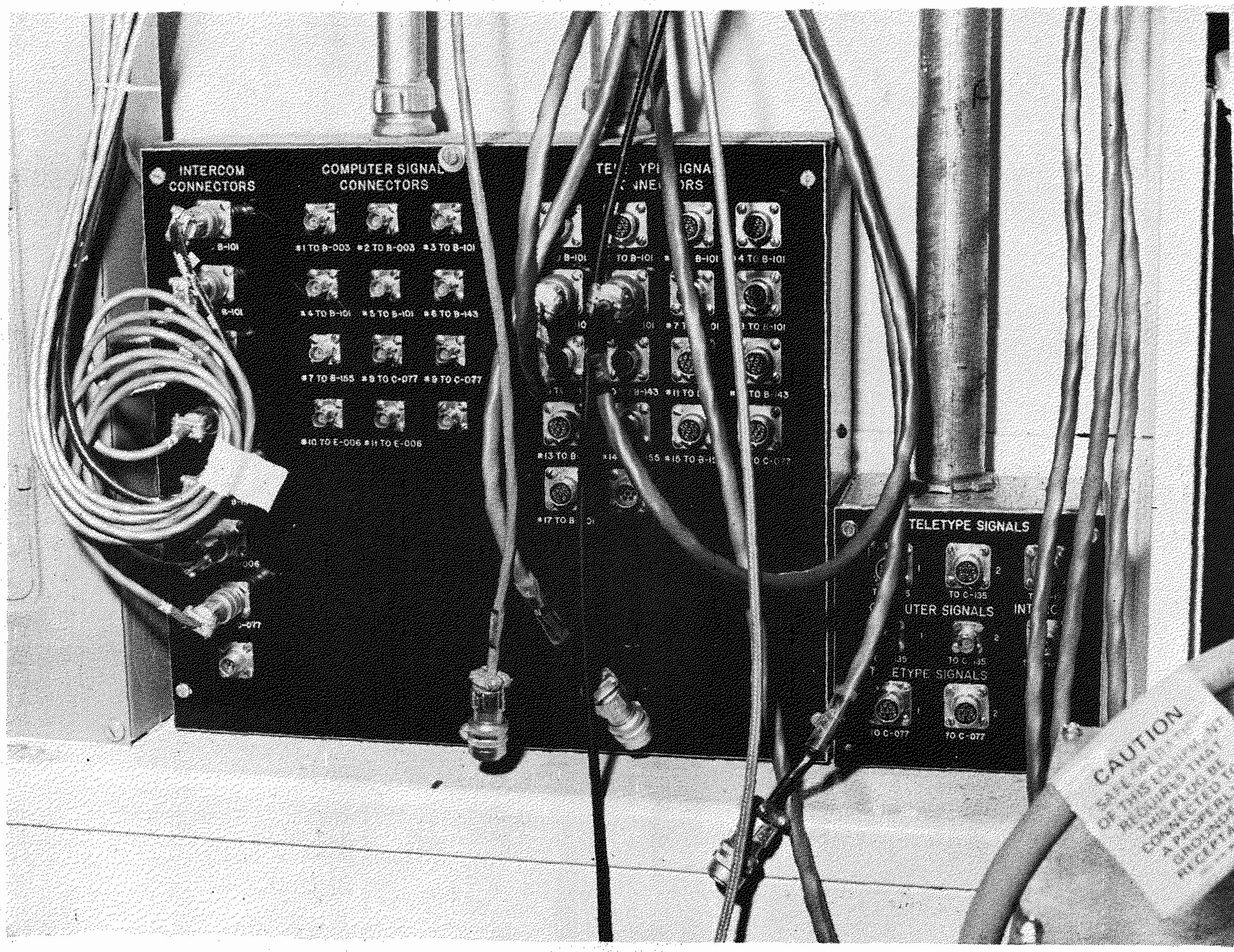

FIGURE 3. Signal Panel

FIGURE 4. Perkin-Elmer IR Spectrometer

INFRARED SPECTROMETER

The IR spectrometer is a Perkin-Elmer Model 180 (Perkin-Elmer Corp., Norwalk, CT) and is shown in Figure 4. The IR spectrometer is also equipped with an X-Y plotter. To initiate analysis of a sample, the operator signs on at the terminal. The microcomputer prints questions on the terminal about data, sample identification, starting and ending wavenumbers, the wavenumber interval of the scan, and a few other pieces of information. The IR spectrometer has a small data buffer. As shown in Figure 5, data from the energy scan are transmitted to the microcomputer in a package containing six ASCII characters for the wavenumber and five ASCII characters for the transmittance in ratiometer counts. Binary data are sent to the plotter by the microcomputer.

The microcomputer verifies the accuracy of the wavenumber transmitted, and it removes control characters and spaces from the data. If the wavenumber is incorrect, it is placed in a separate file. Correct wavenumbers are not retained. The five ASCII data characters are converted into two 8-bit binary bytes. The transmittance data file and the erroneous wavenumber file are sent to the PDP-15 after the scan is completed. Up to 4K data points in the scan are permitted.

Provision is made for the chemist to use the IR spectrometer X-Y recorder to plot the IR spectrometer spectra, usually after spectrum smoothing by the PDP-15. The plotter requires 12 bits of information to plot a point. Ten bits are data (transmittance), and two bits give the pen motion. The PDP-15 calculates the time required for the pen to move and sends this information to the microcomputer. The microcomputer will delay between each word sent to the plotter to allow the pen to complete its movement.

PULSE HEIGHT ANALYZER

The PHA is an example of an instrument that contains a memory for all of its data.[1] The PHA stores data from a 4K channel scan. The data package consists of up to 12K of 8-bit bytes. The data format of the 20-bit PHA word is shown in Figure 6. Control characters are used for the three functions of the PHA. Figure 7 shows the modular construction of the PHA.

The microcomputer is programmed to issue the control characters to the PHA at the correct times. The data from the PHA are neither reformatted nor validity checked. The 12K data bytes are sent to the PDP-15 by the microcomputer.

The microcomputer is also programmed to control the PHA for three different modes of operation:

1) Single sample - an operator is available to enter information about each sample prior to the time the sample is counted.
2) Multisamples - the microcomputer-controlled sample changer is shown in Figure 8. No operator is available to enter information about each sample. This information is typed in as a separate file.
3) In-line analyses - an operator enters counting frequency and length of counting time before a run starts.

FIGURE 5. IR SPECTROMETER DATA FORMAT

7 BIT ASCII	
XXXXXX	WAVENUMBER (CLOSEST 0.01 CM^{-1})
40	SPACE
XXXXX	TRANSMITTANCE (RATIOMETER COUNTS)
34 OR 177	TERMINATOR

TO X-Y PLOTTER - BINARY
10 BITS DATA, 2 BITS MOTION

FIGURE 6. PHA DATA FORMAT

MSB

								BYTE
0	x	x	x	x	x	x	x	1
0	x	x	x	x	x	x	x x	2
0	0	x	x	x	x	x	x	3

LSB

DC4	ETB	NAK
START	STOP	CLEAR
	READ	

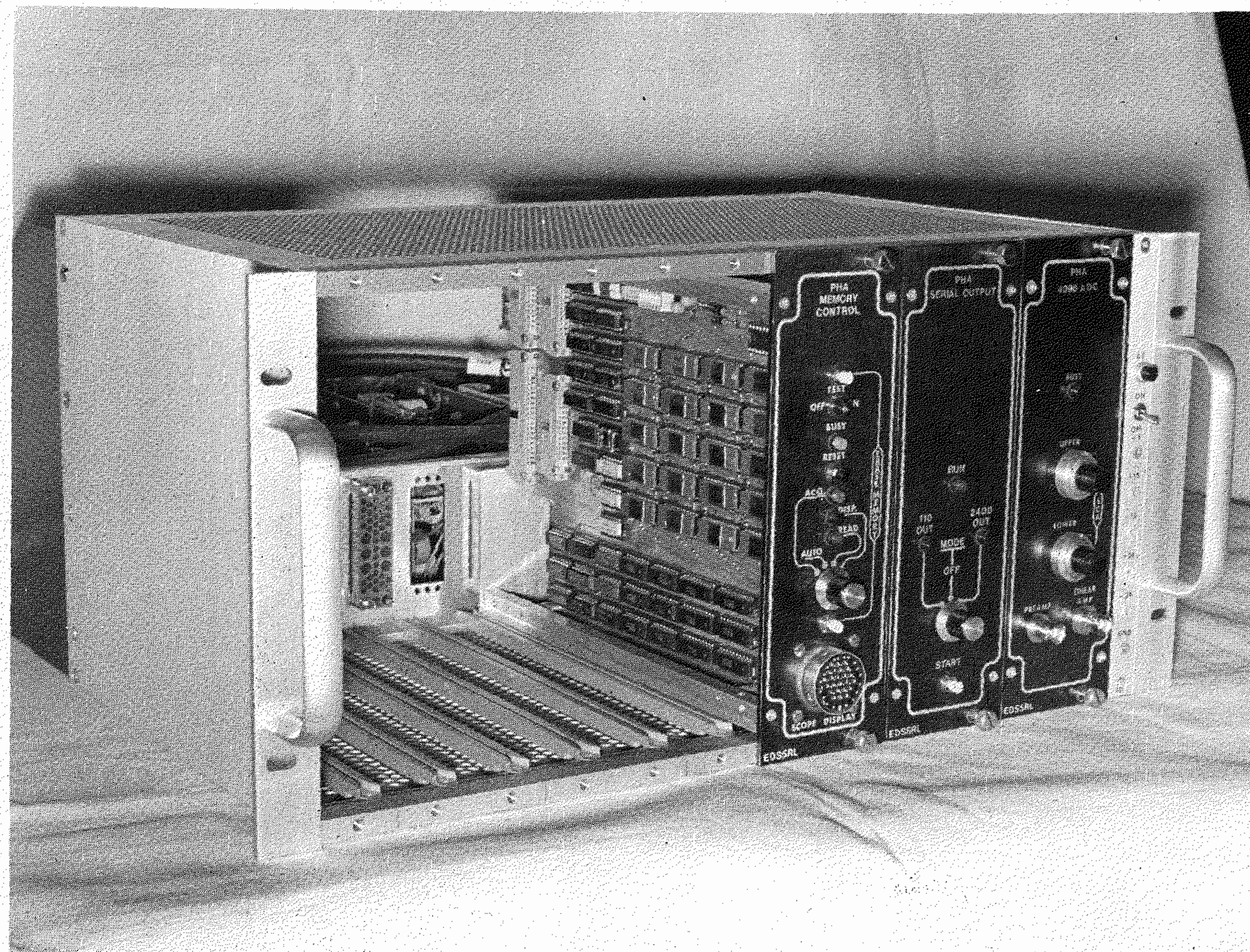

FIGURE 7. Modular Construction of Pulse Height Analyzer

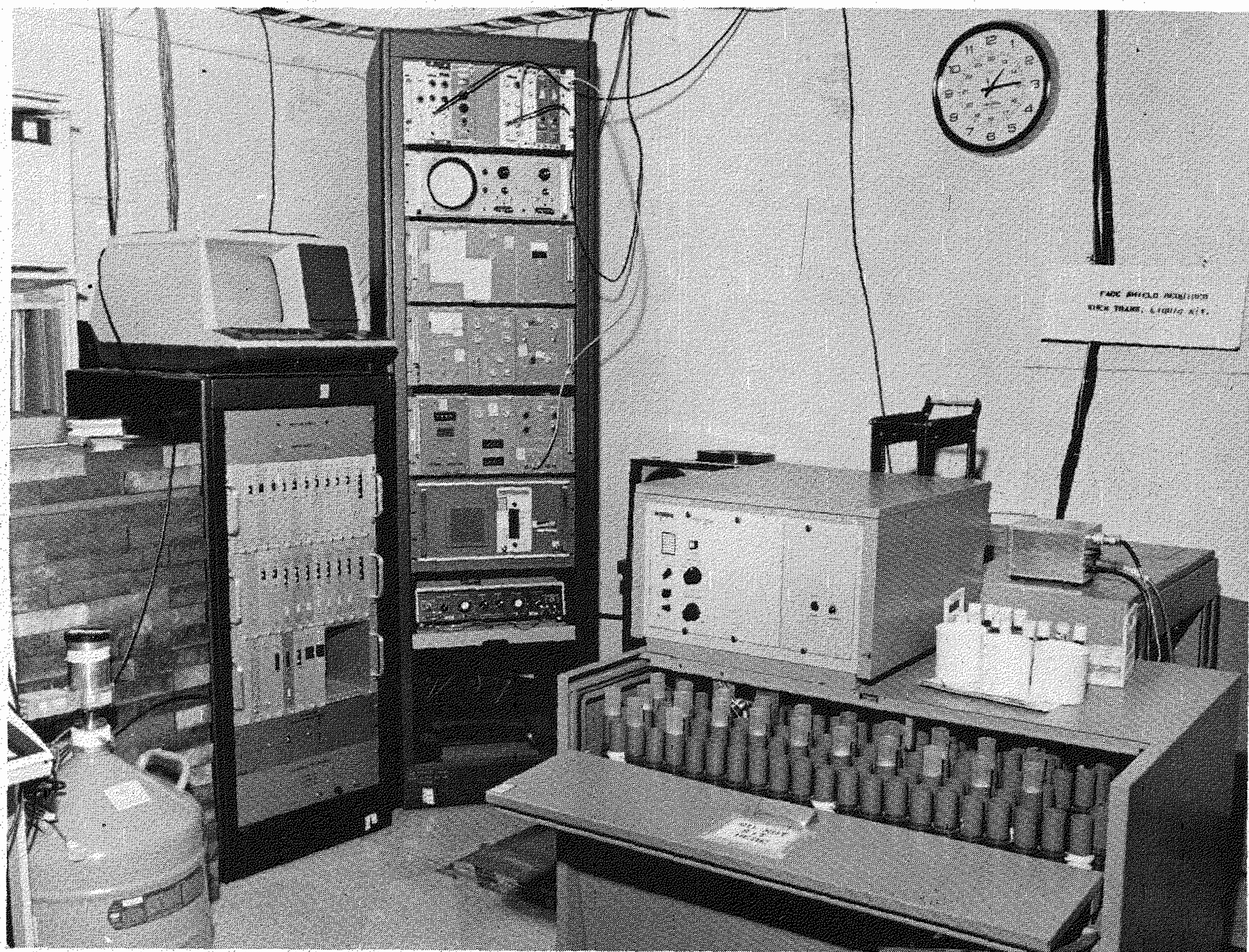

FIGURE 8. Sample Changer for Gamma Samples

ADDITIONAL INSTRUMENTS

Other instruments can be serviced by the microcomputer. The only requirements are that the format of the data package be the same as that for either the IR spectrometer or the PHA and that the signal protocol be within the RS-232 requirements. Figure 9 shows an electroanalytical instrument, which can communicate with either the microcomputer or with a PET™ (Commodore Business Machines, Inc., Palo Alto, CA) desk-top computer. The PET™ can communicate with the microcomputer. An atomic absorption spectrometer has also been used with the microcomputer.

MICROCOMPUTER-TO-PDP-15 DIALOG

The transmission of information from the microcomputer to the PDP-15 involves a software handshaking routine, a predata file, and the information/data file that originated at the instrument.

In Figure 10 it is seen that ASCII characters are exchanged to start and stop the exchange. The predata file alerts the PDP-15 to the instrument identification (ID) and the total number of bytes in the following file.

The elements in the information/data file are shown in Figure 11. The instrument ID and the number of file bytes were also sent in the predata file. The information is sent as 7-bit ASCII characters, and the "*" delimiter shows that the following data bytes can be ASCII, binary, or binary-coded decimal. The PDP-15 treats each of these data types differently.

FIGURE 9. Electroanalytical Instrument

PDP-15 ACTIONS

The RSX/XVM Executive (Digital Equipment Corp.) permits several users at once. The microcomputer is one user. The MACRO (assembly language) program tells the PDP-15 to receive the file, manipulate the bytes, and write the resulting files on the disk. The instrument ID is the key to how the bytes are to be manipulated, and it is the key to the disk file name.

A TTY I/O port on the PDP-15 is used by the microcomputer. The requirements of the multiaccess TTY handler for the normal RSX and those for the microcomputer are given in Figure 12. Reading and writing 8-bit binary bytes exclude parity checks and using control characters as commands. Retaining the ECHO function would double the transmission time and would increase the program size of the microcomputer. The number of bytes the TTY handler can receive with one READ statement was increased from 254 to 24K.

All of these changes to the handler were made so that they do not affect normal operation by other PDP-15 users.

SUMMARY

We have demonstrated that in some cases it is desirable to design and build a microcomputer to be an interface between a variety of instruments and a computer, especially if the computer is not designed to handle a large number of I/O devices. The least desirable feature is having to change the TTY handler in the PDP-15. This could be avoided by greatly expanding the program in the microcomputer.

FIGURE 10. SOFTWARE HANDSHAKING

PRE-DATA FILE

μC		PDP-15
SOH	→	
	←	ACK
ID	→	
NO. BYTES	→	
EOT	→	
	←	ENQ

FIGURE 11. INFORMATION/DATA FILE

NO. FILE BYTES
INST. ID
TIME FILE SENT
INFORMATION
* (DELIMITER)
NO. DATA BYTES
TIME DATA RECEIVED
DATA
DELIMITER

FIGURE 12. CHANGES IN TTY HANDLER

	RSX	C
READ		
ASCII	Y	Y
BINARY	N	Y
ECHO	Y	N
CTRL	Y	N
WRITE		
ASCII	Y	Y
BINARY	N	Y
BUF. SIZE	254	24576

ACKNOWLEDGEMENT

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U.S. Department of Energy.

REFERENCES

1. J. S. Byrd and M. H. Goosey. "A Pulse Height Analyzer with Automatic Differential Deadtime Correction." **Nuclear Instruments and Methods 158,** 565-569 (1979).