UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A MICROCOMPUTER-BASED DATA ACQUISITION AND CONTROL SYSTEM FOR THE DIRECT SHEAR, RING SHEAR, TRIAXIAL SHEAR, AND CONSOLIDATION TESTS

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Open-File Report 83-491
1983

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ILLUSTRATIONS

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DEFINITIONS OF KEYWORDS

Term	Definition
analog signal	A variable voltage or resistance which is the output signal from a sensor.
bit	A single binary digit.
buffer	A 256 byte section of RAM used to temporarily hold information during I/O operations.
bus	The circuitry and elements used to connect and transmit electrical signals from the computer to its attached devices or another computer.
byte	A group of (usually) eight bits.
concatenate	An operation which causes one character string to be tacked onto the end of another.
core	The moveable center portion of an LVDT, used to balance the output signal.
counter	A memory location (variable name) used to count the number of times a certain event occurs.
digital	A binary representation of an analog quantity.
file	A collection of data, text, or instructions that are stored on a mass storage device and referenced by a filename.
flag	A value that causes a specified branch based on a value of zero or one. Here the flag is an integer.
hardware	Computer equipment.
high-thermal relay	A relay capable of operating electric motors.
homed or home	Brought back to an open switch position.
interface	A module which allows two or more devices to communicate with each other.
low-thermal relay	A relay which handles only low electrical currents.
multiplexer	A high-speed relay switching device which provides the means for many inputs into a single source.

DEFINITIONS OF KEYWORDS--Continued

Term	Definition
multi-tasking	A computer device capable of processing more than one task at a time.
null	(1) An empty string. (2) An undefined numberic value. (3) The center position of a sensor or a mechanical device. (4) A quanity which when added to another quanity produces a null (0).
prompt	A question mark (?) or a question and a question mark (?).
real	A 12-digit number between 9.99999999999E+499 and 9.99999999999E-499.
record	The smallest addressable portion of a storage file.
scanner	A computer controlled multiplexing relay box.
sensor	A sensing device, like a load cell, a thermistor, or a LVDT.
short	A 5-digit number between 9.9999E+99 and 9.9999E-99.
software	Computer programs.
string	A variable that contains alphanumeric text. The variable names will end with a $.

ABBREVIATIONS

Abbreviation	Definition
A to D	a converter which changes analog signals to digital signals
AP ROM	advanced programming read only memory
ASCII	American Standard Code for Information Interchange
ASTM	American Society for Testing and Materials
BCD	binary coded decimal
BPB	banana plug box
CRSC	constant rate of strain consolidation
CRT	cathode ray tube
D	(1) direct wiring, (2) a digit
dc	direct current
ELE	Engineering Laboratory Equipment. An intermediate display and power supply
HP-IB	Hewlett Packard Interface Bus (IEEE 488 - 1978)
Hz	frequency measure (hertz)
ID	intermediate display
IEEE 488	see HP-1B
I/O	computer input/output operation
K	(1) 1024 units of computer memory, (2) 1000 units
kg	kilogram
kN	kilonewton.
LEDEX	a motor-powered rotary switch
LVDT	linear variable differential transducer
mm	millimeter
ms	millisecond
PP1	power package one

ABBREVIATIONS--Continued

Abbreviation	Definition
PP2	power package two
PS	power supply
RAM	random access memory
ROM	reading only memory
SC	signal conditioning
s	seconds
SKF	special function key
SW	switch
TRANS	transducer
TS	terminal strip (wiring)
UMC	UMC 4000 load/strain indicator box
V	volts

A Microcomputer-Based Data Acquisition and Control System for the Direct Shear, Ring Shear, Triaxial Shear, and Consolidation Tests

By Philip S. Powers

ABSTRACT

This report is intended to provide internal documentation for the U.S. Geological Survey laboratory's automatic data acquisition system. The operating procedures for each type of test are designed to independently lead a first-time user through the various stages of using the computer to control the test.

Continuing advances in computer technology and the availability of desktop microcomputers with a wide variety of peripheral equipment at a reasonable cost can create an efficient automated geotechnical testing environment. A geotechnical testing environment is shown in figure 1. Using an automatic data acquisition system, laboratory test data from a variety of sensors can be collected, and manually or automatically recorded on a magnetic device at the same apparent time. The responses of a test can be displayed graphically on a CRT in a matter of seconds, giving the investigator an opportunity to evaluate the test data, and to make timely, informed decisions on such matters as whether to continue testing, abandon a test, or modify procedures. Data can be retrieved and results reported in tabular form, or graphic plots, suitable for publication.

Thermistors, thermocouples, load cells, pressure transducers, and linear variable differential transformers are typical sensors which are incorporated in automated systems. The geotechnical tests which are most practical to automate are the long-term tests which often require readings to be recorded outside normal work hours and on weekends. Automation applications include incremental load consolidation tests, constant-rate-of-strain consolidation tests, direct shear tests, ring shear tests, and triaxial shear tests.

INTRODUCTION

Certain geotechnical soil tests require a considerable amount of time to complete. For example, the repeated direct shear test may require periodic readings for several hours, or up to a month. To control the equipment and record the data manually at 5-min intervals would require a technician to be available 24 hours a day, 7 days a week, for a period of a month or longer. Then data would have to be analyzed, plotted, and reported. Through automation, nearly all the data acquisition, data analyses, and some of the equipment control can be performed by the desktop computer.

To realize the full capability of computer automation in a diverse laboratory testing environment it is necessary to be able to run any two computer programs at the same apparent time, or create new programs while the automation program is running. The following methods were considered for simulating a multitasking environment.

1. A microcomputer with 64 K bytes of RAM, or more, and a source of commercial software capable of meeting all the data reduction and data acquisition requirements for both the present and the future.

2. A computer with a smaller main memory (about 32 K bytes) which can operate data acquisition equipment with an assembled machine language program in high memory, while program development and data reduction is handled in a high-level language in the lower memory.

3. A computer with a smaller main memory (about 32 K bytes) which is capable of switching programs into memory by utilizing custom software and high-speed mass storage equipment (hard disk drive).

4. A special multitasking computer which has several separate memory blocks available, and switches the CPU from block to block. The high-speed mass storage device is a shared device (either floppy or hard disk).

5. Two separate computer systems, each with a minimum memory size of 32 K bytes, which are capable of data transfer between each other.

Items 1 through 4 were rejected for the following respective reasons: a rapidly changing facility requires frequent software modifications, original equipment was not equipped for assembly language program development, an inexpensive high-speed mass storage device was not available at the required time, and a multitasking microcomputer system was not available at the required time. The 5th option was the one chosen, primarily because an inexpensive microcomputer with data transfer compatibility became available at the right time.

The U.S. Geological Survey laboratory utilizes the inexpensive Hewlett Packard 85 desktop computer for a dedicated data acquisition system, and the more powerful HP-9835A for a data processing and plotting computer. This system is shown in figure 2.

The first equipment automated in the U.S. Geological Survey laboratory was the direct shear machine and three consolidometers. Later, ring shear equipment, two triaxial test devices, and a fourth consolidometer were added. An Advanced Programming ROM was added to the system, and the program was modified to take advantage of special features offered by the new ROM.

As the number of automated devices increased, so did the memory requirements of the data acquisition program. In an effort to conserve RAM for the developing program, nonessential comments were removed first, variables were declared as efficiently as possible, statements were abbreviated, and single statements were combined into multiple statements wherever possible.

The system's ability to process multiple statement lines conserves considerable memory, and has been utilized extensively. When multiple statements come after the IF statement, a small (hidden) subroutine is effectively created. A hidden subroutine means that the statements after the IF statement will not be seen or processed unless the conditions of the IF statement are met.

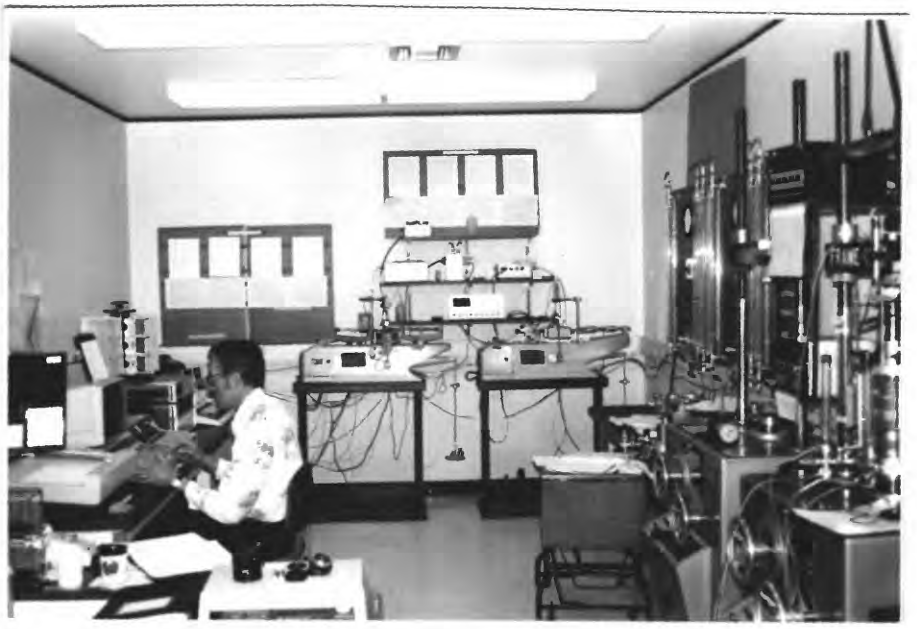

Figure 1.--Automated geotechnical testing facility.

Figure 2.--Plotter, data processing microcomputer, and data acquisition microcomputer.

The HP-IB Bus and the data cartridges were both considered as methods of transfering the data between the two microcomputers. The transfer over the HP-IB Bus was discarded, for the moment, because whenever data plots were created both computers needed control of the bus at the same time.

GENERAL PROGRAM FEATURES

Test data is stored on the tape cartridge when it is acquired by the HP-85. Data acquisition is momentarily suspended while the data tape is physically transferred to the HP-9835A. After the data has been read into the memory of the HP-9835A the tape is replaced in the HP-85 and the scanning continued. This approach to data acquisition and equipment control leaves the HP-9835A system available for program development, data reduction and analysis, and plotting of results. The HP-85 with the data acquisition program will control, store, and display the data from up to 10 soil tests.

To prevent the computer's operating system from "getting hung up" and halting the program due to computational problems or other errors, both DEFAULT ON condition and the ON ERROR GOTO statement are activated. This means that internal default values will be used wherever possible, and an error condition will return the program to the data scanning mode. These provisions mean that data acquisition will continue for most of the tests, even though a problem has occurred with a test.

Data Files

All programs and data files can reside on one tape, or the data files may be on a separate tape. The data is stored in files with names that are easily associated with the type of test. The data files for the test data need to be created. Use the CREATE command with the appropriate arguments (sizes).

Table 1.--**Data file names and file sizes**

Name	Bytes/record	Number of records
CON1	40	32
CON2	40	32
CON3	40	32
DSHR	40	300
RSHR	40	200
TRX1	80	150
TRX2	80	150
TRX3	80	100
TRX4 (CRSC)	80	100

Random storage and access tape files are used. The first record of every file stores the sample identification. The second record stores the name of the person who submitted the sample. The third record stores the normal applied load. The fourth record stores the rate of movement. The fifth

record is open or contains the month, day, and year that the test was run. The sixth record of every file contains the number of data sets that are stored on tape. The remaining records in the file are reserved for the actual test data.

Another data file required is FACTOR (40 bytes per record and 25 records long). Data must be inserted into the file FACTOR before "Autost" or SETUP will run properly. To insert the initial data set follow these steps:

LOAD "SETUP" press [END LINE]
press [RUN]

when the display prompts

(ENTER 1, ENTER 2, or ENTER 3)

press [PAUSE] type "CONT 2000"
press [END LINE].

The first 11 numbers inserted in the file are used as multipliers to convert the gathered data to the appropriate engineering units. The 12th (last) record is a string which sets the initial configuration of the A to D converter. Page 100, appendix II shows the records used for each tests. When this procedure has been completed the program will be returned to the same place where it paused, and the procedure will not be needed again until a new tape is used.

Programs

There are three programs (written in HP extended BASIC) that operate the data acquisition system. However, there are many programs used for data reporting, transferring, and plotting. The schematic program structure is shown in figure 3. Only the three acquisition programs will be described below.

Program	Description
1. Autost	When the program tape is inserted, and the system turned on, the program "Autost" is automatically loaded and started. The only function of "Autost" is to load and start the program SETUP.
2. SETUP	This program, when run, presents three options: (1) change the current setup conditions in the file; (2) display the setup conditions in the file; (3) load the automation program and pass initial values and the information from the file FACTOR to the program.

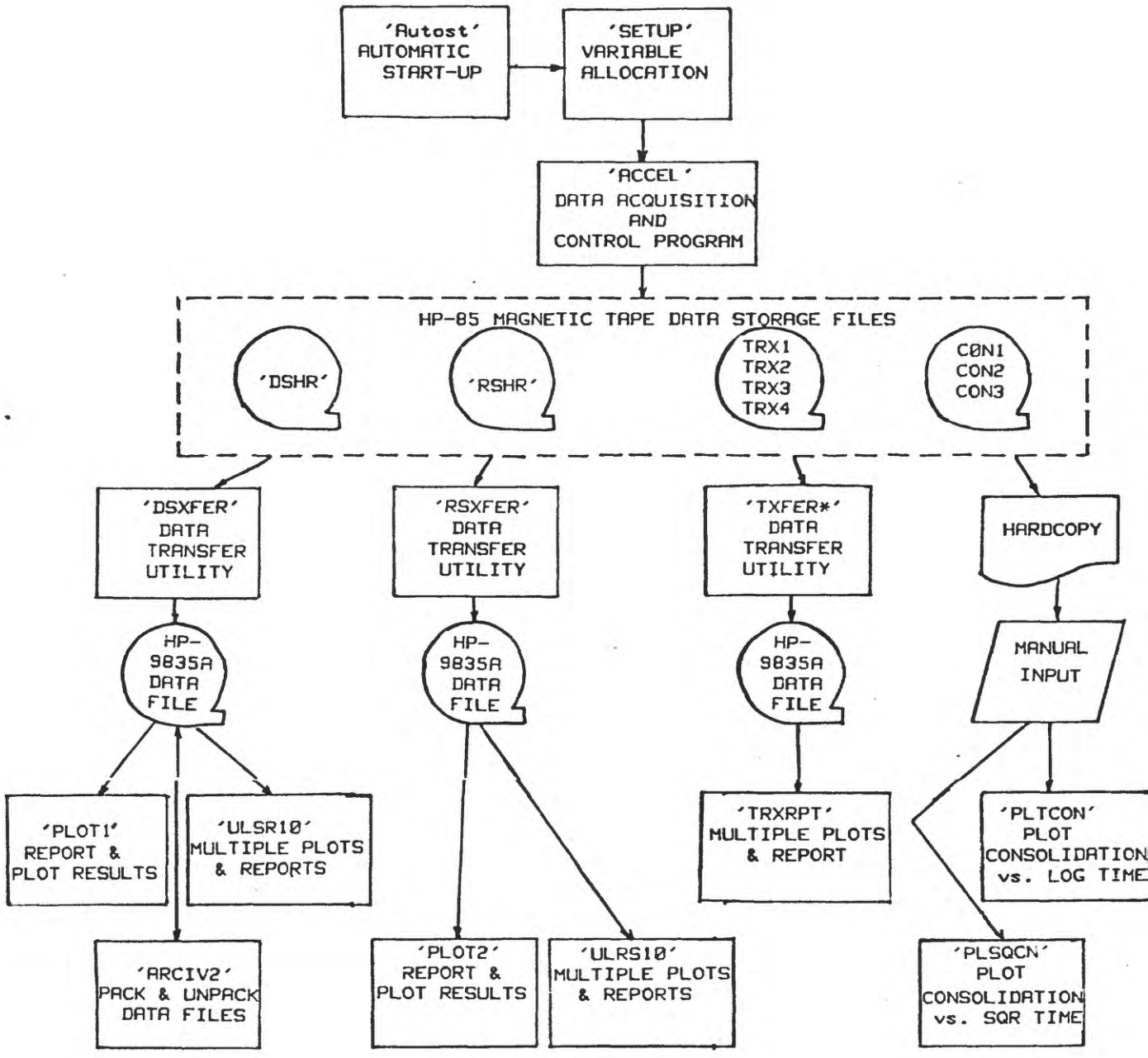

Figure 3.--Schematic diagram showing programs and data files.

Initial values are assigned by SETUP and passed to the automation program ACCEL. A fourth option, which is not displayed, must be executed to put initial values in the file FACTOR. If this is not done the first time, error conditions will result. The procedure for this option was discussed on the previous page.

3. ACCEL — This is the data acquisition and control program. This program must be loaded by either "Autost" or SETUP. This program provides the means to monitor and control up to 10 different tests simultaneously.

Command Key Definitions

The operation of the program is based on a command language (18 commands). A flag is set when a user defined key is selected. This flag dictates how the command language is applied in the program. The following table is a list of the system commands for the program:

	Key	Definition	Beginning line
1.	A	Puts flagged test into automated readings mode.	850
2.	D	Stores readings from test which have most recently been read.	750
3.	E	Exits from the command mode and returns to the scan mode.	900
4.	H	Displays the selected test name, time and date, and column headings. (Aid to identify displayed readings.)	700
5.	I	Prepares for the next test by initializing selected variables, flags, and data files.	800
6.	I1	Stores sample/test identification for test in memory and on tape.	9100
7.	I2	Displays current sample/test identification on the CRT.	9200
8.	L	Lists the stored information on a flagged (selected) test.	950
9.	M	Displays abbreviated definitions of the commands on the CRT.	450
10.	N	Stores a NULL set of readings for a selected test (if required).	650

	Key	Definition	Beginning line
11.	P	Plots on the CRT or printer the vertical change in height (Y-axis) versus the number of stored readings (X-axis). (Plots all tests except triaxial shear.)	5605
12.	R	Gathers and displays a single set of readings on the CRT (values in memory).	600
13.	R1	Used to reopen the data storage files on the data tape and the buffers which automatically close when the data tape is removed during the data transfer phase.	10
14.	S	Displays the automated system status. (Number of stored readings for each test.)	550
15.	S1	Stops the progression of automated readings by changing the status of automated flags.	9300
16.	T	Gathers a TOUCH reading, stores the reading on tape, and inserts the word TOUCH into the data listing. This command is for triaxial tests only, where visible contact of the piston and sample is noted or felt.	500
17.	V	Displays the voltage readings for the flagged tests (conversion factors not applied).	400
18.	Z	Deletes the last set of stored values for a selected (flagged) test.	1150

COMPUTER AUTOMATION EQUIPMENT

Since the automation program is the topic of this report, and that program runs on the HP-85 desktop computer, the 85's system features will be discussed at greater length than the HP-9835A.

The HP-85 system has a built in CRT with high resolution graphics (256 X 192 points), and an integral thermal printer with graphics producing capabilities. The maximum available user memory is 32 K bytes of RAM. The CRT has a memory of four pages of 16 lines each. A copy key will reproduce the CRT image on the thermal printer. There are eight principal user defined keys located in the upper left portion of the keyboard which are utilized for test selection. The HP-85 is programmed in extended BASIC, which has many special features.

The HP-9835A is a desktop system which can be programmed in standard BASIC or extended BASIC. The system that is in use in the laboratory has approximately 50,000 bytes (characters) of RAM, with an expansion capacity of an additional 200,000 bytes. A schematic diagram (fig. 4) shows the relationship of the components of the data acquisition systems to the equipment.

Hewlett Packard 9835A--desktop computer

Options required:
1. Serial I/O
2. Real time clock
3. Input/Output ROM
4. Plotter ROM
5. HP-IB Bus (IEEE 488-1978)

Texas Instruments Model 820--Printer/Terminal (up to 160 characters per second)

Hewlett Packard 9872B--4-color plotter

Hewlett Packard 3455A--digital voltmeter (analog to digital converter) (Hewlett Packard Company, 1976)

Hewlett Packard 3495A--multiplexer scanner (Hewlett Packard Company, 1978)

Options required:
1. Two 20-channel low-thermal relay assemblies
2. Two 10-channel relay actuator assembly

Hewlett Packard 85--desktop computer

Options required:
1. HP-IB Bus (Hewlett Packard Company, 1980c)
2. ROM drawer
3. I/O ROM (Hewlett Packard Company, 1980a)
4. 16 K memory module
5. BCD interface (Hewlett Packard Company, 1980b)
6. AP ROM (Advanced programming) (Hewlett Packard Company, 1981)

Hewlett Packard software to convert HP-85 data tape to HP-9835A format (Hewlett Packard Company, 1979). Electronic hardware interfacing, signal conditioning, and power supplies are not included in the listing of required equipment.

PROGRAM AUTOMATION FEATURES

Direct Shear Test

The automated repeated direct shear apparatus is manufactured by Wykeham Farrance of England and is shown in figure 5. The automation of this test is controlled by the output of the horizontal LVDT. Conversion information stored in the data file FACTOR converts voltages to engineering units. The shear load cell and vertical and horizontal LVDT's are dc powered, and their outputs are sent directly to the scanner, and then to the analog to digital converter.

The data acquisition program will protect the equipment from inadvertent overloads. The program requests the capacity of the load cell in pounds (100, 500, or 2000) to be input. At 100 percent of the maximum load, a warning (audio and visual) will be given. At 25 percent overload, the computer will terminate the test for protection of the equipment.

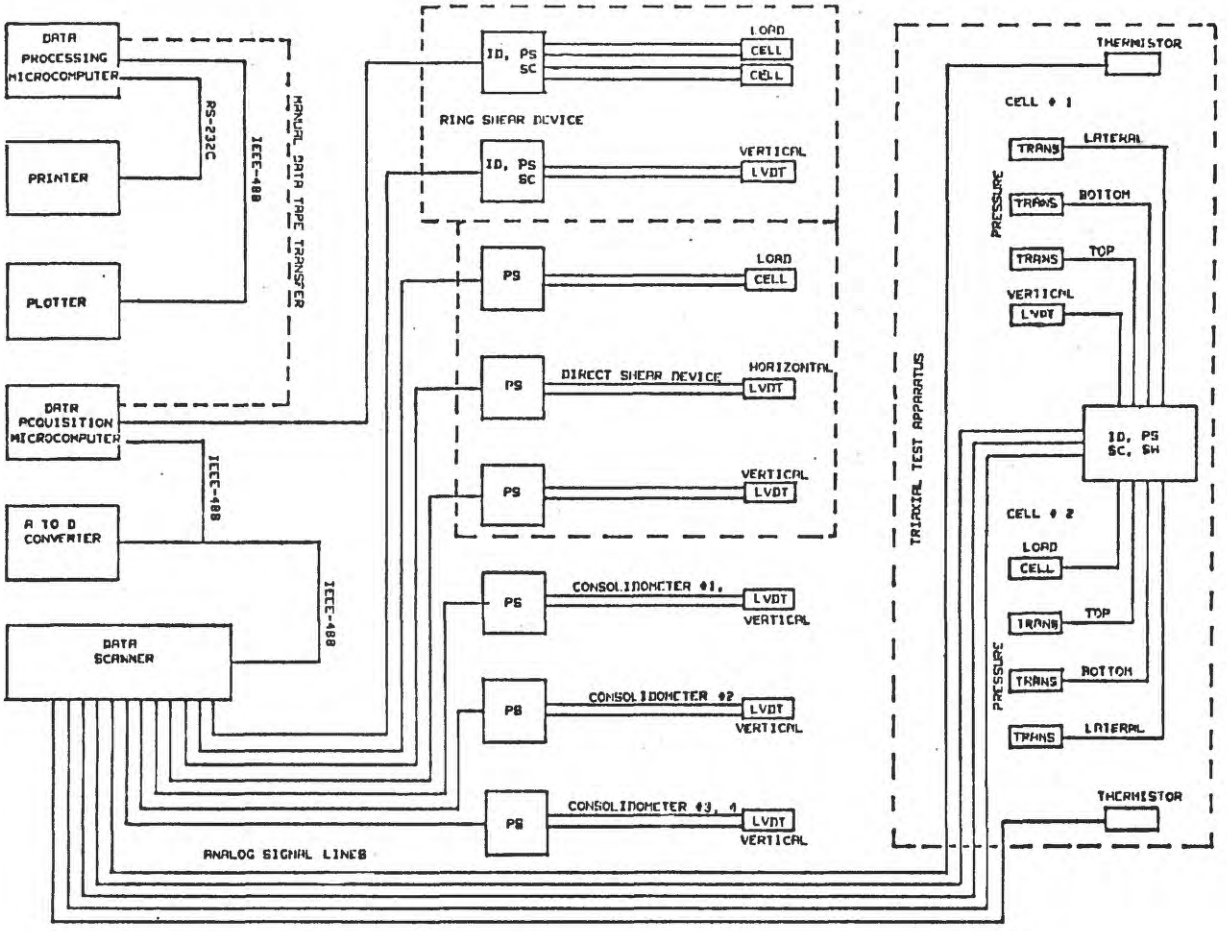

Figure 4.--Data acquisition and control schematic.

The program will control the equipment for 5 shear motions in each direction. The computer controls the direct shear drive motor by turning it on, running the motor in either direction, and turning the motor off.

The vertical change in sample height is another of the stored parameters. There is a vertical deformation of the loading frame due to applied normal load that should be taken into consideration when measuring change in height of a sample. This frame deformation factor is not considered in the data acquisition program, but is corrected for in the data reduction programs on the HP-9835A.

Flags are set for the direct shear test in lines 1505-1510. Lines 6000 through 6499 are used by the direct shear portion of the acquisition program.

An audio signal (beep) at 260 Hz (low frequency) for 200 ms is sounded to indicate tape storage of direct shear data.

The program is initialized with the voltage-to-kilonewton conversion factor for the 100-lb load cell. During the automation phase the program user is requested to enter the capacity of the load cell (100, 500, or 2000) in pounds. The selection of the load at this point of test automation also selects the appropriate conversion factor. These factors are in lines 6031-6034 of the automation program. After changing the load cells, to change the factor

enter the command **A** and press [END LINE],

enter the selected load cell capacity in pounds,

press [PAUSE] and type **CONT 50**,and press [END LINE].

Ring Shear Test

The ring shear apparatus which is controlled by the automation program is manufactured by Wykeham Farrance of England (see fig. 5). The automatic readings are controlled by the rotational rate in degrees per minute of the turrent and real time (Angular change = Time X Rotation rate) .

Calibration of the two load cells and vertical LVDT is done electronically. There is a scale multiplication factor of -0.01 for the load cells and 1000 for the LVDT.

The load cell data is transmitted to the computer through a BCD interface, and through the scanner and A to D converter for the vertical LVDT. The equipment automatically starts and stops on preset parameters.

Test control flags are set for the ring shear test in lines 2000-2010. The automation routines for the ring shear tests are on lines 6500 through 6999.

Two audio signals (beeps) of intermediate frequency (500 Hz) are emitted for 200 ms each whenever a data set is stored on tape.

Consolidation Test

A maximum of three consolidation tests can be run at the same time. The program is designed to acquire data from four load frames (frames 3 and 4 share the same signal conditioning electronics and LVDT). Frames 1 and 4 are of the same type (Karol-Warner (Conbel) model 345) and frames 2 and 3 are of the same type (Karol-Warner (Conbel) model 351). (See figs. 6, 7.)

The program applies a load frame deformation (vertical response due to applied normal load) factor to the sensed data. The same factor is used for the same model load frames. This factor is determined from the application of a series of loads to the consolidation frame and sample apparatus (two filter papers included). The factors were determined over the total range of the frame, and fit with a 5th or 7th degree polynomial function.

The data are gathered according to ASTM D-2435 prescribed time intervals (Lukins, 1982), with two extra (accelerated) readings taken at 1.88 and 3.75 s, and a 7 1/2-min reading taken in place of the 8-min reading. The interrupt times are passed to the built-in system timers (there are three), which interrupt the program to gather the timed readings. The interrupt timers, when set, allow the readings to be gathered at any time except while the program is paused, or during an I/O operation . Timer no. 1 is for consolidometer 1, timer no. 2 for consolidometer 2, and timer no. 3 for consolidometers 3 or 4. When running more than one consolidation test at a time, it is best to offset the starts so the computer has time to make all the readings when they are due. An appropriate time offset might be either 3 or 5 min (odd times). A 1- or 2-min offset will cause some timed readings to arrive at the same instant.

The LVDT's are powered with a dc voltage source, and the analog voltage output is sent directly to the scanner. Software conversion factors (from the file FACTOR) convert the voltage to displacement (millimeters in this application).

The automation controlling routine for consolidometer 1 is located in the program on lines 5000-5199; consolidometer 2, lines 5200-5399; and consolidometers 3 and 4, lines 5400-5599. The first 10 readings for each consolidometer are stored in memory to prevent delays due to tape rewinds. When the time between gathered readings has increased to 7 1/2 min, all the readings are written to tape.

Triaxial Shear Test

Two load frames are required to utilize all the data gathering capabilities of this system (see fig. 8). Load frame 1 shares the same LVDT for axial deformation measurements and the same load cell for normal load measurements with both triaxial cells one and two. The same sharing of sensors is designed for load frame 2, and triaxial cells three and four. Because of the system's design it is recommended that only one frame be in an automated shear condition at a time. If two samples are in the automated shear phase at the same time, the LEDEX switch will be constantly switching back and forth between the inputs from the two tests. The other triaxial cells can be in various stages of sample saturation and consolidation.

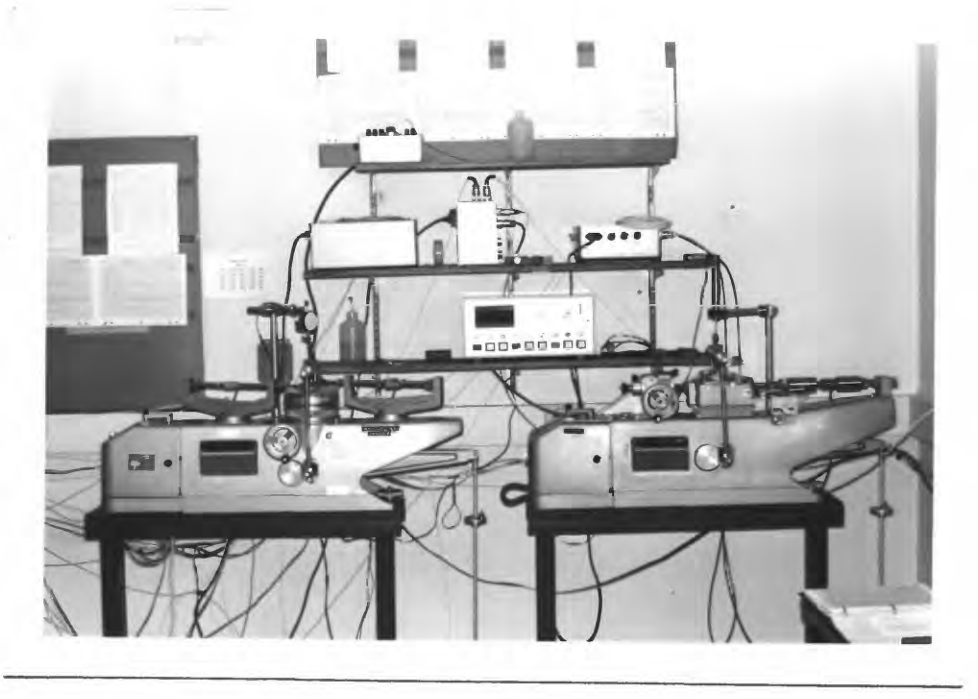

Figure 5.--Automated ring shear and direct shear devices.

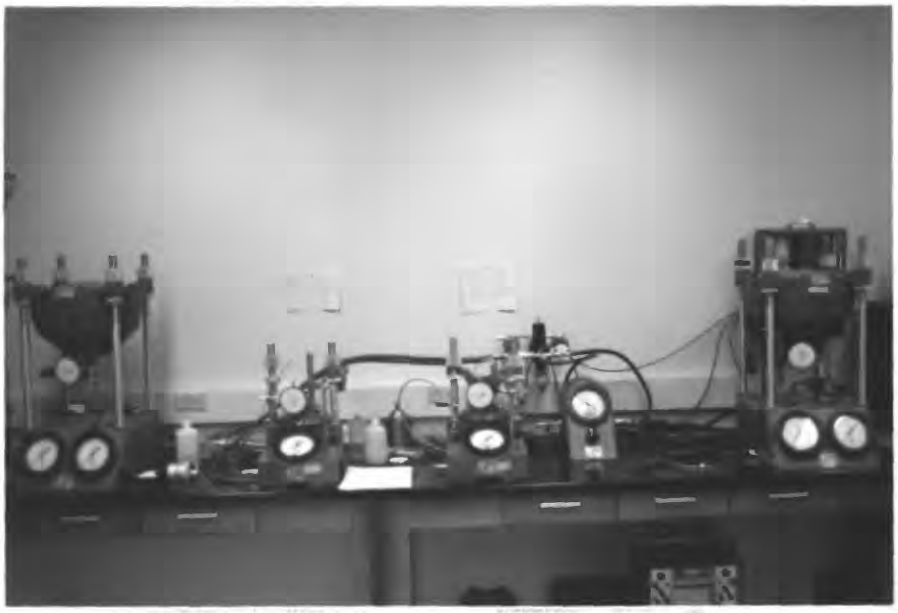

Figure 6.--Consolidometer test frames 4, 3, 2, and 1.

Figure 7.--Consolidometer test frames 3 and 2 with automated sensors and dial gauges attached.

Using our electronics, and this program, 17 low thermal (data) relays, and 6 high thermal (actuator) relays are required to gather the data and control the tests. A 100-V dc pulse, provided through the closure of a series of relays, operates the channel switch on the triaxial balancing and calibration box. A 1.5-s pulse is used to insure that the home position can be reached from any switch position. The switch is homed and then advanced to the first position with a 20 ms, 100-V dc pulse. The first position is for the axial deformation sensor, which controls the data collection. The channel switch is left at this position until the preselected axial change has been exceeded. Each time the channel switch is changed to a new position a channel identification signal is sent through a relay in the series from 20 to 29. A 5-V signal on relay 20 identifies the channel switch as being in position zero. If the signal is on relay 21, then the channel switch is on position one. This relay and channel relationship holds true through relay 29 and channel 9. If the channel identification does not agree with the program counter, the channel switch is homed and the sequence is repeated until all the information with channel verification is completed.

OPERATING PROCEDURES

Direct Shear Test

Introduction

The automatic data acquisition program is stored on the tape labeled HP-85 ACCEL. Insert the tape into the HP-85 computer. Turn the computer on with the switch at the right side of the rear panel. A program named "Autost" will be loaded into memory and started. This program automatically loads and starts the program SETUP. SETUP allows the user to change the calibration factors, or if no changes are required, read the current calibration factors from a data file called FACTOR, load the automation program ACCEL and pass to the automation program the calibration setup information.

Before the data acquisition program is continued, the current date and time should be set. To set the time do the following:

Type **SETTIME HMS ("hh:mm:ss"), yyyddd**, and then [END LINE].

Where hh denotes hours, mm denotes minutes, ss denotes seconds, yyy denotes year, and ddd represents the Julian date.

To check the date

Type DATE$ and press [END LINE].

To check the time

Type TIME$ and press [END LINE].

Before continuing the program, insert the tape with the appropriate data files. Then continue the program. The program will first assign buffers (1-10) to the data files on the data storage tape. The CRT then flashes the display GEOTECHNICAL TEST CONTROL. At the bottom of the screen, the key labels are displayed in their respective locations.

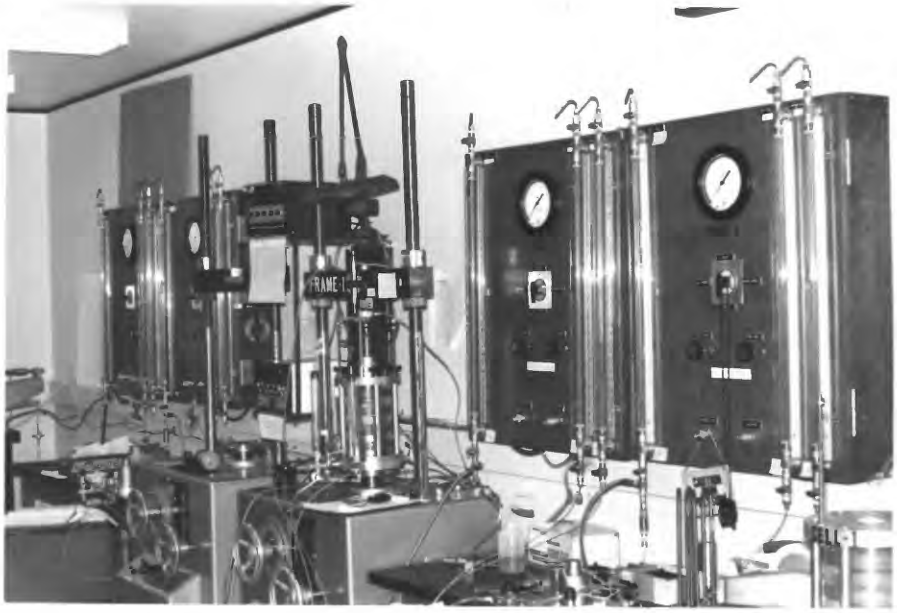

Figure 8.--Automated triaxial shear test systems.

The system controller has eight user-defined special function keys (SKF). Different tests are controlled by each key. SKF [K1] controls consolidation test 1, 2, 3, and 4, and SKF [K2] controls the direct shear test, and so forth. To access any test, press the SKF for that test.

Getting Started

Press SKF [K2]

which corresponds to the direct shear control. The system is now in the direct shear command mode. If you are unfamiliar with the commands available,

enter **M** and press [END LINE],

and a command menu will be displayed on the CRT. These commands are one or two key combinations. To start,

key in the command **I1** and press [END LINE].

This command requests and stores the test identification for the selected test. The CRT will respond with ENTER SAMPLE ID.

Next, enter the name of the submitter and press [END LINE].

The CRT responds after the last entry with ENTER THE NORMAL LOAD IN KILOGRAMS.

Enter the numeric value and press [END LINE].

The CRT then requests the shear box rate. Again,

enter this value (mm/min) and press [END LINE].

When the sample identification information process has been completed, another question mark will appear on the CRT. This question mark indicates that the system is still in the command mode and is awaiting another command. Next, view the sample identification information to insure correct input.

Enter an **I2** and press [END LINE].

The CRT displays the identification information. If the information needs editing, enter the command **I1** and re-enter all the information. Otherwise,

press [END LINE] to proceed.

Note: Most inputs are limited to 17 characters (alpha, numeric, and some special characters are allowed in this input). Commas are not allowed in the input.

Inframe Consolidation Phase

To store consolidation data before automating the direct shear test, follow these instructions:

press the SKF [K2]

to access the command mode for the direct shear test. The CRT will prompt for a command.

Enter the command **R** and press [END LINE].

The CRT will display DIRECT SHEAR DATA along with the column headings of Horizontal Displacement, Load, and Vertical Displacement. Press the key **V** and read the uncorrected values from the direct shear machine (voltage).

Readings obtained with the **R** command are the same as raw voltage values unless a null correction factor has been applied. A reading using **R** may have a previous null correction factor or the null correction factors may be equal to zero. At this point,

press the **N** key and [END LINE]

to record new null correction factors.

Press the key **R** and [END LINE] again.

The CRT should display the vertical displacement, horizontal displacement, and load figures as all being zeros. To store a set of readings

enter the command **D** and press [END LINE].

When through gathering consolidation data on the direct shear device and having printed a copy of the data, clean up the data file by

entering the **I** command and pressing [END LINE].

The CRT displays the prompt, asking if the direct shear data has been copied, and are you ready to purge the direct shear data file. Since a clean file is needed for the automated direct shear data

enter a **Y** for YES and press [END LINE],

and purge the consolidation data. Next,

press [END LINE] to proceed.

Press **E** for exit and then [END LINE].

The CRT then displays the geotechnical test control information and the key labels, and is prepared to continue scanning its sensors for gathering data.

Shear Phase

Before pressing the **A** (automate) command,

enter the **R** command and press [END LINE]

to read the sensors. The values the CRT first displays are not nulled. To null the displayed value,

press the key **N** and [END LINE].

This takes the current reading from all the sensors and stores them as null values to be subtracted from all the subsequent readings. If the **N** command is not used the stored reading can possibly be incorrect.

To automate the test, first be sure that the direct shear command mode is active, then

enter an **A** and press [END LINE].

The CRT responds by asking for the load cell capacity in pounds.

Enter 100, 500 or 2000, and press [END LINE].

This information is used to first warn, and then to shut the test down to protect from serious overloads. Next the CRT requests the amount of displacement in millimeters from the null position that the table is to travel.

Enter the numeric value and press [END LINE].

The CRT responds by requesting the number of pulls (0 to 10) required.

Enter the required value and press [END LINE].

Enter zero (0) for a single one directional pull.

The next prompt requests the amount of table travel between readings in millimeters. This value initiates the acquisition of the data. There are 300 allocated data storage records on the data storage tape for this test. To determine the travel between readings, take the number of pulls and multiply by the number of readings per pull. If the result is less than 300, there is enough room. For example, if the table travel from the null position to the end is 3.2 mm, and 0.2 is input for the value of table travel between readings, then in the first half cycle 16 readings will be taken and stored. Each subsequent cycle will require 32 readings. Therefore, up to 8 cycles of data (272 readings) can be stored. An attempt to store another cycle of data will result in an error condition.

Next, the CRT requests whether the test is to start in tension or compression.

Enter a **T** for tension or a **C** for compression, and press [END LINE].

Tension means the load cell is pulled as opposed to compressed. The direct shear motor will start and the relays and the scanner begin switching through the sensors. The test is now automated. The next phase is to return from the command mode back to the scanning and display mode.

To do this, enter the command E and press [END LINE].

E stands for exit command mode. This will put the computer back into the scanning mode to allow the continuance of the acquisition of data on this device and other devices.

As the test continues in the automation phase, the relays will switch, and a beep is emitted when each data set is acquired and stored. The CRT flashes approximately one time per second while in the scanning mode.

The computer will automatically turn the direct shear motor off after the preprogrammed number of cycles. At the end of the test the computer will print on its printer DIRECT SHEAR TEST FINISHED, and the date and time.

Data Transfer Phase

If the test appears completed before the preprogrammed number of cycles has been reached, the test can be stopped. Stop the test by using the command **S1** (data remains intact on data storage tape), or you may stop the test by using the command I (data is cleared from tape). Before using the I command, the data should be copied from the HP-85 to the HP-9835. To find out the number of data items that are stored

press **S** for system status on the HP-85,

which counts the number of data sets stored.

To make a tape copy of the test data,

put the program into the command mode

and suspend the program using the [PAUSE] key.

Load the tape cartridge labeled "Data Utilities HP-85 to 9835" into the HP-9835 system.

Next, type in the command LOAD "DSXFER" and press [EXECUTE].

This loads a binary file and a BASIC utility which enables the HP-9835 to read the data stored on the HP-85 tape.

Once this program is in memory, remove the data utility tape. While the program operation is suspended on the HP-85, do a catalog directory listing on the HP-85 to know which file to access. Take the data tape from the HP-85 and insert it into the tape drive mechanism on the HP-9835.

Now [RUN] the data transfer program.

The HP-9835 will request which file number you want to dump. Look at the catalog directory for the HP-85, and note, for instance, that the file number for the direct shear test is 4.

Type **4** and press [CONTINUE].

You will then hear the tape drive mechanism search for the file. Next,

enter the record length in bytes and press [CONTINUE].

For this particular file there are 40 bytes per record, which is sufficient to store all of the data for the direct shear test. Then the computer asks for the file size in logical records.

Enter this number, for example, **10** and press [CONTINUE].

The CRT will then display the first 10 records from that file location. Again, the first four records are allocated to the sample identification, the fifth record is the date the test was run, the sixth record counts the number of data items stored, and the remainder will be the values of the stored data items.

The next step is to take an HP-9835 data tape and place it in the tape drive mechanism,

then press [CONTINUE] when ready.

The CRT next prompts for the generic file name. Generic means the identification information will be the first four characters of the file name. The remaining two character positions in the file name will be available for counting the number of cycles of the test. For instance,

enter a file name **ERT** and press [CONTINUE].

A file titled ERT1 has been created and all the information that had been stored in the first 10 records from the HP-85 has now been placed into that file in a suitable format.

Remember that while the data tape from the HP-85 is removed, the data acquisition is suspended. It is important that the tape removal from the HP-85 be coordinated with the consolidation tests so that a reading does not come due during the period of suspension. If this happens, the timing sequence will be thrown off. Replace the tape back into the HP-85. The process of removing the data tape automatically causes the data files to close. To re-open the data files, press continue to re-enter the command mode.

Then enter the command **R1** and [END LINE].

This will reopen all closed data files so that future data may be stored in those files. If the files had not re-opened, an error message would have been produced and the system would have been unable to store any more data. After the reopening of the data files, the system should be returned back to the scanning mode where the CRT displays the labels for the special function keys and the data gathering for the remaining tests will continue.

To do this use the **E** command.

Now is the time to initialize the direct shear test variables (counters, pointers, data) and clean up the data storage file on the tape.

Use the I command to accomplish this task.

Everything is now reset and ready to go for the next direct shear test.

Ring Shear Test

Introduction

These instructions assume that the automation program is up and running and in the scanning mode. If this is true, the CRT will flash GEOTECHNICAL TEST CONTROL, press user-defined keys to control test and display. If not, refer to the introduction section of the operating procedures for controlling a direct shear test.

Getting Started

Before proceeding, be sure that the [kilograms/pounds] push button on the display unit of the power supply is depressed into the kilogram mode. To control the ring shear test,

press the SKF [K3].

The CRT displays in a position corresponding to the SKF [K3], RSHR. The CRT will then respond by asking for the entry of a command. If you are unfamiliar with the commands that are available,

enter M for Menu, and press [END LINE].

A good starting command is S for the system status.

Type S and press [END LINE].

The computer updates the status from the information stored on tape. The CRT displays SYSTEM STATUS, INDEX, TESTS, and the number of STORED READINGS for all the pieces of equipment that are under its control. If for example, zero is displayed for the ring shear, all the flags have been reset and the tape file storage area is clear.

Next press [END LINE] to proceed.

A question mark will appear. This is requesting the next command. Next, select the command I1

Type I1 and press [END LINE].

The CRT then requests the entry of sample identification. The entry is limited to 17 characters.

Enter the appropriate sample identification and press [END LINE].

The next request is to enter the name of the submitter (limited to 17 characters).

Enter the name of the submitter and press [END LINE].

Next, the CRT requests the entry of the normal load in kilograms.

Enter the normal load in kilograms and press [END LINE].

Next,

enter the rotational rate (mm/min)

and then press [END LINE].

This rate is determined from prior consolidation test results. A chart for turret rotational speeds is posted near the ring shear machine. Enter the appropriate rotational rate. For example, enter 0.5 (mm/min). The rotational rate and time are used to determine when to acquire and store data.

Next, verify the test identification information by using the **I2** command.

Type **I2** and press [END LINE].

The identification information is displayed. Also, the normal load in kilograms is converted to kilonewtons. If the information is correct,

press [END LINE] to proceed.

If the information is incorrect, re-enter the information using the **I1** command.

While still in the command mode,

type the command H for HEADING, and press [END LINE].

A column identification heading appears on the CRT display to identify the columns. Next, look at the voltage outputs for the vertical LVDT on the ring shear device. To do this,

type **V** for Voltage, and press [END LINE].

The appropriate relays will close and the information will be displayed as voltage. The loads for the ring shear are displayed as kilograms load. There will be five columns of information displayed across the screen. The first column is channel A in kilonewtons, the second column is channel B in kilonewtons, the third displayed column is the mean of A and B in kilonewtons. The next column is the mean angular displacement in millimeters. The fifth column is the vertical displacement in millimeters. Any adjustments that need to be made to the system should be made now. That is, adjustments to the LVDT's or zero adjustments on the power supply for the load cells.

When ready to proceed,

type **N** and press [END LINE].

This obtains a NULL value from the vertical LVDT. Then

type **R** and press [END LINE]

to read the sensors again. All displayed data should come back on the CRT having the value of zero. If not, re-zero, and NULL again. Then read and display the data. When there are zeros across the display you are ready to proceed to the next phase of testing.

Make sure that the sample is prepared and ready, the load cells are properly positioned, and the normal load is ready to be applied.

Shear Phase

By typing the A (automated readings) command and [END LINE], the computer responds with the information to begin automation. The computer then clears the screen and provides the following information, ZERO CORRECTIONS MAY BE IMPLEMENTED BY FRONT DRAWER DIP SWITCHES AND POTS. ENTER YES TO STORE A NULL CORRECTION FACTOR FOR THE VERTICAL DISPLACEMENT. If a null factor for vertical displacement has already been stored,

press [END LINE].

The computer then responds by clearing the screen and prompting, ENTER THE AMOUNT OF ROTATIONAL DISPLACEMENT IN MILLIMETERS FOR THIS TEST. Enter the number of millimeters of rotational displacement. There are approximately 270 mm for one complete revolution. For example,

enter **270** and press [END LINE].

The next prompt is to ENTER ROTATIONAL RATE IN MILLIMETERS PER MINUTE. This information has been previously entered, but must be entered again. For example,

enter **0.5** (millimeters per minute) and press [END LINE].

The computer then responds by asking us to ENTER AMOUNT OF ROTATION IN MILLIMETERS BETWEEN STORED READING. The current limit of readings on the tape data file is 200. For example, elect to store a reading every 2 mm.

Enter **2** and press [END LINE].

The computer then responds by displaying PRESS [END LINE]; SOON A QUESTION MARK WILL APPEAR.

Press [END LINE],

and the ring shear motor will start, and the test is automated.

Enter E for Exit and press [END LINE]

to exit the ring shear device control, so that any readings that are due on the other equipment can be gathered.

The first reading will be stored immediately on tape and two low-frequency beeps will sound. This low-frequency beeping denotes that data points have been stored for the ring shear test. The CRT then resumes flashing and is back in the scanning phase.

To review the data that has been stored from the ring shear test, either during or after the test,

press the SKF [K3].

Then press the key L and [END LINE].

The CRT responds by asking ENTER AN A TO LIST ALL THE DATA, OR P FOR A PARTIAL LIST. If the data file is long and only a partial list of data is required,

enter P and press [END LINE],

and then enter the starting point and press [END LINE].

Otherwise,

enter an **A** and press [END LINE]

and all the data will be listed. Failure to enter either an **A** or a P will cause the CRT to repeat the question. The appropriate column headings, along with the date, will be displayed before the listing of your data. The CRT display can be copied on the printer by

pressing the [COPY] key.

At the termination of this test, the computer will print on its printer RING SHEAR TEST COMPLETED and the date and time.

Data Transfer Phase

Follow the same data transfer section given for operational procedures for direct shear test and data transfer phase. Be sure to note that there will be a different file number for this test than for the direct shear test. (Use the appropriate file number.) Also note that there will be a different version of the utility program on the data transfer tape. Use the program RSXFER instead of the version for the direct shear test. All other instructions for the data transfer phase of the direct shear test apply to the ring shear test except the file name, which may be up to six-characters long (the computer does not add a counter to the file name). When the data has been successfully transferred, replace the tape cartridge, use the command **R1** to reopen your data files, and the computer will return to the scanning mode.

Consolidation Test

Introduction

These instructions assume that the program is up and running and in the scanning phase. If not, refer to the introduction section of the operating

procedures for controlling a direct shear test. In the scanning phase the CRT will be flashing GEOTECHNICAL TEST CONTROL, and the labels of the user-defined keys. The SKF [K1] will branch to the routines which control the consolidation automation. SKF [K1] key controls consolidometers 1, 2, 3, and 4.

Press the SKF [K1] and the CRT will prompt

ENTER CONSOLIDATION TEST #1, #2, #3, OR #4.

NOTE: 3 AND 4 USE SAME DATA FILE AND LVDT.

Select the number of the consolidometer that is to be controlled and enter that number.

For this example,

enter **2** and then press [END LINE].

The CRT prompts ENTER COMMAND, ENTER M FOR MENU. If you are unfamiliar with the commands available to you in this program,

enter **M** for Menu, and press [END LINE]

Getting Started

The first key command used should be an S for system status.

Enter S and press [END LINE].

The system status is updated and displayed on the CRT. This updating takes place between the system's buffer and the tape drive unit. The status is given as an index number, the system test (for this case consolidometer 2, or CON2), and the number of stored readings. If the number of stored readings is zero, the file has been previously initialized, in which case

press [END LINE] to proceed.

A question mark will appear on the CRT. This is a prompt to enter a system command.

Next, enter the identifying information. The key command is an **I1**.

Enter **I1** and press [END LINE].

The CRT will respond by requesting the sample identification (limited to 17 characters or numbers).

Enter the sample identification and press [END LINE],

and the CRT will request the name of the submitter (limit to 17 characters).

Enter the submitter's name and press [END LINE].

The CRT prompts for the normal load in kilograms on the sample.

Enter the normal load and press [END LINE].

Another prompt will appear.

Next, use the **I2** command to verify the identifying information.

Enter **I2** and press [END LINE].

During the verification of the test identification, the normal load is converted to kilonewtons and displayed. If the identifying information is correct,

press [END LINE] to proceed to the next command.

If it is not correct, still press [END LINE] and re-enter the information using the **I1** command.

The next step should be to read the raw voltage. To do so,

enter **V** and press [END LINE].

This will close the appropriate relays to read the voltage from the LVDT on consolidometer two. The voltage should be near zero if the LVDT core is close to the nominal center of the LVDT. If not, adjust the core of the LVDT until your voltage reading is somewhere near zero.

When this process has been completed, the next step might be to obtain null values for the sensors.

So, enter **N** and press [END LINE].

This will read and store the nulls for this test.

Press **R** to obtain a corrected reading, then [END LINE].

The CRT responds by displaying INPUT THE AMOUNT OF LOAD IN KILOGRAMS FOR THE PREVIOUS TEST, 0 IF NONE.

Enter the previous load in kilograms and press [END LINE].

The next prompt will be ENTER THE AMOUNT OF LOAD IN KILOGRAMS FOR THIS TEST.

Enter the current load for this test and press [END LINE].

The computer will compute the frame correction factor, which is a 5th or 7th degree polynomial, and will display the corrected readings on the screen.

Consolidation Phase

Enter **A** for Automation and press [END LINE].

The CRT will remind you that it is important not to have any stored readings before automation. If there are readings remove them by using the **Z** command or initialize and press **A** to automate again.

Enter E for Exit and press [END LINE].

The test is now automated. Approximately 4 seconds after you have entered E, [END LINE], you will hear a beep. A single beep is for consolidometer 1, two beeps for consolidometer 2, and three beeps for consolidometer 3 or 4. This time delay should allow for enough time to walk to the consolidometer apparatus, and apply the load. When you hear the first beeps, the procedure is to flip the switch which applies the load to the sample. This will gather a zero reading, and timed readings for the rest of the test. The computer will continue to take readings at the following elapsed times: 0.0, 1.8 s, 3.75, 7.5, 15, 30 s, 1 min, 2, 4, 7.5, 15, 30 min, 1 hour, 2, 4, 8, 16, 24, 48, and 72 hours. The first two readings in the above series are in addition to the standard A.S.T.M. D 2435 timing sequence.

Test Data Review Phase

After the test is under way, the data may be reviewed. To review the data

select the SKF [K1],

and select the number of the consolidometer. In this example,

enter **2** and press [END LINE].

Then,

enter **L** and press [END LINE]

for a listing of the stored data. The computer will list the date and time, identify the consolidometer, and list all the data that has been stored for the test. To obtain a hardcopy of the CRT screen,

press [SHIFT], and press [COPY]

at the same time. If more data is displayed than can be displayed, the screen may be rolled up

(press [ROLL])

or down

(press [SHIFT] ROLL).

The consolidation data can be plotted on the CRT by using the command **P**. When the data review phase is complete,

enter **E** and press [END LINE]

for exit, to return the computer back to the scanning phase.

Test Termination Phase

When you are ready to terminate the test,

press the SKF [K1].

Then select the consolidometer test to terminate. Here,

select two **2**, and then enter S1.

If you do not enter S1 the computer will attempt to continue to read every 24 hours. Therefore, it is necessary to

enter the command **S1** and press [END LINE].

Use the command **I2** and press [END LINE]

to list the identifying information for the test. List the data, and using the screen-editing techniques, clean up the screen.

Using the [COPY] key,

copy the data on the thermal printer. When the data has been copied, clean up the tape so that everything will be ready to run another consolidation test.

Use the I command to initialize.

The data for the consolidation test is not designed to be transferred through the tape drive from the HP-85 to the HP-9835. Since there aren't many data points in a test, the data for reduction and plotting purposes is entered from the keyboard into the HP-9835. When finished with listing a program, starting a program, or terminating a test, immediately return control from the keyboard back to the computer so that it may gather any readings that are due on the direct shear, ring shear, or triaxial tests. To do this, just

enter the command E for Exit, and press [END LINE].

Any readings that are due from the other automated equipment will now be made.

Triaxial Shear Test

Introduction

These instructions assume the program is in memory and running. If not, see the instructions under the introduction of "Controlling a direct shear test." The SKF [K5] through [K8] are used for controlling the triaxial shear and constant rate of strain consolidation tests. Press the SKF [K5] and you will have access to TRIAX 1 data and test control. There are six (6) sensors that are monitored for each test. These are:

1.	top pore pressure	2.	bottom pore pressure
3.	lateral cell pressure	4.	axial change in length
5.	axial force	6.	and cell temperature.

A volume-change sensor may be added later. Besides the monitored data, the real time in hours, minutes, and seconds is read and stored. All the sensors except cell temperature are calibrated at the switch, balance and calibration module (Model Series V/E-24). The measurements are displayed on the LED display by the Vishay/Ellis-20A digital strain indicator. The cell

temperature is converted to degrees Fahrenheit by a "LOG" function in the computer program.

There are many different types of triaxial shear tests, such as consolidated undrained, consolidated drained, and unconsolidated undrained. The automation program as it exists should accommodate any type of triaxial test.

Getting Started

Before storing any readings, the previous test information should be purged, and the pointers reset to zero. While in the command mode

enter I

to initialize the test conditions.

Sample identification and test control information is entered next. In addition to the standard test information, the lateral- and back-pressure readings are requested by the system. The lateral pressure is the initial (preshear) pressure reading and the back pressure is the reading taken before closing the pore pressure valves to the chamber. The values of lateral pressure (psi) and back pressure (Psi) are separated by a "/" (lateral pressure/back pressure). The input here should be the lateral pressure before shear and the back pressure before to closing the valves. This input data is used elsewhere, so the format is important. The input format is DDD.D/DD.D, where the D represents a digit. An example of an unacceptable form is "235.25/75.5" (too many digits in the first number).

Readings can be taken manually using the command key **R**.

Enter **R**

and then the enter the command D

to store the values. These feature can be used to obtain the necessary data to determine the B-factor or degree of saturation, and to record the change in length during consolidation. If the TOUCH can be seen or felt the readings can be marked in the data with the command key **T**.

Enter **T** and

the alpha characters TOUCH are inserted into the data listing at the selected point.

When ready to automate the gathering of readings press the command key **A**.

Enter **A**

and the CRT will request the displacement between readings in millimeters. Some thought should be made before you answer this question. Keep in mind that it will take from 15 to 20 s to gather a set of readings (make sure you have enough time). Also, note that the data file on the tape is set for 150

data sets. This can be changed to meet different requirements. Compute before hand how many readings will be taken by dividing the desired axial displacement by the displacement between readings.

An initial axial displacement reference reading is taken and held in memory. If the automatic control option is selected the computer will start the load frame motor. The program checks to see if the preselected axial change has been exceeded. When the change in length between readings has been reached the reference reading is replaced by the current value and a set of data is written onto tape storage. A new reference value is then taken. Return the program back to the scan mode by

entering E for exit.

The test is now in the automated phase and readings will continue until the pre-selected change in length has been exceeded.

Test Termination Phase

When the preselected length has been exceeded the computer will turn off the equipment and stop storing readings. At the end of the test the thermal printer will print TRIAXIAL TEST # (1, 2, 3, or 4) FINISHED, and the time and date. Manual operation of the test requires the user to start and stop the load frame.

Data Transfer Phase

The same procedure that is used for the direct shear data transfer is also used for the triaxial test data transfer. Refer to the instructions in that section regarding data transfer.

TROUBLESHOOTING GUIDE

1. At least 50 percent of the devices on the HP-IB interface bus must be turned on for the program to execute.

2. Double check to see if all the power supplies are turned on, and all the wires properly connected.

3. If an error is causing a problem, and you need to know the type of error, pause the program and type OFF ERROR. Then continue the program where it was paused. When the error causing statement is encountered the error message will be displayed.

   NOTE: that while the program is in the scanning mode the ON ERROR statement is repeatedly activated.

4. To determine the value of a variable, constant, or content of a string, pause the program, type in the variable's name, and press [END LINE]. The contents of the variable will be displayed.

5. To change the value of a variable, string, or a constant, pause the program, type in the variable's name = value or "string," and press [END LINE]. Use the above guide number 4 to verify the change.

6. To recover data when the program has been accidentlly stopped and cannot be restarted, do the following:

   Bring the program back up and running.

   [PAUSE] the program.

   Restore the counters for the disturbed tests.

   (For example assume that both the direct shear and ring shear tests had been automated and readings stored. The array name that stores the counters is R1(). The sixth record of each data file holds the value of the test counters. Counter R1(4) is for the direct shear, and counter R1(5) is for the ring shear. If you know how many readings had been stored then, assign the values to the appropriate counters. If you do not know the latest number of readings that had been stored you can read the stored information from tape and assign that value to the counter variables directly. To read the value of the counters stored on tape type **READ # 4,6; R1(4)**, and press [END LINE]. This procedure will reset the direct shear counter to where it was before the stop. To reset the ring shear type **READ # 5, 6; R1(5)**, and then [END LINE]. To better understand this process read the section on "Variable definitions", for (R1()) and the section "Program and Data Files" in this report.

SUMMARY

The data acquisition system has proven that it is practical and reliable. The system has been in operation for over a year. Using the minidata tape drive as a random mass storage device does work, although a disk-based system would be superior. The process of writing the data to tape as it is acquired insures against data losses due to power failures, or worse, an operator error. It should be noted that the HP-85 system can be unforgiving when it comes to operator error. One problem, which has occurred occasionally, is when the system has been paused and is waiting for the user to press [CONTINUE]. If the operator should enter a number now, the system interprets this as an attempt to edit an existing line, and immediately goes into the EDIT mode. The program cannot be continued from this point (ERROR 16 CONTINUE BEFORE RUN), and the program in memory may have been altered.

Another method of data transfer between the HP-9835A and the HP-85 would be to assign the HP-85 as the bus controller, and using a special function key in the scanning phase, pass control to the other computer for a designated interval of time. The HP-85 can then assume control of the bus when it is needed.

Another possibility which was not initially considered, would be to remove one interface from the HP-9835A (if the interface is not required) and replace it with another HP-IB interface. This interface could always be under control of the HP-9835A, while the other could be used to transfer information.

The subprogram features (CALL and SUB) of the AP ROM can be used, possibly to further reduce memory requirements of the program. These features have not been tried because the data acquisition system would be down for some time until the new program could be incorporated into the system and tested. In most testing environments, it is always a high priority to keep the testing going.

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APPENDIX I

AUTOMATION PROGRAM ACCEL

Examples of Program Output

The 'S' command produces this status report.

```
07:44:11 SYSTEM STATUS 82/04/22
INDEX   TEST        STORED READINGS
-------------------------------------
 1     CONSL1---------   0
 2     CONSL2---------   0
 3     CON3/4---------   0
 4     DIRSHR---------  35
 5     RIGSHR---------  15
 6     ******---------   0
 7     TRIAX1---------  53
 8     TRIAX2---------   0
 9     TRIAX3---------   0
10     CRSCN ---------   0
PRESS CONT TO CONTINUE.
```

The 'I2' command produces this sample identification.

```
Sample_id      COL. RV. CR1
Name of submitter    SCHUSTER
The normal load Kg.   178.17
NORMAL LOAD IN kN. 1.74731319
The shear rate.  0.0048
```

The 'L' command with the 'A' option produces this data listing.

```
L
ENTER 'A' TO LIST ALL DATA, 'P'
FOR PART LIST
?
A
07:44:50                  82/04/22
          DIRECT SHEAR DATA
 H DISP(mm) LOAD (kN) V DISP(mm)
-------------------------------------
  -.000      -.000       -.000
   .201       .682       -.029
   .403       .969       -.056
   .603      1.133       -.076
   .803      1.198       -.085
  1.003      1.148       -.088
  1.203      1.079       -.088
  1.403      1.019       -.088
  1.603       .968       -.087
  1.803       .921       -.086
  2.003       .880       -.084
  2.203       .844       -.082
  2.403       .813       -.081
  2.604       .783       -.079
  2.804       .757       -.077
  3.004       .734       -.076
  4.707       .722       -.076
  3.104       .722       -.076
  3.304       .701       -.074
  3.504       .682       -.073
  3.704       .663       -.073
  3.904       .647       -.070
  4.104       .632       -.071
```

The 'M' command produces this menu of the command options.

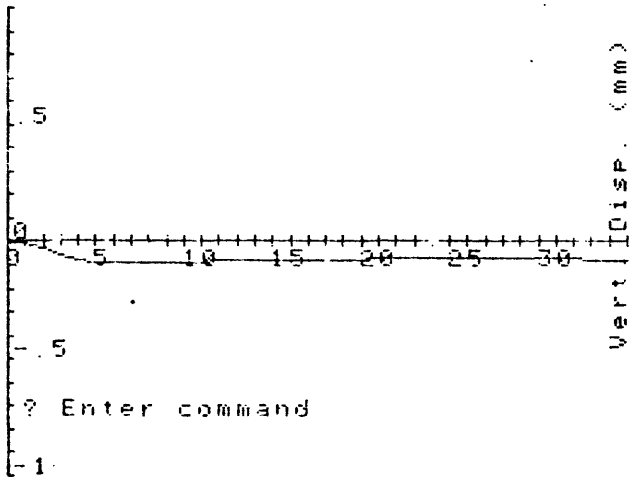
```
M

R -------READ CORRECTED DATA
M -------DISPLAY COMMAND MENU
H -------DISPLAY COLUMN HEADING
P -------PLOT DISP VS.READINGS
S -------SYSTEM STATUS
V -------RAW VOLTAGE READINGS
T -------RECORD TOUCH READING
R1 ------TO RE-OPEN DATA FILES
PRESS CONTINUE TO CONTINUE.



D -------STORES DISPL. READING
L -------LIST ON CRT TEST DATA
I -------INITIALIZES TAPE FILE
I1 ------TO STORE TEST I.D.
I2 ------DISP TEST I.D.
A -------AUTO RECORD & STORE
N -------STORE NULL FACTORS
S1------STOPS TEST BEFORE FINISH
E -------EXIT COMMAND ROUTINE
```

The 'P' command produces this type of plot for the vertical displacement (consolidation, direct shear, and ring shear).



Program Listing (BASIC)

```
1 DISP "INSERT DATA FILE TAPE NOW. THEN CONTINUE." @ PAUSE @ OPTION BASE 1
2 COM A1$[30]
3 COM SHORT C5(10),F1
4 COM INTEGER A1,A2,A3,A5,C1,C2,C3,C4,C8,D1,E1,E3,F,I1,J,K,L,P2,R1,R(3),R1(10),T1,T2,T3,T4,U
5 COM SHORT D(10),V(20),C9,I,N1,N2,N3,T5,T(5)
6 COM A4$[2],N4$[15],Z$[5],S1$[12],C1$[2],D$[2]
7 S5$="70"
8 COM C1(11),C2(11),C3(11)
9 COM A,B,C,C(4),D,D2,D3,D4,E2,F(6),I2,M1,M2,N4,N5,N6,N7,R0,R7,R8,R9,S,S1,S2,S3,S4,S5,S7,T,T6
10 COM T7,T8,T9,X1,X2,X3
12 ASSIGN# 1 TO "CON1" @ ASSIGN# 2 TO "CON2" @ ASSIGN# 3 TO "CON3"
13 DATA "CONSL1","CONSL2","CON3/4","DIRSHR","RIGSHR","******","TRIAX1","TRIAX2","TRIAX3","CRSCN"
14 ASSIGN# 4 TO "DSHR" @ ASSIGN# 5 TO "RSHR"
16 ASSIGN# 7 TO "TRX1" @ ASSIGN# 8 TO "TRX2" ! @ ASSIGN# 9 TO "TRX3" @ ASSIGN# 10 TO "TRX4"
22 S1$,S2$,D$=""
25 OUTPUT 722 ;A1$
26 DATA 0,.03,.063,.125,.25,.5,1,2,4,7.5,15,30,60,120,240,480,960,1440,2880,4320,5760
50 IF T1<>1 AND T2<>1 THEN OUTPUT 709 ;"70" ELSE OUTPUT 709 ;"70,61"
51 ON KEY# 1,"CONS" GOTO 1000
52 ON ERROR GOTO 290
53 ON KEY# 2,"DSHR" GOTO 1500
54 ON KEY# 3,"RSHR" GOTO 2000
56 ON KEY# 4,"AUDIO" GOTO 2500
58 ON KEY# 5,"TRX1" GOTO 3000
60 ON KEY# 6,"TRX2" GOTO 3500
70 ON KEY# 7,"TRX3" GOTO 4000
80 ON KEY# 8,"CRSC" GOTO 4500
90 CLEAR @ KEY LABEL
95 REMOTE 722 @ LOCAL LOCKOUT 7
97 DISP "GEOTECHNICAL TEST CONTROL"
100 !
105 IF A1=0 THEN 115
110 ON TIMER# 1,S1 GOTO 5000
115 IF A2=0 THEN 125
120 ON TIMER# 2,S2 GOTO 5200
125 IF A3=0 THEN 140
130 ON TIMER# 3,S3 GOTO 5400
140 IF D1=1 THEN GOSUB 6000
150 IF R1=1 THEN GOSUB 6500
160 IF T1=1 THEN GOSUB 7000
170 IF T2=1 THEN GOSUB 7000
180 IF T3=1 THEN GOSUB 8000
190 IF T4=1 THEN GOSUB 8500
196 IF A5=1 THEN GOTO 197 ELSE GOTO 200
197 BEEP 1,5
200 GOTO 50
290 CLEAR @ DISP "ERROR - - RETURN TO SCAN"
291 BEEP @ WAIT 2500 @ OFF ERROR
292 A2,A1,A3,C1,C2,C3,C4,F=0
293 GOTO 50
300 CLEAR @ DISP "ENTER COMMAND"
305 DISP "ENTER M FOR MENU"
310 INPUT C1$
311 IF C1$="I1" THEN GOSUB 9100
```

```
312 IF C1$="P" THEN GOSUB 5605
313 IF C1$="I2" THEN GOSUB 9200
315 IF C1$="V" THEN GOSUB 400
316 IF C1$="R1" THEN GOTO 10
320 IF C1$="M" THEN GOSUB 450
322 IF C1$="T" THEN GOSUB 500
330 IF C1$="S" THEN GOSUB 550
331 IF C1$="S1" THEN GOSUB 9300
335 IF C1$="R" THEN GOSUB 600
340 IF C1$="N" THEN GOSUB 650
345 IF C1$="H" THEN GOSUB 700
350 IF C1$="D" THEN GOSUB 750
355 IF C1$="I" THEN GOSUB 800
360 IF C1$="A" THEN GOSUB 850
365 IF C1$="E" THEN GOTO 900
370 IF C1$="L" THEN GOSUB 950
371 IF C1$="Z" THEN GOSUB 1150
372 GOTO 310
400 !
402 IF F=3 THEN 404
403 GOTO 414
404 GOSUB 9500
405 OUTPUT 709 ;S1$ @ WAIT 1000
406 RESET 3 @ CONTROL 3,3 ; 8,2,1,0@ ENTER 3 ; R9,R0
407 R1$=VAL$(R9)&VAL$(R0) @ D2=VAL(R1$)*C5(4)
408 OUTPUT 709 ;S2$ @ WAIT 1000
409 ENTER 3 ; R9,R0@ OUTPUT 709 USING "K" ; "07" @ WAIT 500 @ ENTER 722 ; D4$@ D4=VAL(D4$)*C5(6)
410 OUTPUT 709 ;S1$ @ R1$=VAL$(R9)&VAL$(R0) @ D3=VAL(R1$)*C5(5)
411 IF C1$="R" THEN RETURN
412 DISP USING 7041 ; D2,D3,(D2+D3)/2,E2*M1,D4-N4
414 IF F=1 AND C1=1 THEN 416
415 GOTO 418
416 IF F=1 AND C1=1 THEN OUTPUT 709 USING "K" ; "02" @ WAIT 500 @ ENTER 722 ; V1$@ V1=VAL(V1$)
417 DISP "       ";V1
418 IF F=1 AND C2=1 THEN OUTPUT 709 USING "K" ; "05" @ WAIT 500 @ ENTER 722 ; V2$@ V2=VAL(V2$)
419 IF F=1 AND C2=1 THEN 421
420 GOTO 422
421 DISP "       ";V2
422 IF C4=1 OR C3=1 THEN OUTPUT 709 USING "K" ; "08" @ WAIT 500 @ ENTER 722 ; V3$@ V3=VAL(V3$)
423 IF F=1 AND C3=1 THEN GOTO 425
424 GOTO 426
425 DISP "       ";V3
426 IF F=2 THEN OUTPUT 709 USING "K" ; "01" @ WAIT 500 @ ENTER 722 ; W1$@ W1=VAL(W1$)
427 IF F=2 THEN OUTPUT 709 USING "K" ; "03" @ WAIT 500 @ ENTER 722 ; W2$@ W2=VAL(W2$)
428 IF F=2 THEN OUTPUT 709 USING "K" ; "04" @ WAIT 500 @ ENTER 722 ; W3$@ W3=VAL(W3$)
436 IF F<>2 THEN GOTO 438
437 DISP USING 7042 ; W1,W2,W3
438 IF F<5 THEN 445
440 GOSUB 9700
441 I1=(F-5)*5
442 DISP USING 7040 ; V(I1+1),V(I1+2),V(I1+3),V(I1+4),V(I1+5)*C5(10)
443 DISP "TEMP (DEG F): ";T(F-4)
444 C1$=""
445 RETURN
```

```
450 DISP "R -------READ CORRECTED DATA"
451 DISP "M -------DISPLAY COMMAND MENU"
452 DISP "H -------DISPLAY COLUMN HEADING"
453 DISP "P -------PLOT DISP VS.READINGS"
454 DISP "S -------SYSTEM STATUS"
455 DISP "V -------RAW VOLTAGE READINGS"
456 DISP "T -------RECORD TOUCH READING"
457 DISP "R1 ------TO RE-OPEN DATA FILES"
458 DISP "PRESS ENDLINE TO PROCEED."
459 LINPUT Y$
461 CLEAR
462 DISP "D -------STORES DISPL. READING"
463 DISP "L -------LIST ON CRT TEST DATA"
464 DISP "I -------INITIALIZES TAPE FILE"
465 DISP "I1 ------TO STORE TEST I.D."
466 DISP "I2 ------DISP TEST I.D."
467 DISP "A -------AUTO RECORD & STORE"
468 DISP "N -------STORE NULL FACTORS"
469 DISP "S1------STOPS TEST BEFORE FINISH"
470 DISP "E -------EXIT COMMAND ROUTINE" @ DISP "Z -------DELETES LAST READING"
471 DISP "PRESS ENDLINE TO PROCEED."
472 LINPUT Y$
473 C1$=""
474 GOTO 300
500 REM
505 IF F<5 THEN RETURN
510 R1(F+2)=R1(F+2)+1
515 PRINT# F+2,R1(F+2)+6 ; 9999
540 GOSUB 750
545 RETURN
550 !
552 RESTORE
555 DISP TIME$;HGL$(" SYSTEM STATUS ");DATE$
557 DISP "INDEX   TEST     STORED READINGS"
558 GOSUB 1100
560 FOR I=1 TO 10
562 READ T$
565 DISP USING 7043 ; I;T$;R1(I)
570 NEXT I
575 DISP "PRESS ENDLINE TO PROCEED"
576 C1$=""
580 LINPUT Y$
585 RETURN
600 REM
601 IF F>=5 THEN 400
602 IF F=3 THEN 606
605 DISP "CORRECTED READINGS."
606 IF F=3 THEN GOSUB 400
608 IF F=3 THEN D2=D2#F1 @ D3=D3#F1
609 IF F=3 THEN DISP USING 7044 ; D2,D3,(D2+D3)/2,E2#M1,D4-N4
610 D2=D2/F1 @ D3=D3/F1
611 IF F=2 THEN OUTPUT 709 USING "K" ; "01" @ WAIT 500 @ ENTER 722 ; W1$@ W1=VAL(W1$)
612 IF F=2 THEN OUTPUT 709 USING "K" ; "03" @ WAIT 500 @ ENTER 722 ; W2$@ W2=VAL(W2$)
614 IF F=2 THEN OUTPUT 709 USING "K" ; "04" @ WAIT 500 @ ENTER 722 ; W3$@ W3=VAL(W3$)
616 IF F<>2 THEN 620
617 W2=(W2-N2)#C5(2) @ W3=(W3-N3)#C5(3)
```

```
618 DISP USING 7042 ; (N1-N1)*C5(1),N2,N3
620 IF C1=1 THEN OUTPUT 709 USING "K" ; "02" @ WAIT 500 @ ENTER 722 ; V1$@ V1=VAL(V1$)
621 IF C1=1 AND C(1)=0 THEN GOSUB 9600
622 IF C1=1 THEN 624
623 GOTO 625
624 V1=N5-V1 @ DISP "       ";V1*C5(7)+F(1)
625 IF C2=1 AND C(2)=0 THEN GOSUB 9625
626 IF C2=1 THEN OUTPUT 709 USING "K" ; "05" @ WAIT 500 @ ENTER 722 ; V2$@ V2=VAL(V2$)
627 IF C2=1 THEN 629
628 GOTO 630
629 V2=N6-V2 @ DISP "       ";V2*C5(8)+F(2)
630 IF C3=1 AND C(3)=0 THEN GOSUB 9650
631 IF C4=1 AND C(4)=0 THEN GOSUB 9675
632 IF C3=1 OR C4=1 THEN OUTPUT 709 USING "K" ; "08" @ WAIT 500 @ ENTER 722 ; V3$@ V3=VAL(V3$)
633 IF C3=1 OR C4=1 THEN 635
634 GOTO 636
635 V3=N7-V3 @ DISP "       ";V3*C5(9)+F(3)
636 !
645 RETURN
650 !
652 IF F=3 THEN OUTPUT 709 USING "K" ; "07" @ WAIT 500 @ ENTER 722 ; N4$@ N4=VAL(N4$)*C5(6)
660 IF F=2 THEN OUTPUT 709 USING "K" ; "01" @ WAIT 500 @ ENTER 722 ; N1$@ N1=VAL(N1$)
662 IF F=2 THEN OUTPUT 709 USING "K" ; "03" @ WAIT 500 @ ENTER 722 ; N2$@ N2=VAL(N2$)
664 IF F=2 THEN OUTPUT 709 USING "K" ; "04" @ WAIT 500 @ ENTER 722 ; N3$@ N3=VAL(N3$)
665 IF F=1 AND C1=1 THEN OUTPUT 709 USING "K" ; "02" @ WAIT 500 @ ENTER 722 ; N5$@ N5=VAL(N5$)
667 IF F=1 AND C2=1 THEN OUTPUT 709 USING "K" ; "05" @ WAIT 500 @ ENTER 722 ; N6$@ N6=VAL(N6$)
669 IF C4=1 OR C3=1 THEN OUTPUT 709 USING "K" ; "08" @ WAIT 500 @ ENTER 722 ; N7$@ N7=VAL(N7$)
675 IF F>=5 THEN DISP "INPUT VALUES ARE NULLED ON THE  VISHAY/21 BOX" @ WAIT 5000
695 RETURN
700 CLEAR @ C1$="" @ DISP TIME$,DATE$
701 IF F=1 THEN 720
702 IF F=2 THEN 730
704 IF F=3 THEN 735
706 IF F=4 THEN 740
708 IF F>=5 THEN 745
710 CLEAR @ RETURN
720 IF C1=1 THEN DISP "          CONSL #1"
722 IF C2=1 THEN DISP "          CONSL #2"
723 IF C3=1 THEN DISP "          CONSL #3"
724 IF C4=1 THEN DISP "          CONSL #4"
725 DISP "     CONSOLIDATION DATA"
727 DISP "      VERTICAL CHANGE            No.       mm        min."
728 GOSUB 1100
729 RETURN
730 DISP "       DIRECT SHEAR DATA"
731 DISP " H DISP(mm) LOAD (kN) V DISP(mm)"
732 GOSUB 1100
733 RETURN
735 DISP "        RING SHEAR TEST"
736 DISP "  CH    CH    MEAN  ANG   VERT"
737 DISP "   A     B     A,B  DISP  DISP"
738 DISP "  (kN)  (kN)   (kN) (mm)  (mm)"
739 GOSUB 1100 @ RETURN
740 DISP "        PERMEABILITY TEST"
741 DISP "        HEIGHT OF H2O COLUMN"
742 GOSUB 1100
```

```
743 RETURN
745 DISP "     TRIAXIAL SOIL TEST";F-4
746 DISP "AXDF   TOP   BOT   LAT   NLOAD" ! VOL"
747 DISP "(mm)  (psi) (psi) (psi)  (kG)"
748 GOSUB 1100
749 RETURN
750 CRT OFF
751 IF C1=1 THEN V1=V1*C5(7)+F(1) @ R1(1)=R1(1)+1
752 IF C1=1 AND R1(1)<=10 THEN C1(R1(1))=V1
754 IF R1(1)=10 AND C1=1 THEN 755 ELSE 756
755 FOR I=1 TO 10 @ PRINT# 1,I+6 ; C1(I) @ NEXT I @ PRINT# 1,6 ; I
756 IF R1(1)>10 AND C1=1 THEN PRINT# 1,6 ; R1(1) @ PRINT# 1,R1(1)+6 ; V1
757 IF C2=1 THEN V2=V2*C5(8)+F(2) @ R1(2)=R1(2)+1
758 IF C2=1 AND R1(2)<=10 THEN C2(R1(2))=V2
759 IF R1(2)=10 AND C2=1 THEN 760 ELSE 761
760 FOR I=1 TO 10 @ PRINT# 2,I+6 ; C2(I) @ NEXT I @ PRINT# 2,6 ; I
761 IF R1(2)>10 AND C2=1 THEN PRINT# 2,6 ; R1(2) @ PRINT# 2,R1(2)+6 ; V2
762 IF C3=1 OR C4=1 THEN V3=V3*C5(9)+F(3) @ R1(3)=R1(3)+1
763 IF (C4=1 OR C3=1) AND R1(3)<=10 THEN C3(R1(3))=V3
764 IF R1(3)=10 AND (C4=1 OR C3=1) THEN 765 ELSE 766
765 FOR I=1 TO 10 @ PRINT# 3,I+6 ; C3(I) @ NEXT I @ PRINT# 3,6 ; I
766 IF R1(3)>10 AND (C4=1 OR C3=1) THEN PRINT# 3,6 ; R1(3) @ PRINT# 3,R1(3)+6 ; V3
767 IF F=2 THEN W1=(W1-N1)*C5(1)
768 IF F=2 THEN R1(4)=R1(4)+1 @ PRINT# 4,6 ; R1(4) @ PRINT# 4,R1(4)+6 ; W1,W2,W3
769 IF F=2 THEN W1=N1+W1/C5(1)
770 IF F=3 THEN R1(5)=R1(5)+1
771 IF F=3 THEN D4=D4-N4
772 IF F=3 THEN PRINT# 5,6 ; R1(5) @ PRINT# 5,R1(5)+6 ; D2,D3,D4,R7
780 IF F=4 THEN R1(6)=R1(6)+1
786 IF F=5 THEN R1(7)=R1(7)+1 @ PRINT# 7,6 ; R1(7)
787 IF F=5 THEN PRINT# 7,R1(7)+6 ; V(1),V(2),V(3),V(4),V(5)*C5(10),T(1),TIME$
790 IF F=6 THEN R1(8)=R1(8)+1 @ PRINT# 8,6 ; R1(8)
791 IF F=6 THEN PRINT# 8,R1(8)+6 ; V(6),V(7),V(8),V(9),V(10)*C5(10),T(2),TIME$
792 IF F=7 THEN R1(9)=R1(9)+1 @ PRINT# 9,6 ; R1(9)
793 IF F=7 THEN PRINT# 9,R1(9)+6 ; V(11),V(12),V(13),V(14),V(15)*C5(10),T(3),TIME$
794 IF F=8 THEN R1(10)=R1(10)+1 @ PRINT# 10,6 ; R1(10)
795 IF F=8 THEN PRINT# 10,R1(10)+6 ; V(16),V(17),V(18),V(19),V(20)*C5(10),T(4),TIME$
796 IF F=3 THEN BEEP 200,200 @ WAIT 100 @ BEEP 200,200
797 IF F=2 THEN BEEP 100,200
798 CRT ON
799 RETURN
800 CRT OFF
801 IF C1=1 THEN GOTO 803
802 GOTO 808
803 OFF TIMER# 1 @ FOR I=1 TO 10 @ C1(I)=0 @ NEXT I
806 FOR I=6 TO R1(1)+6 @ PRINT# 1,I ; 0 @ NEXT I
807 C(1),F(1),R1(1),V1,S,S1,N5,X1=0 @ FOR I=1 TO 5 @ PRINT# 1,I ; "" @ NEXT I
808 IF C2=1 THEN GOTO 810
809 GOTO 815
810 Y$="" @ OFF TIMER# 2 @ FOR I=1 TO 10 @ C2(I)=0 @ NEXT I
813 FOR I=6 TO R1(2)+6 @ PRINT# 2,I ; 0 @ NEXT I
814 C(2),F(2),R1(2),V2,S2,S4,N6,X2=0 @ FOR I=1 TO 5 @ PRINT# 2,I ; "" @ NEXT I
815 IF C3=1 OR C4=1 THEN 817
816 GOTO 823
817 Y$="" @ OFF TIMER# 3 @ FOR I=1 TO 10 @ C3(I)=0 @ NEXT I
820 FOR I=6 TO R1(3)+6 @ PRINT# 3,I ; 0 @ NEXT I
```

```
821 C(3),F(3),F(6),R1(3),V3,S3,S5,N7,X3=0 @ FOR I=1 TO 5 @ PRINT# 3,I ; "" @ NEXT I
823 IF F=1 THEN A,B=0
824 IF F=2 THEN 826
825 GOTO 830
826 FOR I=6 TO R1(4)+6 @ PRINT# 4,I ; 0 @ NEXT I
827 DISP "PRESS ENDLINE TO PROCEED" @ LINPUT Y$
828 R1(4),E1,N1,N2,N3,P2,D1,W1,W2,W3=0 @ Y$=""
830 IF F=3 THEN 833
831 GOTO 836
833 FOR I=6 TO R1(5)+6 @ PRINT# 5,I ; 0 @ NEXT I @ CRT ON
834 DISP "PRESS ENDLINE TO PROCEED" @ LINPUT Y$
835 R1,D2,D3,D4,E2,E3,N4,M1,M2,R0,R7,R8,R9,T8,T9,T,R1(5)=0 @ Y$=""
836 IF F>=5 THEN 838 ELSE 842
838 FOR I=6 TO R1(F+2)+6 @ PRINT# F+2,I ; 0 @ NEXT I
840 T1,T2,S8,R1(F+2)=0
842 CRT ON
848 RETURN
849 !
850 REM
854 DISP "FINAL STEP TO START AUTOMATION  IS 'E' FOR EXIT." @ WAIT 1500 @ CLEAR
855 IF C1=1 THEN A1=1
857 IF C2=1 THEN A2=1
859 IF C3=1 OR C4=1 THEN A3=1
861 IF F=2 THEN GOSUB 6000 @ D1=1
862 IF F=4 THEN DISP "PERM TEST NOT YET IMPLEMENTED."
863 IF F=3 THEN GOSUB 6500
864 IF F<4 THEN 895
865 DISP "ENTER DISPLACEMENT BETWEEN READ-INGS IN mm."
867 IF F=5 THEN INPUT D(7)
868 IF F=5 THEN GOSUB 7000 @ T1=1 @ OUTPUT 709 ;"61" @ S5$="70,61"
870 IF F=6 THEN INPUT D(8)@ GOSUB 7000 @ T2=1 @ OUTPUT 709 ;"61" @ S5$="70,61"
871 IF F=7 THEN INPUT D(9)@ GOSUB 8000 @ T3=1
872 IF F=8 THEN INPUT D(10)@ GOSUB 8500 @ T4=1
893 DISP "ENTER YOUR COMMAND."
895 RETURN
900 !
905 C1$=""
907 C1,C2,C3,C4,F=0
910 GOTO 50
950 A4$="" @ J,C8=0 @ RESTORE @ FOR I=1 TO 10 @ READ T$@ NEXT I
951 IF F=1 THEN 956 ELSE DISP "ENTER 'A' TO LIST ALL DATA, 'P' FOR PART LIST." @ INPUT A4$
952 IF A4$="P" THEN 955
953 IF A4$="A" THEN J=0 @ GOTO 956
954 CLEAR @ GOTO 951
955 DISP "ENTER STARTING WITH #?" @ INPUT J
956 IF F=1 THEN GOSUB 700
957 IF C1=1 THEN 980
958 IF C2=1 THEN 984
959 IF C3=1 OR C4=1 THEN 988
961 IF F=2 THEN 991
963 IF F=3 THEN 996
970 IF F<5 THEN RETURN
971 GOSUB 700
972 FOR I=7+J TO R1(F+2)+6
973 READ# F+2,I ; Z1@ IF Z1=9999 THEN DISP "TOUCH READING" @ GOTO 978
974 READ# F+2,I ; Z1,Z2,Z3,Z4,Z5 ! ,Z6
```

```
976 DISP USING 7040 ; Z1,Z2,Z3,Z4,Z5 ! ,Z6
978 NEXT I
979 RETURN
980 IF R1(1)<10 THEN 981 ELSE 982
981 FOR I=1 TO R1(1) @ READ X@ DISP USING 7046 ; I,C1(I),X @ NEXT I @ GOTO 983
982 FOR I=7 TO R1(1)+6 @ READ# 1,I ; V1@ READ X@ DISP USING 7046 ; I-6,V1,X @ NEXT I
983 RETURN
984 IF R1(2)<10 THEN 985 ELSE 986
985 FOR I=1 TO R1(2) @ READ X@ DISP USING 7046 ; I,C2(I),X @ NEXT I @ GOTO 987
986 FOR I=7 TO R1(2)+6 @ READ# 2,I ; V2@ READ X@ DISP USING 7046 ; I-6,V2,X @ NEXT I
987 RETURN
988 IF R1(3)<10 THEN 989 ELSE 990
989 FOR I=1 TO R1(3) @ READ X@ DISP USING 7046 ; I,C3(I),X @ NEXT I @ GOTO 987
990 FOR I=7 TO R1(3)+6 @ READ# 3,I ; V3@ READ X@ DISP USING 7046 ; I-6,V3,X @ NEXT I @ RETURN
991 GOSUB 700 @ C=W1 @ FOR I=7+J TO R1(4)+6 @ READ# 4,I ; W1,W2,W3
992 IF W1=9999 THEN DISP "END OF CYCLE # ";C8 @ C8=C8+1 @ GOTO 994
993 DISP USING 7042 ; W1,W2,W3
994 NEXT I
995 W1=C @ RETURN
996 GOSUB 700 @ FOR I=7+J TO R1(5)+6 @ READ# 5,I ; D2,D3,D4,R7@ D2=D2*F1 @ D3=D3*F1
997 DISP USING 7044 ; D2,D3,(D2+D3)/2,R7,D4
998 NEXT I @ RETURN
1000 !
1005 F=1
1007 X=0
1008 DISP "ENTER CONSOLIDATION TEST #1,2,3, OR 4. NOTE: 3 & 4 SHARE SAME    DATA FILE & LVDT."
1009 INPUT X
1010 IF X=1 THEN C1=1
1012 IF X=2 THEN C2=1
1014 IF X=3 THEN C3=1
1015 IF X=4 THEN C4=1
1016 GOTO 300
1100 DISP RPT$("-",32)
1110 RETURN
1150 IF C1=1 THEN R1(1)=R1(1)-1
1155 IF C2=1 THEN R1(2)=R1(2)-1
1160 IF C3=1 THEN R1(3)=R1(3)-1
1165 IF F=1 THEN 1199
1170 R1(F+2)=R1(F+2)-1
1199 GOTO 550
1495 !
1500 !
1505 F=2
1510 GOTO 300
1995 !
2000 !
2005 F=3
2010 GOTO 300
2495 !
2496 !
2500 !
2502 Z$=""
2505 DISP "ENTER 'Y' TO TURN AUDIO ON."
2506 DISP "ENTER 'N' TO TURN AUDIO OFF"
2507 INPUT Z$
2508 IF Z$="N" THEN A5=0 @ GOTO 50
```

```
2509 IF Z$="Y" THEN A5=1 ELSE CLEAR @ GOTO 2500
2510 GOTO 50
2995 !
3000 !
3005 F=5
3010 GOTO 300
3495 !
3500 !
3505 F=6
3510 GOTO 300
3995 !
4000 !
4005 F=7
4010 GOTO 300
4495 !
4500 !
4505 F=8
4510 GOTO 300
4995 !
5000 !
5001 WAIT 4000
5002 IF C(1)=0 THEN GOSUB 9600
5005 R(1)=1 @ S=7500/4
5010 IF R(1)=1 THEN GOTO 5012
5011 S1=S @ S=S1*2 @ IF S-S1=420000 THEN S1=450000 @ S=900000
5012 IF S-S1=240000 THEN S1=210000 @ S=420000
5013 IF X1=1 THEN S=186400000 @ S1=100000000
5014 IF S-S1=57600000 THEN S=57600000 @ S1=28800000 @ X1=1
5016 ON TIMER# 1,S-S1 GOTO 5010
5017 OUTPUT 709 USING "K" ; "02" @ WAIT 500 @ ENTER 722 ; V1$@ V1=VAL(V1$) @ V1=N5-V1
5018 C1=1 @ C2,C3,F=0 @ GOSUB 750
5030 A1,C1,R(1)=0 @ BEEP
5035 GOTO 50
5200 !
5201 WAIT 4000
5202 IF C(2)=0 THEN GOSUB 9625
5205 R(2)=1 @ S4=7500/4
5210 IF R(2)=1 THEN GOTO 5215
5211 S2=S4 @ S4=S2*2 @ IF S4-S2=420000 THEN S2=450000 @ S4=900000
5212 IF S4-S2=240000 THEN S2=210000 @ S4=420000
5213 IF X2=1 THEN S4=186400000 @ S2=100000000
5214 IF S4-S2=57600000 THEN S4=57600000 @ S2=28800000 @ X2=1
5215 ON TIMER# 2,S4-S2 GOTO 5210
5217 OUTPUT 709 USING "K" ; "05" @ WAIT 500 @ ENTER 722 ; V2$@ V2=VAL(V2$)
5220 V2=N6-V2
5225 C2=1 @ C1,C3,F=0 @ GOSUB 750
5235 A2,C2,R(2)=0
5245 BEEP @ WAIT 100 @ BEEP
5395 GOTO 50
5400 !
5401 WAIT 4000
5402 IF C(3)=0 AND C(4)=0 THEN PRINT "FRAME CORRECTION NOT APPLIED ON CONSOLIDOMETER #3 OR #4."
5405 R(3)=1 @ S5=7500/4
5410 IF R(3)=1 THEN GOTO 5415
5411 S3=S5 @ S5=S3*2
5412 IF S5-S3=420000 THEN S3=450000 @ S5=900000
```

```
5413 IF S5-S3=240000 THEN S3=210000 @ S5=420000
5414 IF X3=1 THEN S5=186400000 @ S3=100000000
5415 IF S5-S3=57600000 THEN S3=28800000 @ S5=57600000 @ X3=1
5418 ON TIMER# 3,S5-S3 GOTO 5410
5419 OUTPUT 709 USING "K" ; "08" @ WAIT 500 @ ENTER 722 ; V3$@ V3=VAL(V3$)
5420 V3=N7-V3
5425 C3=1 @ C1,C2,F=0 @ GOSUB 750
5435 A3,C3,R(3)=0
5445 BEEP @ WAIT 100 @ BEEP @ WAIT 100 @ BEEP
5495 GOTO 50
5605 IF C1=1 THEN GOTO 5625
5610 IF C2=1 THEN GOTO 5630
5612 IF C4=1 OR C3=1 THEN GOTO 5635
5614 IF F=2 OR F=3 THEN X=R1(F+2) @ J=F+2 @ GOTO 5650
5620 IF F>2 THEN DISP "PLOT NOT YET IMPLEMENTED." @ WAIT 1000 @ RETURN
5624 !
5625 !
5627 X=R1(1) @ J=1 @ GOTO 5650
5628 !
5629 !
5630 !
5632 X=R1(2) @ J=2 @ GOTO 5650
5633 !
5634 !
5635 !
5636 X=R1(3) @ J=3
5637 J=3
5650 IF X=0 THEN RETURN
5652 GCLEAR @ SCALE 0,X,-1,1
5654 XAXIS 0,1 @ YAXIS 0,.1
5658 FOR I=0 TO X-1 STEP 5
5660 MOVE I,-.105 @ LABEL VAL$(I)
5661 LABEL VAL$(I)
5662 NEXT I
5664 FOR I=-1 TO 1 STEP .5
5666 MOVE .4,I @ LABEL VAL$(I)
5670 NEXT I
5671 LDIR 90 @ MOVE X,-.45
5673 LABEL "Vert. Disp. (mm)"
5674 I=1
5678 GOSUB 5700
5680 MOVE 0,Y @ LDIR 0
5682 FOR I=1 TO X
5684 GOSUB 5700 @ IF Y=9999 THEN GOTO 5690
5688 DRAW I,Y
5690 NEXT I
5691 CRT ON
5695 MOVE 1,-.75 @ LABEL "  Enter command"
5698 RETURN
5700 !
5701 CRT OFF
5705 IF F=1 THEN READ# J,I+6 ; Y
5710 IF F=2 THEN READ# J,I+6 ; Y2,Y1,Y
5715 IF F=3 THEN READ# J,I+6 ; Y4,Y3,Y2,Y1,Y
```

```
5720 RETURN
5732 !
5750 !
6000 !
6002 IF S7=1 THEN GOTO 6300
6005 IF D1=1 THEN GOTO 6250
6007 P2=0
6027 CLEAR
6028 DISP "ENTER 100 OR 500 OR 2000 FOR    LOAD CELL CAPACITY." @ INPUT C9
6031 IF C9=100 THEN C5(2)=-13.93
6032 IF C9=500 THEN C5(2)=-116.3
6034 IF C9=2000 THEN C5(2)=-115.13
6036 CLEAR
6037 DISP "MAX FOR RGPEATED SHEAR IS 4.6mm"
6038 DISP "MAX FOR ONE DIRECTION PULL IS   9.2mm"
6039 DISP
6040 DISP "ENTER THE HORZ. DISP. FROM NULL THAT YOU WANT TABLE TO TRAVEL"
6045 INPUT T6
6048 CLEAR
6050 DISP "ENTER (0) FOR ONE DIRECTIONAL   PULL"
6055 DISP "ENTER THE NUMBER OF PULLS."
6060 INPUT P1
6070 CLEAR
6075 DISP "ENTER THE AMOUNT OF TABLE TRAVEL BETWEEN READINGS IN mm"
6080 INPUT T7
6100 DISP "ENTER T FOR TENSION OF                C FOR COMPRESSION"
6110 INPUT D$
6115 IF D$="T" THEN GOTO 6130
6120 OUTPUT 709 ;"47,48"
6125 GOTO 6135
6130 OUTPUT 709 ;"47,49"
6135 !
6250 !
6253 OUTPUT 709 USING "K" ; "01"
6254 WAIT 500 @ ENTER 722 ; T5$@ T5=VAL(T5$)
6255 IF E1<5 THEN GOTO 6258
6257 IF ABS(T5-N1)*C5(1)>T6 THEN GOSUB 6300
6258 IF E1=0 AND P2=0 THEN GOTO 6261
6259 V4=W1-N1 @ V5=T5-N1
6260 IF ABS(V4-V5)*C5(1)<T7 THEN RETURN
6261 W1=T5 @ E1=E1+1 @ OUTPUT 709 USING "K" ; "03"
6262 WAIT 500 @ ENTER 722 ; W2$@ W2=VAL(W2$)
6263 OUTPUT 709 USING "K" ; "04"
6264 WAIT 500 @ ENTER 722 ; W3$@ W3=VAL(W3$)
6265 W2=(W2-N2)*C5(2)
6267 W3=(W3-N3)*C5(3) @ F=2
6268 GOSUB 750
6269 F=0
6270 !
6272 IF ABS(W2)<8.9/(2000/C9) THEN 6495
6276 PRINT "YOU ARE NEAR ";C9;"# LOAD CAPACITY"
6280 FOR I=1 TO 50 @ BEEP @ WAIT 200 @ NEXT I
6282 IF ABS(W2)>11.13/(2000/C9) THEN 6285
6284 GOTO 6495
6285 PRINT "LOAD CELL IN OVERLOAD CONDITION."
6286 PRINT "COMPUTER HAS TERMINATED THE TEST"
```

```
6287 OUTPUT 709 ;"5" @ D1=0
6290 GOTO 6495
6295 !
6300 E1=0
6301 P2=P2+1
6302 IF P2>P1 THEN D1=0 @ PRINT "DIRECT SHEAR TEST COMPLETED."
6303 IF P2>P1 THEN PRINT ;TIME$,DATE$
6304 IF P2>P1 THEN GOTO 6310
6305 GOSUB 6261
6308 R1(4)=R1(4)+1 @ PRINT# 4,6 ; R1(4) @ PRINT# 4,R1(4)+6 ; 9999,9999,9999
6310 !
6313 IF R1=1 THEN OUTPUT 709 ;"50,40"
6314 IF R1<>1 THEN OUTPUT 709 ;"5"
6317 S7=0
6318 IF P2>P1 THEN RETURN
6320 WAIT 1000
6325 !
6340 IF D$="T" THEN GOTO 6370
6345 ! CHANGE FROM COMP TO TENS
6350 D$="T"
6355 OUTPUT 709 ;"47,49"
6360 WAIT 5000
6365 RETURN
6370 D$="C"
6375 OUTPUT 709 ;"47,48"
6380 WAIT 5000
6390 !
6495 RETURN
6496 !
6500 !
6505 IF R1=1 THEN GOTO 6750
6507 R1=1
6510 DISP "AUTOMATION RING SHEAR TEST"
6515 DISP " "
6534 DISP "LOAD ZERO CORRECTIONS MAY BE"
6536 DISP "IMPLEMENTED BY FRONT DRAWER DIP"
6538 DISP "SWITCHES AND POTS."
6539 DISP " " @ Y$=""
6540 DISP "ENTER 'YES' TO STORE NULL CORR."
6542 DISP "FACTOR (VERT DISP), ELSE ENDLINE"
6544 INPUT Y$
6545 IF Y$="YES" THEN OUTPUT 709 USING "K" ; "07" @ WAIT 500 @ ENTER 722 ; N4$@ N4=VAL(N4$)$10
6550 CLEAR
6555 DISP "ENTER AMOUNT OF ROTATIONAL DISP"
6556 DISP "IN MILLIMETERS FOR THIS TEST." @ INPUT M2
6560 CLEAR
6562 DISP "ENTER ROTATION RATE IN mm/min.)" @ INPUT M1
6563 CLEAR
6565 DISP "ENTER AMOUNT OF ROTATION IN mm"
6566 DISP "BETWEEN STORED READINGS."
6567 DISP "CURRENT LIMIT IS 200 READINGS." @ INPUT T8
6570 CLEAR
6575 DISP "PRESS ENDLINE AND SOON A ? WILL"
6576 DISP "APPEAR.  THEN ENTER 'E' FOR EXIT"
6577 LINPUT Y$
6578 !
```

```
6580 T=TIME
6585 J1=DATE
6750 T9=TIME-T+86400*(DATE-J1)
6752 E2=T9/60
6755 R8=E2*M1
6757 IF R7>=M2 THEN GOTO 6850
6760 IF E3=0 THEN GOTO 6770
6765 IF R8-R7<T8 THEN RETURN
6770 R7=R8 @ E3=1
6775 GOSUB 9500
6780 OUTPUT 709 ;S1$
6781 WAIT 1000
6782 RESET 3 @ CONTROL 3,3 ; 8,2,1,0@ ENTER 3 ; R9,R0
6785 R1$=VAL$(R9)&VAL$(R0) @ D2=-(VAL(R1$)/100)
6790 OUTPUT 709 ;S2$
6792 WAIT 1000
6795 ENTER 3 ; R9,R0
6796 R1$=VAL$(R9)&VAL$(R0) @ D3=-(VAL(R1$)/100)
6798 OUTPUT 709 USING "K" ; "07" @ WAIT 500 @ ENTER 722 ; D4$@ D4=VAL(D4$)*10
6799 F=3
6800 GOSUB 750
6805 F=0
6807 OUTPUT 709 ;S1$
6810 RETURN
6850 IF D1=1 AND D$="T" THEN OUTPUT 709 ;"50,47,49"
6855 IF D1=1 AND D$="C" THEN OUTPUT 709 ;"50,47,48"
6857 IF D1<>1 THEN OUTPUT 709 ;"50"
6860 PRINT "RING SHEAR TEST COMPLETED" @ R1=0
6863 PRINT DATE$,TIME$
6865 RETURN
7000 !
7005 !
7040 IMAGE DD.DD,X,DDD.D,X,DDD.D,X,DDD.D,X,DDD.D
7041 IMAGE DD.DD,"kG",DD.DD,"kG",DD.DD,XX,DDD.DD,DD.DD
7042 IMAGE DDD.DDD,XXXX,DD.DDD,XXXXX,DD.DDD
7043 IMAGE DD,XXXX,6A,"---------",DDD
7044 IMAGE D.DDD,X,D.DDD,X,D.DDD,X,DDD.DD,X,DD.DDD
7046 IMAGE DD,6X,MDD.DDDD,6X,DDDD.DD
7050 IF T1=1 OR T2=1 THEN 7250
7055 DISP "TO AUTOMATE START FRAME DRIVE #1"
7056 DISP "SWITCH TO MANUAL TO STOP,       USE COMMAND 'S1'"
7060 S8=0
7065 DISP "INPUT MAX CHANGE IN LENGTH FOR  COMPUTER STOP (mm)"
7068 INPUT S8
7250 OUTPUT 709 USING "K" ; "20"
7255 WAIT 500
7260 ENTER 722 ; I2
7265 IF I2>2.5 AND I2<7.5 THEN GOTO 7272
7270 GOTO 7350
7272 IF T1=1 OR T2=1 THEN 7290
7275 OUTPUT 709 USING "K" ; 30
7276 WAIT 500
7280 ENTER 722 ; L1$
7285 L1=VAL(L1$)*1000
7290 OUTPUT 709 USING "K" ; "30"
7292 WAIT 500
```

```
7295 ENTER 722 ; V$
7300 V(1),V(6)=VAL(V$)$1000
7305 IF T1=1 OR F=5 THEN 7310
7307 IF V(6)-L1>D(8) THEN F=6 @ L1=V(6) @ GOSUB 9700 @ V(6)=L1 @ GOSUB 750 @ F=0
7308 IF V(6)>=S8 THEN OUTPUT 709 ;"70" @ PRINT "TRIAX 2 FINISHED" @ PRINT TIME$,DATE$ @ T2=0
7309 GOTO 7315
7310 IF V(1)-L1>D(7) THEN F=5 @ GOSUB 9700 @ GOSUB 750 @ F=0 @ L1=V(1)
7312 IF V(1)>=S8 THEN T1=0 @ OUTPUT 709 ;"70" @ PRINT "TRIAX 1 FINISHED" @ PRINT TIME$,DATE$
7315 RETURN
7350 OUTPUT 709 ;"60"
7355 WAIT 1500
7360 OUTPUT 709 ;S5$
7361 WAIT 1000
7362 OUTPUT 709 ;"60"
7363 WAIT 15 @ OUTPUT 709 ;S5$
7364 WAIT 300
7365 GOTO 7250
7500 !
7995 !
8000 !
8015 RETURN
8495 !
8500 !
8505 !
8515 RETURN
8600 !
9000 !
9010 IF F<>8 THEN RETURN
9015 RETURN
9100 GOSUB 9280
9112 DISP "Enter Sample_id"
9115 INPUT S4$
9120 DISP "Enter name of submitter"
9125 INPUT R4$
9127 IF F>=5 THEN DISP "ENTER LATERAL/BACK PRESSURE (psi)" @ GOTO 9135
9130 DISP "Enter the normal load in Kg."
9135 INPUT N4$
9136 IF F=3 THEN DISP "ENTER ROTATIONAL RATE IN mm/min" @ GOTO 9145
9137 IF F=3 THEN GOTO 9145
9140 IF F>1 THEN DISP "Enter the shear rate."
9142 IF F=1 THEN B4$="NA" @ GOTO 9146
9145 INPUT B4$
9146 IF F=3 THEN M1=VAL(B4$)
9148 PRINT# I,1 ; S4$
9150 PRINT# I,2 ; R4$
9152 PRINT# I,3 ; N4$
9153 PRINT# I,4 ; B4$
9154 PRINT# I,5 ; DATE$
9155 RETURN
9200 GOSUB 9280
9248 READ# I,1 ; S4$
9250 READ# I,2 ; R4$
9252 READ# I,3 ; N4$
9254 READ# I,4 ; B4$
9258 DISP "Sample_id     ";S4$
9260 DISP "Name of submitter    ";R4$
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9262 IF F)=5 THEN DISP "LATERAL PRESS/BACKPRESSURE (psi): ";N4$ @ GOTO 9268
9265 DISP "The normal load Kg.  ";N4$
9266 DISP "NORMAL LOAD IN kN.";VAL(N4$)*F1
9267 IF F=3 THEN DISP "SHEAR ROTATION RATE mm/min";B4$ @ GOTO 9270
9268 DISP "The shear rate.  ";B4$
9270 DISP "PRESS ENDLINE TO PROCEED."
9275 LINPUT Y$
9277 RETURN
9280 IF C1=1 THEN I=1
9282 IF C2=1 THEN I=2
9283 IF C3=1 OR C4=1 THEN I=3
9284 IF F=1 THEN RETURN
9286 I=F+2 @ RETURN
9300 !
9305 IF C1=1 THEN OFF TIMER# 1 @ A1,N5,C(1)=0
9308 IF C2=1 THEN OFF TIMER# 2 @ A2,N6,C(2)=0
9310 IF C3=1 OR C4=1 THEN OFF TIMER# 3 @ A3,N7,C(3)=0
9350 IF F=2 THEN P2=P1 @ S7=1
9355 IF F=3 THEN R7=M2
9360 IF F=5 THEN T1=0 @ OUTPUT 709 ;"70"
9365 IF F=6 THEN T2=0 @ OUTPUT 709 ;"70"
9370 IF F=7 THEN T3=0
9375 IF F=8 THEN T4=0
9400 RETURN
9500 !
9510 IF D1<>1 AND R1<>1 THEN S1$="50" @ S2$="41"
9515 IF D1<>1 AND R1=1 THEN S1$="50,40" @ S2$="41"
9520 IF D1=1 AND R1<>1 AND D$="T" THEN S1$="50,47,49" @ S2$="41"
9525 IF D1=1 AND R1<>1 AND D$="C" THEN S1$="50,47,48" @ S2$="41"
9530 IF D1=1 AND R1=1 AND D$="T" THEN S1$="50,40,47,49" @ S2$="41"
9540 IF D1=1 AND R1=1 AND D$="C" THEN S1$="50,40,47,48" @ S2$="41"
9545 RETURN
9600 !
9605 DISP "INPUT THE LOAD IN KILOGRAMS FOR  THE PREVIOUS TEST. 0 IF NONE." @ INPUT C(1)@ D=C(1)
9608 GOSUB 9670 @ CLEAR
9611 F(1)=B
9613 DISP "ENTER THE LOAD IN KILOGRAMS FOR THIS TEST." @ INPUT C(1)@ D=C(1)
9617 GOSUB 9670 @ CLEAR
9618 F(1)=B-F(1)
9619 RETURN
9625 !
9627 DISP "INPUT THE LOAD IN KILOGRAMS FOR PREVIOUS TEST.    ZERO IF NONE." @ INPUT C(2)
9629 GOSUB 9638
9631 F(2)=A
9633 DISP "ENTER THE LOAD IN KILOGRAMS FOR THIS TEST." @ INPUT C(2)
9634 GOSUB 9638 @ CLEAR
9635 F(2)=A-F(2)
9636 RETURN
9638 A=1.31E-16*C(2)^5-3.72E-13*C(2)^4+.000000000477*C(2)^3-.0000003325*C(2)^2+.0001478*C(2)+.0006
9640 A=A*25.4
9645 RETURN
9650 !
9651 !
9652 DISP "INPUT THE LOAD IN KILOGRAMS FOR PREVIOUS TEST.    ZERO IF NONE." @ INPUT C(3)
9653 C(2)=C(3)
9654 GOSUB 9638 @ CLEAR
```

```
9655 F(3)=A
9658 DISP "ENTER THE LOAD IN KILOGRAMS FOR THIS TEST." @ INPUT C(3)@ C(2)=C(3)
9660 GOSUB 9638 @ CLEAR
9661 IF READTIM(2)=0 THEN C(2)=0
9662 F(3)=A-F(3)
9666 RETURN
9670 !
9672 B=3.8E-23*D^7-4.2E-19*D^6+1.9E-15*D^5-4.42E-12*D^4+.000000056*D^3-.000003831*D^2+.0015*D+.013
9673 RETURN
9675 DISP "ENTER THE LOAD IN KILOGRAMS FOR PREVIOUS TEST" @ INPUT C(4)@ D=C(4)
9677 GOSUB 9670 @ CLEAR
9679 F(6)=B
9681 DISP "ENTER THE LOAD IN KILOGRAMS FOR THIS TEST" @ INPUT C(4)@ D=C(4)
9683 GOSUB 9670 @ CLEAR
9685 F(3)=B-F(6)
9690 RETURN
9700 !
9725 OUTPUT 722 ;"F4 R3 A0 H0 M3 T1 D0"
9750 IF F=5 OR T1=1 THEN OUTPUT 709 USING "K" ; "15" @ WAIT 400
9775 IF F=6 OR T1=2 THEN OUTPUT 709 USING "K" ; "16" @ WAIT 400
9780 ENTER 722 ; T1$
9785 IF F=5 OR T1=1 THEN T(1)=392.65-45.64*LOG(VAL(T1$))
9790 IF F=6 OR T2=1 THEN T(2)=392.65-45.64*LOG(VAL(T1$))
9800 OUTPUT 722 ;A1$
9805 OUTPUT 709 ;"60"
9810 WAIT 1500
9811 IF T1=1 OR T2=1 THEN S5$="70,61" ELSE S5$="70"
9815 OUTPUT 709 ;S5$
9820 WAIT 1000
9826 OUTPUT 709 ;"60" @ WAIT 20 @ OUTPUT 709 ;S5$
9827 WAIT 300
9828 GOSUB 9955
9830 IF (F=5 OR F=6) AND U<>0 THEN DISP "WRONG CHANNEL" @ GOTO 9800
9837 OUTPUT 709 USING "K" ; "31"
9850 FOR I=1 TO 5
9851 IF F=6 AND I=5 THEN GOTO 9865
9852 OUTPUT 709 USING "K" ; "30"
9853 WAIT 500 @ ENTER 722 ; V$
9854 V((F-5)*5+I)=VAL(V$)*1000
9855 IF L=1 THEN GOTO 9856 ELSE GOSUB 9900
9856 OUTPUT 709 ;"60"
9857 WAIT 20 @ OUTPUT 709 ;S5$ @ WAIT 200
9858 OUTPUT 709 USING "K" ; (F-5)*4+I+20
9859 WAIT 400 @ ENTER 722 ; I2
9860 IF I2>2.5 AND I2<7.5 THEN DISP "CHANNEL OK" ELSE L=0 @ PRINT "WRONG CHANNEL" @ GOTO 9800
9862 OUTPUT 709 USING "K" ; "31"
9863 WAIT 100
9865 NEXT I
9867 L=0
9870 RETURN
9900 IF F=6 THEN GOTO 9910
9907 RETURN
9910 FOR K=1 TO 4
9912 OUTPUT 709 ;"60"
9914 WAIT 20
9916 OUTPUT 709 ;S5$
```

```
9918 WAIT 400
9920 NEXT K
9922 OUTPUT 709 USING "K" ; "24"
9924 WAIT 400
9926 ENTER 722 ; I2
9928 IF I2>2.5 AND I2<7.5 THEN DISP "CHANNEL OK" ELSE PRINT "WRONG CHANNEL" @ GOTO 9800
9930 OUTPUT 709 USING "K" ; "30"
9932 WAIT 400 @ ENTER 722 ; V$
9934 V(10)=VAL(V$)*1000
9936 L=1
9937 OUTPUT 709 USING "K" ; "31"
9938 WAIT 100
9940 RETURN
9955 FOR K=0 TO 10
9960 OUTPUT 709 USING "K" ; 20+K
9965 WAIT 400
9970 ENTER 722 ; I2
9975 IF I2>2.5 AND I2<7.5 THEN U=K @ GOTO 9990
9980 IF I2>=7.5 THEN U=K+10 @ GOTO 9990
9985 NEXT K
9990 RETURN
9999 END
```

Cross Reference Listing (ACCEL)

```
VAR       OCCURS IN LINE
A1$       2 ,25 ,9800
C5(,)     3 ,407 ,409 ,410 ,442
          617 ,617 ,618 ,624
          629 ,635 ,652 ,751
          757 ,762 ,767 ,769
          787 ,791 ,793 ,795
          6031 ,6032 ,6034 ,6257
          6260 ,6265 ,6267
F1        3 ,608 ,608 ,610 ,610
          996 ,996 ,9266
A1        4 ,105 ,292 ,855 ,5030
          9305
A2        4 ,115 ,292 ,857 ,5235
          9308
A3        4 ,125 ,292 ,859 ,5435
          9310
A5        4 ,196 ,2508 ,2509
C1        4 ,292 ,414 ,416 ,620
          621 ,622 ,665 ,720
          751 ,752 ,754 ,756
          801 ,850 ,907 ,957
          1010 ,1150 ,5018 ,5030
          5225 ,5425 ,5605 ,9280
          9305
C2        4 ,292 ,418 ,419 ,625
          626 ,627 ,667 ,722
          757 ,758 ,759 ,761
          808 ,857 ,907 ,958
          1012 ,1155 ,5018 ,5225
          5235 ,5425 ,5610 ,9282
          9308
C3        4 ,292 ,422 ,423 ,630
          632 ,633 ,669 ,723
          762 ,763 ,764 ,766
          815 ,859 ,907 ,959
          1014 ,1160 ,5018 ,5225
          5425 ,5435 ,5612 ,9283
          9310
C4        4 ,292 ,422 ,631 ,632
          633 ,669 ,724 ,762
          763 ,764 ,766 ,815
          859 ,907 ,959 ,1015
          5612 ,9283 ,9310
C8        4 ,950 ,992 ,992 ,992
D1        4 ,140 ,828 ,861 ,6005
          6287 ,6302 ,6850 ,6855
          6857 ,9510 ,9515 ,9520
          9525 ,9530 ,9540
E1        4 ,828 ,6255 ,6258
          6261 ,6261 ,6300
E3        4 ,835 ,6760 ,6770
F         4 ,292 ,402 ,414 ,416
          418 ,419 ,423 ,426
          427 ,428 ,436 ,438
          441 ,443 ,505 ,510
          510 ,515 ,515 ,601
          602 ,606 ,608 ,609
          611 ,612 ,614 ,616
          652 ,660 ,662 ,664
          665 ,667 ,675 ,701
          702 ,704 ,706 ,708
          745 ,767 ,768 ,769
          770 ,771 ,772 ,780
          786 ,787 ,790 ,791
          792 ,793 ,794 ,795
          796 ,797 ,823 ,824
          830 ,836 ,838 ,838
          840 ,861 ,862 ,863
          864 ,867 ,868 ,870
          871 ,872 ,907 ,951
          956 ,961 ,963 ,970
          972 ,973 ,974 ,1005
          1165 ,1170 ,1170 ,1505
          2005 ,3005 ,3505 ,4005
          4505 ,5018 ,5225 ,5425
          5614 ,5614 ,5614 ,5614
          5620 ,5705 ,5710 ,5715
          6267 ,6269 ,6799 ,6805
          7305 ,7307 ,7307 ,7310
          7310 ,9010 ,9127 ,9136
          9137 ,9140 ,9142 ,9146
          9262 ,9267 ,9284 ,9286
          9350 ,9355 ,9360 ,9365
          9370 ,9375 ,9750 ,9775
          9785 ,9790 ,9830 ,9830
          9851 ,9854 ,9858 ,9900
I1        4 ,441 ,442 ,442 ,442
          442 ,442
J         4 ,950 ,953 ,955 ,972
          991 ,996 ,5614 ,5627
          5632 ,5636 ,5637 ,5705
          5710 ,5715
K         4 ,9910 ,9920 ,9955
          9960 ,9975 ,9980 ,9985
L         4 ,9855 ,9860 ,9867
          9936
P2        4 ,828 ,6007 ,6258
          6301 ,6301 ,6302 ,6303
          6304 ,6318 ,9350
R1        4 ,150 ,835 ,6313 ,6314
          6505 ,6507 ,6860 ,9510
          9515 ,9520 ,9525 ,9530
          9540
R (,)     4 ,5005 ,5010 ,5030
          5205 ,5210 ,5235 ,5405
          5410 ,5435
```

Cross Reference Listing (ACCEL)--Continued

```
C1(,)   8 ,752 ,755 ,803 ,981
C2(,)   8 ,758 ,760 ,810 ,985
C3(,)   8 ,763 ,765 ,817 ,989
A       9 ,823 ,9631 ,9635
        9638 ,9640 ,9640 ,9655
        9662
B       9 ,823 ,9611 ,9618
        9672 ,9679 ,9685
C       9 ,991 ,995
C (,)   9 ,621 ,625 ,630 ,631
        807 ,814 ,821 ,5002
        5202 ,5402 ,5402 ,9305
        9308 ,9310 ,9605 ,9605
        9613 ,9613 ,9627 ,9633
        9638 ,9638 ,9638 ,9638
        9638 ,9652 ,9653 ,9653
        9658 ,9658 ,9658 ,9661
        9675 ,9675 ,9681 ,9681
D       9 ,9605 ,9613 ,9672
        9672 ,9672 ,9672 ,9672
        9672 ,9672 ,9675 ,9681
D2      9 ,407 ,412 ,412 ,608
        608 ,609 ,609 ,610
        610 ,772 ,835 ,996
        996 ,996 ,997 ,997
        6785
D3      9 ,410 ,412 ,412 ,608
        608 ,609 ,609 ,610
        610 ,772 ,835 ,996
        996 ,996 ,997 ,997
        6796
D4      9 ,409 ,412 ,609 ,771
        771 ,772 ,835 ,996
        997 ,6798
E2      9 ,412 ,609 ,835 ,6752
        6755
F (,)   9 ,624 ,629 ,635 ,751
        757 ,762 ,807 ,814
        821 ,821 ,9611 ,9618
        9618 ,9631 ,9635 ,9635
        9655 ,9662 ,9662 ,9679
        9685 ,9685
I2      9 ,7260 ,7265 ,7265
        9859 ,9860 ,9860 ,9926
        9928 ,9928 ,9970 ,9975
        9975 ,9980
M1      9 ,412 ,609 ,835 ,6562
        6755 ,9146
M2      9 ,835 ,6556 ,6757
        9355
N4      9 ,412 ,609 ,652 ,771
        835 ,6545
N5      9 ,624 ,665 ,807 ,5017
        9305
N6      9 ,629 ,667 ,814 ,5220
        9308
N7      9 ,635 ,669 ,821 ,5420
        9310
R0      9 ,406 ,407 ,409 ,410
        835 ,6782 ,6785 ,6795
        6796
R7      9 ,772 ,835 ,996 ,997
        6757 ,6765 ,6770 ,9355
R8      9 ,835 ,6755 ,6765
        6770
R9      9 ,406 ,407 ,409 ,410
        835 ,6782 ,6785 ,6795
        6796
S       9 ,807 ,5005 ,5011
        5011 ,5011 ,5011 ,5012
        5012 ,5013 ,5014 ,5014
        5016
S1      9 ,110 ,807 ,5011 ,5011
        5011 ,5011 ,5012 ,5012
        5013 ,5014 ,5014 ,5016
S2      9 ,120 ,814 ,5211 ,5211
        5211 ,5211 ,5212 ,5212
        5213 ,5214 ,5214 ,5215
S3      9 ,130 ,821 ,5411 ,5411
        5412 ,5412 ,5413 ,5413
        5414 ,5415 ,5415 ,5418
S4      9 ,814 ,5205 ,5211
        5211 ,5211 ,5211 ,5212
        5212 ,5213 ,5214 ,5214
        5215
S5      9 ,821 ,5405 ,5411
        5411 ,5412 ,5412 ,5413
        5413 ,5414 ,5415 ,5415
        5418
S7      9 ,6002 ,6317 ,9350
T       9 ,835 ,6580 ,6750
T6      9 ,6045 ,6257
T7      10 ,6080 ,6260
T8      10 ,835 ,6567 ,6765
T9      10 ,835 ,6750 ,6752
X1      10 ,807 ,5013 ,5014
X2      10 ,814 ,5213 ,5214
X3      10 ,821 ,5414 ,5415
S2$     22 ,408 ,6790 ,9510
        9515 ,9520 ,9525 ,9530
        9540
R1$     407 ,407 ,410 ,410
        6785 ,6785 ,6796 ,6796
D4$     409 ,409 ,6798 ,6798
V1$     416 ,416 ,620 ,620
        5017 ,5017
V1      416 ,417 ,620 ,624
        624 ,624 ,751 ,751
        752 ,756 ,807 ,982
        982 ,5017 ,5017 ,5017
V2$     418 ,418 ,626 ,626
        5217 ,5217
V2      418 ,421 ,626 ,629
        629 ,629 ,757 ,757
        758 ,761 ,814 ,986
        986 ,5217 ,5220 ,5220
V3$     422 ,422 ,632 ,632
        5419 ,5419
V3      422 ,425 ,632 ,635
        635 ,635 ,762 ,762
        763 ,766 ,821 ,990
        990 ,5419 ,5420 ,5420
```

Cross Reference Listing (ACCEL)--Continued

```
I       5 ,560 ,565 ,565 ,570
        755 ,755 ,755 ,755
        755 ,760 ,760 ,760
        760 ,760 ,765 ,765
        765 ,765 ,765 ,803
        803 ,803 ,806 ,806
        806 ,807 ,807 ,807
        810 ,810 ,810 ,813
        813 ,813 ,814 ,814
        814 ,817 ,817 ,817
        820 ,820 ,820 ,821
        821 ,821 ,826 ,826
        826 ,833 ,833 ,833
        838 ,838 ,838 ,950
        950 ,972 ,973 ,974
        978 ,981 ,981 ,981
        981 ,982 ,982 ,982
        982 ,985 ,985 ,985
        985 ,986 ,986 ,986
        986 ,989 ,989 ,989
        989 ,990 ,990 ,990
        990 ,991 ,991 ,994
        996 ,996 ,998 ,5658
        5660 ,5660 ,5661 ,5662
        5664 ,5666 ,5666 ,5670
        5674 ,5682 ,5688 ,5690
        5705 ,5710 ,5715 ,6280
        6280 ,9148 ,9150 ,9152
        9153 ,9154 ,9248 ,9250
        9252 ,9254 ,9280 ,9282
        9283 ,9286 ,9850 ,9851
        9854 ,9858 ,9865
N1      5 ,618 ,660 ,767 ,769
        828 ,6257 ,6259 ,6259
N2      5 ,617 ,662 ,828 ,6265
N3      5 ,617 ,664 ,828 ,6267
T5      5 ,6254 ,6257 ,6259
        6261
T (,)   5 ,443 ,787 ,791 ,793
        795 ,9785 ,9790
A4$     6 ,950 ,951 ,952 ,953
N4$     6 ,652 ,652 ,6545 ,6545
        9135 ,9152 ,9252 ,9262
        9265 ,9266
Z $     6 ,2502 ,2507 ,2508
        2509
S1$     6 ,22 ,405 ,410 ,6780
        6807 ,9510 ,9515 ,9523
        9525 ,9530 ,9540
C1$     6 ,310 ,311 ,312 ,313
        315 ,316 ,320 ,322
        330 ,331 ,335 ,340
        345 ,350 ,355 ,360
        365 ,370 ,371 ,411
        444 ,473 ,576 ,700
        905
D $     6 ,22 ,6110 ,6115 ,6340
        6350 ,6370 ,6850 ,6855
        9520 ,9525 ,9530 ,9540
S5$     7 ,868 ,870 ,7360 ,7363
        9811 ,9811 ,9815 ,9826
        9857 ,9916
R1(,)   4 ,510 ,510 ,515 ,565
        751 ,751 ,752 ,752
        754 ,756 ,756 ,756
        757 ,757 ,758 ,758
        759 ,761 ,761 ,761
        762 ,762 ,763 ,763
        764 ,766 ,766 ,766
        768 ,768 ,768 ,768
        770 ,770 ,772 ,772
        780 ,780 ,786 ,786
        786 ,787 ,790 ,790
        790 ,791 ,792 ,792
        792 ,793 ,794 ,794
        794 ,795 ,806 ,807
        813 ,814 ,820 ,821
        826 ,828 ,833 ,835
        838 ,840 ,972 ,980
        981 ,982 ,984 ,985
        986 ,988 ,989 ,990
        991 ,996 ,1150 ,1150
        1155 ,1155 ,1160 ,1160
        1170 ,1170 ,5614 ,5627
        5632 ,5636 ,6308 ,6308
        6308 ,6308
T1      4 ,50 ,160 ,840 ,868
        7050 ,7272 ,7305 ,7312
        9360 ,9750 ,9775 ,9785
        9811
T2      4 ,50 ,170 ,840 ,870
        7050 ,7272 ,7308 ,9365
        9790 ,9811
T3      4 ,180 ,871 ,9370
T4      4 ,190 ,872 ,9375
U       4 ,9830 ,9975 ,9980
D (,)   5 ,867 ,870 ,871 ,872
        7307 ,7310
V (,)   5 ,442 ,442 ,442 ,442
        442 ,787 ,787 ,787
        787 ,787 ,791 ,791
        791 ,791 ,791 ,793
        793 ,793 ,793 ,793
        795 ,795 ,795 ,795
        795 ,7300 ,7300 ,7307
        7307 ,7307 ,7308 ,7310
        7310 ,7312 ,9854 ,9934
C9      5 ,6028 ,6031 ,6032
        6034 ,6272 ,6276 ,6282
```

```
W1$     426 ,426 ,611 ,611
W1      426 ,437 ,611 ,618
        767 ,767 ,768 ,769
        769 ,828 ,991 ,991
        992 ,993 ,995 ,6259
        6261
W2$     427 ,427 ,612 ,612
        6262 ,6262
W2      427 ,437 ,612 ,617
        617 ,618 ,768 ,828
        991 ,993 ,6262 ,6265
        6265 ,6272 ,6282
W3$     428 ,428 ,614 ,614
        6264 ,6264
W3      428 ,437 ,614 ,617
        617 ,618 ,768 ,828
        991 ,993 ,6264 ,6267
        6267
Y $     459 ,472 ,580 ,810
        817 ,827 ,828 ,834
        835 ,6539 ,6544 ,6545
        6577 ,9275
T $     562 ,565 ,950
N1$     660 ,660
N2$     662 ,662
N3$     664 ,664
N5$     665 ,665
N6$     667 ,667 ,9934
N7$     669 ,669
S8      840 ,7060 ,7068 ,7308
        7312
Z1      973 ,973 ,974 ,976
Z2      974 ,976
Z3      974 ,976
Z4      974 ,976
Z5      974 ,976
X       981 ,981 ,982 ,982
        985 ,985 ,986 ,986
        989 ,989 ,990 ,990
        1007 ,1009 ,1010 ,1012
        1014 ,1015 ,5614 ,5627
        5632 ,5636 ,5650 ,5652
        5658 ,5671 ,5682
Y       5680 ,5684 ,5688 ,5705
        5710 ,5715
Y2      5710 ,5715
Y1      5710 ,5715
Y4      5715
Y3      5715
P1      6060 ,6302 ,6303 ,6304
        6318 ,9350
T5$     6254 ,6254
V4      6259 ,6260
V5      6259 ,6260
J1      6585 ,6750
L1$     7280 ,7285
L1      7285 ,7307 ,7307 ,7307
        7310 ,7310
V $     7295 ,7300 ,9853 ,9854
        9932 ,9934
S4$     9115 ,9148 ,9248 ,9258
R4$     9125 ,9150 ,9250 ,9260
B4$     9142 ,9145 ,9146 ,9153
        9254 ,9267 ,9268
T1$     9780 ,9785 ,9790
```

Program Description by Line Numbers

Routing description	Program lines
Initialize variables, declarations	0 - 49
Scanning and key label display	50 - 199
On error reset	200 - 299
User command selections	300 - 399
Command language routines	400 - 999
Set consolidation flags	1000 - 1110
Command language routine (Z)	1150 - 1199
Not in use	1200 - 1499
Set direct shear flags	1505 - 1510
Not in use	1511 - 1999
Set ring shear flags	2000 - 2010
Not in use	2011 - 2499
Audio signal on during scan	2500 - 2510
Set triax 1 flags	3000 - 3010
Not in use	3011 - 3499
Set triax 2 flags	3500 - 3510
Not in use	3511 - 3999
Set triax 3 flags	4000 - 4010
Not in use	4011 - 4499
Set triax 4 (CRSC) flags	4500 - 4510
Not in use	4511 - 4999
Automate consolidation 1	5000 - 5199
Automate consolidation 2	5200 - 5399
Automate consolidation 3 or 4	5400 - 5599
Plot vertical displacements (ring shear, direct shear, and consolidation tests).	5600 - 5999
Automate the direct shear test	6000 - 6499
Automate ring shear test	6500 - 6999
Output format images	7040 - 7046
Automate triaxial tests 1 and (or) 2	7000 - 7499

Program Description by Line Numbers--Continued

Routing descriptions	Program lines
Not in use (reserved for triax 3 and 4 (CRSC))	7500 - 8999
Command language routines	9000 - 9499
Ring shear and direct shear relay subroutines	9500 - 9699
Not in use	9700 - 9799
Triaxial 1 and 2 relay control subroutines	9800 - 9999

(Line 9999 is last legal line number.)

Variable Definitions

[for Program ACCEL]

Variable	Type	Description
A:	real	Contains the value of the polynomial used to correct for frame change due to applied load for frames 2 and 3. (See line 9638.)
A1:	flag	Controls automation of consolidometer 1. When A1 = 0 the system is not in automated mode.
A2:	flag	Same as A1 except for consolidometer 2.
A3:	flag	Same as A1 except for consolidometer 3.
A5:	flag	When set equal to one causes an audible signal to be sounded for each loop through the scanning mode. When equal to zero the audible is turned off. This is to aid in the prevention of leaving the program in a suspended or nonscanning state.
A1$:	string	Holds the front panel configuration commands to set up the HP-9855A digital multimeter.
A4$:	string	Holds the alpha characters "P", "A", or " ". Used to select all or part of a listing of data.
B:	real	Contains the value of the polynomial used to correct for frame change due to applied load for frames 1 and 4. (See line 9672.)
B4$	string	Contains the string of information about the shear rate/shear rotational rate for the direct/ring/triaxial shear tests.
C:	real	Holds the current value of horizontal displacement for the direct shear test while the past readings are listed. Then the value is returned to the variable W1 for use in determining whether another automated reading is needed.
C1:	flag	Holds **0** or a **1**. When equal to a **1** then consolidometer #1 has been selected for control.
C2:	flag	Same as C1 except for consolidometer 2.
C3:	flag	Same as C1 except for consolidometer 3.
C4:	flag	Same as C1 except for consolidometer 4.
C8:	integer	Counts the number of cycles for the repeated direct shear test.

Variable Definitions--Continued

Variable	Type	Description
C9:	short	Holds the number of pounds selected for the load cell in use on the direct shear test. Currently 100, 500, or 2000 pounds. This variable is used to protect the load cell from extreme overloads. A warning is given on the thermal printer and 50 beeps are made when the capacity of the cell is reached. At 25 percent overload a message is printed on the thermal printer and the system terminates the test.
C(1):	real	Temporary variable which holds the values in kilograms for the previous and current loads used on consolidometer 1.
C(2):	real	Similar to C(1) except for consolidometer 2 and is also used directly as the independent variable in the frame change polynomial for both frames 2 and 3.
C(3):	real	Similar to C(1) except for consolidometer 3. This value is passed to C(2) for use in the frame change polynomial.
C(4):	real	Similar to C(1) except for consolidometer 4. This value is passed to the variable D for use in the frame change polynomial.
C1():	real	An array which contains the first 10 readings taken for consolidometer 1. These readings are stored in memory and not on tape since they come rapidly and tape winding may delay data gathering sequences.
C2():	real	Same as C1() except for consolidometer 2.
C3():	real	Same as C1() except for consolidometer 3.
C5():	short	A 10-element array which holds the conversion factors for changing voltages shear tests to engineering units.
C5(1)	1.62	Factor is multiplied times voltage to produce direct shear horizontal displacement in millimeters.
C5(2)	-2.95	The factor is multiplied times a voltage to produce direct shear vertical displacement in millimeters.
		Negative sign changes output voltages so consolidation has negative sign associated with it.

Variable Definitions--Continued

Variable	Type	Description
C5(3)		-1420.5*0.009807 The factor converts voltage to kilograms and then converts kilograms to kilonewtons for the direct shear load. Negative sign is associated with tension.
C5(4)	-1/100	Changes the sign and magnitude of the output from the channel A Load Cell. Converts to kilograms.
C5(5)	-1/100	Same as C5(4) except for channel B.
C5(6)	10.	Scale multiplier for the null variable N4.
C5(7)	1/35675	Converts volts to millimeters for consolidometer 1.
C5(8)		(1/0.5674-0.0037) Converts volts to millimeters for consolidometer 2.
C5(9)	1/35607	Converts volts to millimeters for consolidometers 3 and 4.
C5(10)	10	Scale multiplier used to shift the decimal place one place to the right for the load cell used in triax frame 1.
C1$:	string	Contains the user's response for an input from the menu of command language options.
D:	real	A temporary variable which passes its value to the frame change polynomial for consolidometers 1 and 4, where D is the independent variable in the polynomial. (See line 9672.)
D1:	flag	Contains the value 1 or 0. When D1=1 then the direct shear test is under automation control.
D2:	real	Contains the output from the channel A load cell (through BCD interface from the power supply and display unit (Model UMC 4000)) on the ring shear device applied to it. (See line 407.)
D3:	real	Same as D2 except for channel B output. (See line 410 for -0.01 multiplier.)
D4:	real	Contains the output from the ring shear device. Unit is powered and displayed on the ELE readout and display unit. D4 has a constant multiplier 10 applied to it. (See line 409.)

Variable Definitions--Continued

Variable	Type	Description
D():	short	An array whose seventh through tenth elements contain the displacements in millimeters between readings for the triaxial tests. D(7) for triax 1; D(8) for triax 2; D(9) for triax 3; D(10) for triax 4 or CRSC. NOTE: D(7) and D(8) should always be equal as well as D(9) and D(10) should always be equal.
D$:	string	Contains the character response for tension (**T**) or compression (**C**) for the repeated direct shear test.
D4$:	string	Contains the data from the vertical LVDT on the ring shear test. D4$ is quickly converted to the numeric variable D4.
E1:	integer	Counts the number of stored readings on each cycle of the direct shear test. Its purpose is to give the direct shear device enough time to get back under the table travel limit before checking to see if the travel has gone beyond the limit again.
E2:	real	Contains the time in decimal minutes that the ring shear test was automated. This time is used to compute rotational displacement from the start of the test.
E3:	flag	Contains the value **0** or **1**. When E3 is equal to zero the ring shear prevented from returning from the automation phase without getting the first reading.
F:	flag	Contains values from zero to eight, when: F=0 System in scan mode F=1 Consolidometer control F=2 Direct shear control F=3 Ring shear control F=4 Permeability control F=5 Triax 1 control F=6 Triax 2 control F=7 Triax 3 control F=8 Triax 4 (CRSC) NOTE: F=4, 7, 8 are not in use as of this time.
F1:	short	Constant receives its value from the tape data file FACTOR converts kilograms to kilonewtons. 0.009807.

Variable Definitions--Continued

Variable	Type	Description
F2:	flag	Contains 0 or 1. F1 is equal to 0 when the program is first run. F1 is set equal to 1 in line 16. The Flag allows the tape files to be reopened without initializing all the variables. Removing the tape from the drive closes the files, and the **R1** command reopens them.
F(1):	real	Holds first the solution to the frame change polynomial for consolidometer 1, and second, the difference between the polynomial solutions for the current and previous loads. This factor is then added to the amount of change that consolidometer 1 has computed.
F(2):	real	Same as F(1) except for consolidometer 2.
F(3):	real	Same as F(1) except for consolidometer 3.
F(6):	real	Holds the first solution to the frame change polynomial for consolidometer 4.
I:	short	Counter used in many of the FOR loops. I is an integer in most instances, but not all.
I1:	integer	Pointer used to locate data for triaxial tests 1-4 within the array V(). V(1) - V(5) For triax 1 V(6) - V(10) For triax 2 V(11) - V(15) For triax 3 V(16) - V(20) For CRSC
I2:	real	Used to hold the channel verification voltage (values between 2.5 and 7.5) for triaxial tests 1 and 2.
J:	integer	Pointer used to point to the starting number for listing the data that is stored for all the tests. All or partial listing starting with number (J).
J1:	real	Holds the date from the Date function. Used to compute rotational displacement since the start of the ring shear test.
K:	integer	Counter used to position LEDEX switch past sensor positions used for triax 1 (Positions to read sensors for triax 2). Also used as counter for channel verification of triax 1 and 2.

Variable Definitions--Continued

Variable	Type	Description
L:	flag	Holds the value **0** or **1** This flag is used to select the proper LEDEX positions for the triaxial tests.
L1:	real	Holds the first and subsequent axial deformation readings on automation of either triax 1 or 2.
L1$	string	Represents the input from the digital multimeter. L1$ is quickly converted to the numeric variable L1.
M1:	real	Holds the rotational rate in mm/min for the ring shear test.
M2:	real	Holds the total amount of desired rotational displacement (mean value) for the ring shear test.
N1:	short	Reference value used to null readings for the horizontal LVDT on the direct shear apparatus.
N2:	short	Reference value used to null offset readings for the load cell which measures the shearing load on the direct shear apparatus.
N3:	short	Reference value used to null offset readings for the vertical LVDT used on the direct shear apparatus.
N4:	real	Reference value used to null offset in readings for the vertical LVDT used on the ring shear apparatus.
N5:	real	Reference value used to null the offset in readings (for the vertical LVDT) on consolidometer 1.
N6:	real	Reference value used to null the offset in readings (for vertical LVDT) on consolidometer 2.
N7:	real	Reference value used to null the offset in readings (for vertical LVDT) on consolidometers 3 and 4.
N1$, N2$, N3$, N4$ N5$, N6$, N7$		Each a string of data which represents input from the digital multimeter. Each string is quickly converted to it's respective numeric equivalent. (that is N1, N2, N3, N4, N5, N6, and N7).

Variable Definitions--Continued

Variable	Type	Description
P1:	real	Holds the value which had been input by the user for the number of pulls to be completed for the direct shear test. An input of 0 pulls for 5 mm will cause a half cycle pull (from 0 to 5 mm) and then stop. An input of 1 will cause a half cycle pull, and a full cycle pull (from 0 to 5 mm and then from 5 to -5 mm).
P2:	integer	Counts the number of pulls that the direct shear test is currently on.
R0:	real	Represents the least significant digits of the BCD number coming from the UMC-4000 power supply and readout unit. For channel A, and then channel B load cells on ring shear apparatus.
R1:	flag.	Used for the automation of the ring shear equipment. The ring shear is automated when equal to 1, or not automated when equal to 0.
R7:	real	Holds the previous total of computed rotational displacement for the ring shear test.
R8:	real	Holds the product for the time in seconds and the ring shear rotational rate (mm/min) which is the mean rotational displacement (current value).
R9:	real	Represents the most significant digits and the sign of the BCD number coming from the power supply and readout unit for channel A, and then channel B load cells on the ring shear apparatus.
R1$:	string	Concatenation of the sign, most significant and least significant digits for the BCD word which represents the channel A and B inputs from the load cells on the ring shear apparatus.
R4$:	string	Holds the requestor or submitter's name (part of sample identification information).
R(1)	flag	Takes the value of either zero or one. The first time through the timer loop for consolidometer 1, R(1) equals 1, thereafter it is set equal to zero.
R(2):	flag.	Same as R(1) except for consolidometer 2.
R(3):	flag.	Same as R(1) except for consolidometer 3.

Variable Definitions--Continued

Variable	Type	Description
R1():	integer	An array which holds the counters for each test which tells how many readings are stored. R1(1) Counter for consolidometer 1 R1(2) Counter for consolidometer 2 R1(3) Counter for consolidometer 3 or 4 R1(4) Counter for direct shear R1(5) Counter for ring shear R1(6) Not in use R1(7) Counter for triax 1 R1(8) Counter for triax 2 R1(9) Counter for triax 3 R1(10) Counter for triax 4 (CRSC)
S:	real	Holds the time in milliseconds (first reading only) that is used to set timer no. 1 for consolidometer 1 when automated. After the first reading, S holds twice the time in milliseconds.
S1:	real	S1, like S, is used to set timer no. 1. S = 0 for the first reading, and then S1 holds the time in milliseconds between readings on consolidometer 1.
S2:	real	Serves the same function that S1 does, except it is used to set timer no. 2 for consolidometer 2.
S3:	real	Serves the same function that S1 does, except it is used to set timer no. 3 for consolidometers 3 and 4.
S4:	real	Serves the same function as S, except that it is used for consolidometer 2.
S5:	real	Serves the same function as S, except that it is used for consolidometers 3 and 4.
S7:	flag	Holds the value of **0** or **1**. If S7 is equal to zero, and the direct shear test has been automated, then an initial setup routine is done before taking the first readings. Once the setup has been done, S7 is set to **1**, and the setup routine is skipped.
S8:	real	Holds the input for the maximum change in displacement (mm) from the axial LVDT on FRAME 1. (Used for both triaxial tests 1 and 2 to turn the drive motor off.
S1$	string	A character string of numbers which are output to the scanner to open and close high thermal (actuator) relays in the 40's decade.

Variable Definitions--Continued

Variable	Type	Description
S2$:	string	A character string which closes relay 41 in the scanner.
S4$:	string	A character string which holds the sample identification.
S5$:	string	A character string which determines whether high thermal relay number 61 stays closed when other relays in the 60's decade are opened.
T:	real	Holds the time in seconds when the ring shear test began automated readings. Used to compute rotational displacement.
T1:	flag	Contains the value of **0** or **1**. When T1 is equal to **1**, then triax 1 is in an automated mode.
T2:	flag	Serves the same function as T1, except is used for triax 2.
T3:	flag	Serves the same function as T1, except it is used for triax 3.
T4:	flag	Serves the same function as T1, except it is used for triax 4 (CRSC).
T5:	short	Holds the initial value of horizontal displacement for the direct shear test. This value is used to compare with current readings to initiate automatic readings.
T6:	real	Holds the inputted value in mm for the horizontal displacement from the center or null position that the direct shear box will travel for each pull.
T7:	real	Holds the amount of travel in millimeters between stored readings for the direct shear test.
T8:	real	Holds the amount of travel in millimeters between stored readings for the ring shear test.
T9:	real	Holds the time in seconds since the beginning of automation of the ring shear test. (Used to compute rotational displacement.)
T(5)	short	An array which holds the temperature from the triaxial cells one through four. T(1) is for triax 1, T(2) is for triax 2, and so on. T(5) is not in use.

Variable Definitions--Continued

Variable	Type	Description
T$:	string	Used to hold the names of the tests (CONSL1, DIRSHR, and so forth) which are read from the DATA statements.
T5$:	string	Used to input horizontal displacement reading from direct shear test. T5$ is quickly converted to the numeric variable T5.
U:	integer	Holds a value from 0 to 19, and is used to determine which channel the Vishay/Ellis unit is switched on to. (For triaxial tests.)
V1:	real	Holds the numeric value of the vertical LVDT for consolidometer 1.
V2:	real	Same as V1, except it is for consolidometer 2.
V3:	real	Same as V1, except it is for consolidometers 3 or 4.
V4:	real	Holds the previous nulled horizontal displacement reading for the direct shear test. (Used for comparison to determine if the next automated reading is due.)
V5:	real	Same purpose as V4 except V5 holds the current nulled horizontal displacement for the direct shear test.
V$:	string	Used to input the value for the axial displacement for triaxial tests 1 and 2.
V1$:	string	Holds the information coming from the vertical LVDT for consolidometer number one. V1$ is quickly converted to the numeric variable V1.
V2$:	string	Same purpose as V1$ except applies to consolidometer 2 and variable V2.
V3$:	string	Same as V1$ except it applies to consolidometers 3 and 4 and variable V3.
V(01-20)	short	Numeric array, used to hold the readings for triaxial shear tests one through four. Respectively the following information is held in the array. Axial deformation; top pore pressure; bottom pore pressure; lateral pore pressure; and normal load.
	V(1-5)	Holds readings for triax 1.
	V(6-10)	Holds readings for triax 2.
	V(11-15)	Holds readings for triax 3.
	V(16-20)	Holds readings for triax 4 (CRSC).

Variable Definitions--Continued

Variable	Type	Description
W1:	real	Holds the horizontal displacement reading for the direct shear test.
W2:	real	Holds the shear load from the direct shear test.
W3:	real	Holds the vertical displacement from the direct shear test.
W1$:	string	Receives the data input from the horizontal LVDT on the direct shear apparatus.
W2$:	string	Receives the data input from the load cell on the direct shear apparatus.
W3$:	string	Receives the data input from the vertical LVDT on the direct shear apparatus.
X:	real	Holds the time in decimal minutes for the consolidometer readings. X receives its value from the DATA statement. X is also the X-coordinate used in the CRT plotting routines.
X1:	flag	Holds the value of **0** or **1**. When X1 is equal to **1** (happens after the timer clock for consolidometer 1 has taken the 16-hour reading) the next timer reading is set for 24 hours later.
X2:	flag	Same as X1 except for consolidometer 2.
X3:	flag	Same as X1 except for consolidometer 3.
Y:	real	Holds the Y-coordinate for the CRT plotting routines. (Plotting for consolidation, ring shear, and direct shear.)
Y1:	real	Used only to satisfy a READ statement to get to the Y-coordinate value which follows unneccessary information on the tape file. (Used for plotting.)
Y2:	real	Same purpose as Y1.
Y3:	real	Same purpose as Y1.
Y4:	real	Same purpose as Y1.
Y$:	string	Used to hold the user's input response to a Yes or No question. If Y$ is **Yes** then a null factor will be stored during the automation phase of the ring shear. A **No** response or an [END LINE] implies that a null has been stored previously.

Variable Definitions--Continued

Variable	Type	Description
Z1:	real	Holds the input from tape storage for triaxial deformation.
Z2:	real	Holds the input from tape storage for triaxial top pore pressure.
Z3:	real	Holds the input from tape storage for triaxial bottom pore pressure.
Z4:	real	Holds the input from tape storage for the triaxial lateral pore pressure.
Z5:	real	Holds the input from tape storage for triaxial normal load.

Relay Channel Assignments

Relay No.	Function	Wiring	Power source
00	OPEN		
01	DSHR, Hdisp	TS	DC
02	CONS1, Vdisp	TS	PP1
03	DSHR, LOAD	TS	DC
04	DSHR, Vdisp	TS	DC
05	CONS2, Vdisp	TS	PP1
06	OPEN	TS	
07	RSHR, Vdisp	TS	ELE
08	CONS3, Vdisp	TS	PP1
09		TS	
10		TS	
11	OPEN		
12	OPEN		
13	OPEN		
14	OPEN		
15	TRX1, Thermistor	BPB	
16	TRX2, Thermistor	BPB	
17	TRX3, Thermistor	BPB	
18	TRX4, (CRSC), Thermistor	BPB	
19		BPB	
20	Chan ID	TS	PP2
21	Chan ID	TS	PP2
22	Chan ID	TS	PP2
23	Chan ID	TS	PP2
24	Chan ID	TS	PP2
25	Chan ID	TS	PP2
26	Chan ID	TS	PP2
27	Chan ID	TS	PP2
28	Chan ID	TS	PP2
29	Chan ID	TS	PP2
30	TRIAX DATA 1,2	TS	V/E-21
31	TRIGGER EXTERNAL PRINTER (TRIAX)	TS	
32	OPEN	TS	

Relay Channel Assignments--Continued

Relay No.	Function	Wiring	Power source
33	OPEN	TS	
34	OPEN	TS	
35	OPEN	TS	
36	OPEN	TS	
37	OPEN	TS	
38	OPEN	TS	
39	OPEN	TS	
40	START RING SHEAR MOTOR	D	110V
41	REMOTE SWITCH FOR RING SHEAR	D	CONDEC
42	OPEN		
43	OPEN		
44	OPEN		
45	OPEN		
46	OPEN		
47	TURNS DIRECT SHEAR ON	D	110V
48	STARTS IN COMP DIRECTION	D	110V
49	STARTS IN TENSILE DIRECTION	D	110V
50			
51			
52	ANY COMMAND IN 50's		
53	DECADE WILL OPEN ALL		
54	RELAYS IN 40's WHEN		
55	ISSUED BY ITSELF.		
56			
57			
58			
59			
60	TRIP LEDEX SWITCH FOR TRIAX		PP2
61	STARTS MOTOR FOR TRIAX FRAME 1		110V
62	OPEN (RESERVED FOR TRIAX FRAME 2)		
63	OPEN		
64	OPEN		
65	OPEN		

Relay Channel Assignments--Continued

Relay No.	Function	Wiring	Power source
66	OPEN		
67	OPEN		
68	OPEN		
69	OPEN		
70			
71			
72	ANY COMMAND IN 70's		
73	DECADE WILL OPEN ALL		
74	RELAYS IN 40's WHEN		
75	ISSUED BY ITSELF		
76			
77			
78			
79			

APPENDIX II

AUTOMATION SUPPORT PROGRAMS

SETUP and "Autost"

Examples of Values Stored in FACTOR by SETUP

```
     DIRECT SHEAR
 HORIZONTAL LVDT: 1.62
 LOAD CELL      :-13.931
 VERTICAL LVDT  :-2.95
       RING SHEAR
 CHANNEL A CELL :-.01
 CHANNEL B CELL :-.01
 VERTICAL LVDT  : 10
    CONSOLIDATION
 CONSOL # 1     : 2.8031
 CONSOL # 2     : 1.7587
 CONSOL # 3 OR 4: 2.8084
TRIAX 1/2 NORMAL LOAD  : 10
FACTOR TO CONVERT kG TO kN:
 .009807
FRONT PANEL CONFIGURATION IS
"F1 R7 A0 H1 M3 T1 D0"
```

List of variable names that receive the data from the file (FACTOR).

```
C5(1)
 1.62
C5(2)
-13.931
C5(3)
-2.95
C5(4)
-.01
C5(5)
-.01
C5(6)
 10
```

```
C5(7)
 2.8031
C5(8)
 1.7587
C5(9)
 2.8084
C5(10)
 10
F1
 .009807
A1$
"F1 R7 A0 H1 M3 T1 D0"
```

Program Listing of SETUP

```
  OPTION BASE 1
5 COM A1$[30]
6 COM SHORT C5(10),F1
8 COM INTEGER A1,A2,A3,A5,C1,C2,C3,C4,C8,D1,E1,E3,F,I1,J,K,L,P2,R1,R(3),R1(10),T1,T2,T3,T4,U
9 COM SHORT D(10),V(20),C9,I,N1,N2,N3,T5,T(5)
10 COM A4$[2],N4$[15],Z$[5],S1$[12],C1$[2],D$[2]
11 COM C1(11),C2(11),C3(11)
12 COM A,B,C,C(4),D,D2,D3,D4,E2,F(6),I2,M1,M2,N4,N5,N6,N7,R0,R7,R8,R9,S,S1,S2,S3,S4,S5,S7,T,T6
13 COM T7,T8,T9,X1,X2,X3
15 ASSIGN# 1 TO "FACTOR"
16 S,S1,S2,S3,S4,S5,S7,D,D1,R1,T1,T2,U,X1,X2,X3=0
17 T3,T4,T5,T7,R(1),R(2),R(3)=0
18 FOR I=1 TO 10 @ D(I)=0 @ R1(I)=0 @ NEXT I
19 C,C1,C2,C3,C4,C(1),C(2),C(3),C(4),E1,F,F(1),F(2),F(3),F(6),A,A1,A2,A3,A5,B=0
20 N1,N2,N3,N5,N6,N7=0
22 D2,D3,D4,E2,E3,L,M1,M2,N4,R0,R7,R8,R9,T8,T9,T=0
24 FOR I=1 TO 20 @ V(I)=0 @ NEXT I @ I1,I2,T6=0
25 ASSIGN# 1 TO "FACTOR"
30 CLEAR
32 X=0
35 ASSIGN# 1 TO "FACTOR"
37 DISP "WELCOME TO THE WORLD OF         GEOTECHNICAL AUTOMATION."
38 WAIT 2000
40 CLEAR
45 GOTO 1000
50 DISP "ENTER 1 TO DISPLAY CURRENT      SETUP FACTORS."
55 DISP
60 DISP "ENTER 2 TO MAKE CHANGES IN THE  SETUP FACTORS."
80 DISP
90 DISP "ENTER 3 TO LOAD LATEST VERSION  OF THE AUTOMATION PROGRAM."
100 INPUT X
110 ON X GOTO 1000,500,1500
500 CLEAR
510 DISP "  DIRECT SHEAR FACTORS"
520 DISP
522 DISP "CURRENT FACTOR USED TO CONVERT  VOLTAGE TO mm FOR THE HORIZONTAL LVDT IS ";C5(1)
524 DISP
525 Y$=""
526 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
527 LINPUT Y$ @ IF Y$="" THEN 542
528 IF UPC$(Y$[1,1])="Y" THEN GOTO 530 ELSE GOTO 542
530 DISP "ENTER VOLTAGE TO mm FACTOR FOR  THE HORIZONTAL LVDT."
540 INPUT C5(1)
541 PRINT# 1,1 ; C5(1)
542 DISP "CURRENT FACTOR USED TO CONVERT  VOLTAGE TO kN FOR THE LOAD CELL IS ";C5(2)
544 DISP
545 Y$=""
546 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
547 LINPUT Y$ @ IF Y$="" THEN 562
548 IF UPC$(Y$[1,1])="Y" THEN GOTO 550 ELSE GOTO 562
550 DISP "ENTER THE VOLTAGE TO kN FACTOR  FOR THE LOAD CELL."
560 INPUT C5(2)
561 PRINT# 1,2 ; C5(2)
562 DISP "CURRENT FACTOR USED TO CONVERT  VOLTAGE TO mm FOR THE VERTICAL  LVDT IS ";C5(3)
564 DISP
```

```
565 Y$=""
566 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
567 LINPUT Y$ @ IF Y$="" THEN 600
568 IF UPC$(Y$[1,1])="Y" THEN GOTO 570 ELSE GOTO 600
570 DISP "ENTER THE VOLTAGE TO mm FACTOR  FOR THE VERTICAL LVDT."
580 DISP "(Note:  the end result should   have a negative sign for consol)"
590 INPUT C5(3)
595 PRINT# 1,3 ; C5(3)
600 CLEAR
610 DISP "       RING SHEAR FACTORS."
620 DISP
622 DISP "CURRENT FACTOR USED TO MULTIPLY CHANNEL A IS ";C5(4)
625 DISP
630 Y$=""
636 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
640 LINPUT Y$
642 IF Y$="" THEN GOTO 670
645 IF UPC$(Y$[1,1])="Y" THEN GOTO 650 ELSE GOTO 670
650 DISP "ENTER THE NEW CHANNEL A         MULTIPLIER."
655 INPUT C5(4)
660 PRINT# 1,4 ; C5(4)
670 DISP "CURRENT FACTOR USED TO MULTIPLY CHANNEL B IS ";C5(5)
675 DISP
680 Y$=""
685 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
690 LINPUT Y$
692 IF Y$="" THEN GOTO 720
695 IF UPC$(Y$[1,1])="Y" THEN GOTO 700 ELSE GOTO 720
700 DISP "ENTER THE NEW CHANNEL B         MULTIPLIER."
710 INPUT C5(5)
715 PRINT# 1,5 ; C5(5)
720 DISP "CURRENT MULTIPLICATION FACTOR   USED FOR VERTICAL LVDT (mm) IS ";C5(5)
725 Y$=""
730 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
735 LINPUT Y$
737 IF Y$="" THEN GOTO 770
740 IF UPC$(Y$[1,1])="Y" THEN GOTO 750 ELSE GOTO 770
750 DISP "ENTER THE MULTIPLICATION FACTOR FOR VERTICAL LVDT."
760 INPUT C5(6)
765 PRINT# 1,6 ; C5(6)
770 CLEAR
780 DISP "    CONSOLIDATION FACTORS"
785 DISP
790 DISP "CURRENT MULTIPLICATION FACTOR   (converts volts to mm) FOR CONSL # 1 IS";C5(7)
792 DISP
795 Y$=""
800 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
810 LINPUT Y$
812 IF Y$="" THEN GOTO 840
815 IF UPC$(Y$[1,1])="Y" THEN GOTO 820 ELSE GOTO 840
820 DISP "ENTER THE NEW FACTOR FOR CONSL  # 1"
825 INPUT C5(7)
830 PRINT# 1,7 ; C5(7)
840 DISP "CURRENT MULTIPLICATION FACTOR   (converts volts to mm) FOR CONSL # 2 IS";C5(8)
842 DISP
845 Y$=""
```

```
850 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
855 LINPUT Y$
857 IF Y$="" THEN GOTO 890
860 IF UPC$(Y$[1,1])="Y" THEN GOTO 870 ELSE GOTO 890
870 DISP "ENTER THE NEW FACTOR FOR CONSL  # 2"
875 INPUT C5(8)
880 PRINT# 1,8 ; C5(8)
890 DISP "CURRENT MULTIPLICATION FACTOR   (converts volts to mm) FOR CONSL # 3 & 4 IS";C5(9)
892 DISP
895 Y$=""
900 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
905 LINPUT Y$
907 IF Y$="" THEN 930
910 IF UPC$(Y$[1,1])="Y" THEN GOTO 920 ELSE GOTO 930
920 DISP "ENTER THE NEW FACTOR FOR CONSL  # 3 OR 4"
925 INPUT C5(9)
927 PRINT# 1,9 ; C5(9)
930 CLEAR
935 CLEAR
940 DISP "   TRIAX 1 & 2 "
945 DISP
947 DISP "CURRENT MULTIPLICATION FACTOR   FOR NORMAL LOAD (kG) IS ";C5(10)
948 Y$=""
949 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
950 LINPUT Y$
951 IF Y$="" THEN GOTO 960
952 IF UPC$(Y$[1,1])="Y" THEN GOTO 955 ELSE GOTO 960
955 DISP "ENTER THE NEW FACTOR FOR NORMAL LOAD"
957 INPUT C5(10)
958 PRINT# 1,10 ; C5(10)
960 CLEAR
962 Y$=""
963 DISP "THE CURRENT CONVERSION FACTOR   FOR kG TO kN IS:";F1
964 DISP "ENTER 'YES' TO CORRECT, ELSE ENDLINE." @ LINPUT Y$ @ IF Y$="" THEN 982
965 IF UPC$(Y$[1,1])="Y" THEN GOTO 970 ELSE GOTO 982
970 DISP "ENTER THE NEW FACTOR YOU WISH TO USE."
975 INPUT F1
977 PRINT# 1,11 ; F1
980 DISP
982 DISP " THE CURRENT FRONT PANEL        CONFIGURATION ON THE HP-3455A   IS";A1$
984 DISP "ENTER 'YES' TO CORRECT OR ELSE  ENDLINE."
986 Y$=""
988 LINPUT Y$ @ IF Y$="" THEN 995
989 IF UPC$(Y$[1,1])="Y" THEN GOTO 992 ELSE GOTO 995
990 CLEAR
992 DISP "ENTER NEW PANEL CONFIGURATION "
993 LINPUT A1$
994 A1$=TRIM$(A1$)
995 DISP "PRESS CONTINUE TO RETURN TO MENU." @ PAUSE
996 PRINT# 1,12 ; A1$
997 CLEAR
999 GOTO 50
1000 CLEAR
1010 ASSIGN# 1 TO "FACTOR"
1015 FOR I=1 TO 10
1020 READ# 1,I ; C5(I)
```

```
1025 NEXT I
1028 READ# 1,11 ; F1
1029 READ# 1,12 ; A1$
1030 DISP "  THE FACTORS ARE:"
1032 DISP
1040 DISP "     DIRECT SHEAR"
1045 DISP " HORIZONTAL LVDT:";C5(1)
1050 DISP " LOAD CELL      :";C5(2)
1055 DISP " VERTICAL LVDT  :";C5(3)
1060 DISP "       RING SHEAR"
1065 DISP " CHANNEL A CELL :";C5(4)
1070 DISP " CHANNEL B CELL :";C5(5)
1075 DISP " VERTICAL LVDT  :";C5(6)
1077 WAIT 5000 @ CLEAR
1080 DISP "    CONSOLIDATION"
1085 DISP " CONSOL # 1     :";C5(7)
1090 DISP " CONSOL # 2     :";C5(8)
1095 DISP " CONSOL # 3 OR 4:";C5(9)
1100 DISP "TRIAX 1 or 2 NORMAL LOAD  :";C5(10)
1110 DISP "FACTOR TO CONVERT kG TO kN:";F1
1115 DISP "FRONT PANEL CONFIGURATION IS ";A1$
1200 DISP "PRESS CONTINUE TO RETURN TO MENU."
1210 PAUSE
1220 CLEAR
1230 GOTO 50
1500 CLEAR
1505 DISP "HAVE PATIENCE.  AUTOMATION "
1506 DISP " PROGRAM IS BEING LOADED AND"
1507 DISP "VARIABLES ARE BEING ALLOCATED."
1510 CHAIN "ACCEL"
2000 !
2010 FOR I=1 TO 10
2020 DISP "ENTRY FOR C5(";I;")"
2025 INPUT C5(I)
2027 PRINT# 1,I ; C5(I)
2030 CLEAR
2035 NEXT I
2040 DISP "ENTRY FOR F1"
2045 INPUT F1
2046 PRINT# 1,11 ; F1
2047 DISP "ENTRY FOR FRONT PANEL CONFIG."
2048 LINPUT A1$ @ A1$=TRIM$(A1$)
2049 PRINT# 1,12 ; A1$
2050 GOTO 20
```

Cross Reference Listing of SETUP

VAR OCCURS IN LINE

VAR OCCURS IN LINE

```
A1$     5 ,982 ,993 ,994 ,994
        996 ,1029 ,1115 ,2048
        2048 ,2048 ,2049
C5(,)   6 ,522 ,540 ,541 ,542
        560 ,561 ,562 ,590
        595 ,622 ,655 ,560
        670 ,710 ,715 ,720
        760 ,765 ,790 ,825
        830 ,840 ,875 ,880
        890 ,925 ,927 ,947
        957 ,958 ,1020 ,1045
        1050 ,1055 ,1065 ,1070
        1075 ,1085 ,1090 ,1095
        1100 ,2025 ,2027
F1      6 ,963 ,975 ,977 ,1028
        1110 ,2045 ,2046
A1      8 ,19
A2      8 ,19
A3      8 ,19
A5      8 ,19
C1      8 ,19
C2      8 ,19
C3      8 ,19
C4      8 ,19
C8      8
D1      8 ,16
E1      8 ,19
E3      8 ,22
F       8 ,19
I1      8 ,24
J       8
K       8
L       8 ,22
P2      8
R1      8 ,16
R (,)   8 ,17 ,17 ,17
R1(,)   8 ,18
T1      8 ,16
T2      8 ,16
T3      8 ,17
T4      8 ,17
U       8 ,16
D (,)   9 ,18
V (,)   9 ,24
C9      9
I       9 ,18 ,18 ,18 ,18 ,24
        24 ,24 ,1015 ,1020
        1020 ,1025 ,2010 ,2020
        2025 ,2027 ,2027 ,2035
N1      9 ,20
N2      9 ,20
N3      9 ,20
T5      9 ,17
T (,)   9
A4$     10
N4$     10
Z $     10
S1$     10
C1$     10
D $     10
C1(,)   11
C2(,)   11
C3(,)   11
A       12 ,19
B       12 ,19
C       12 ,19
C (,)   12 ,19 ,19 ,19 ,19
D       12 ,16
D2      12 ,22
D3      12 ,22
D4      12 ,22
E2      12 ,22
F (,)   12 ,19 ,19 ,19 ,19
I2      12 ,24
M1      12 ,22
M2      12 ,22
N4      12 ,22
N5      12 ,20
N6      12 ,20
N7      12 ,20
R0      12 ,22
R7      12 ,22
R8      12 ,22
R9      12 ,22
S       12 ,16
S1      12 ,16
S2      12 ,16
S3      12 ,16
S4      12 ,16
S5      12 ,16
S7      12 ,16
T       12 ,22
T6      12 ,24
T7      13 ,17
T8      13 ,22
T9      13 ,22
X1      13 ,16
X2      13 ,16
X3      13 ,16
X       32 ,100 ,110
Y $     525 ,527 ,527 ,528
        545 ,547 ,547 ,548
        565 ,567 ,567 ,568
        630 ,640 ,642 ,645
        680 ,690 ,692 ,695
        725 ,735 ,737 ,740
        795 ,810 ,812 ,815
        845 ,855 ,857 ,860
        895 ,905 ,907 ,910
        948 ,950 ,951 ,952
        962 ,964 ,964 ,965
        986 ,988 ,988 ,989
```

Program Listing of (Autost)

"Autost" is a two-line program. The only function of "Autost" is to provide the capability of automatically loading "SETUP" when the tape is inserted into the tape drive, and the power is turned on.

```
"Autost":  1 CHAIN "SETUP"

           10 END
```