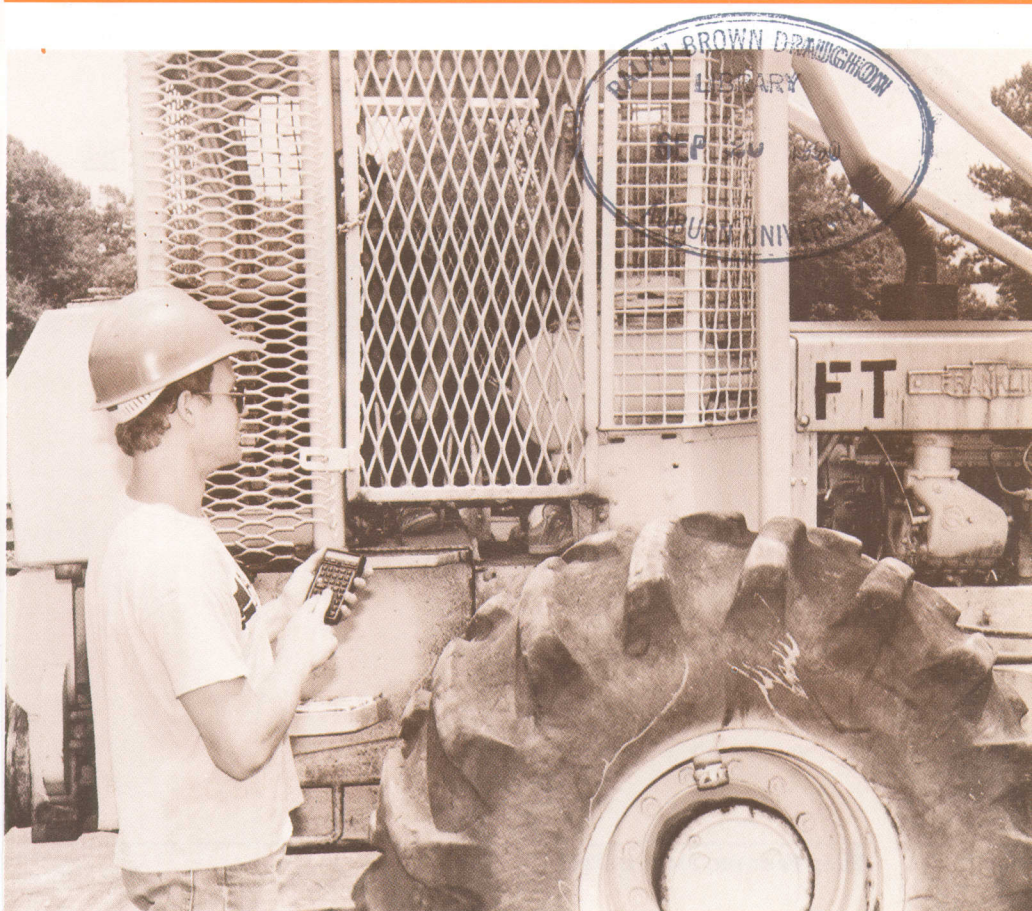


# Application of the Hewlett-Packard 41 CV Calculator in Elemental Time Studies



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# APPLICATION OF THE HEWLETT-PACKARD 41 CV CALCULATOR IN ELEMENTAL TIME STUDIES

J. D. Schroering and B. L. Lanford<sup>1</sup>

## INTRODUCTION

**I**NCREASED COST and mechanization of forest harvesting operations have placed greater emphasis on time and production studies to determine not only productivity of men and machines but also the environmental factors influencing their productivity.<sup>2,3,4</sup> Time and production studies can be taken directly by observing an activity, timing it with a stopwatch, and recording the results, or indirectly by first recording the activity on film or video tape before actually performing the timing. In either case, a timing device must be used to time the operation and a recording device must be used to record and store time and production data.

Advances in computer technology have made possible specific applications in the efficient acquisition and storage of time study data. A lightweight, sturdy, hand-held programmable calculator, the Hewlett-Packard 41-CV<sup>5</sup> has the capability to time the individual elements of an operation and store relatively large amounts of data. Compatibility with cassette drives, disc drives, and microcomputers complement the system by adding editing, analysis, and permanent storage features.

This bulletin describes both the timing and storage features of the HP-41CV hand-held programmable calculator and the compatible HP peripheral devices used for editing, analysis, and data storage. A program designed to time the individual elements of a machine or manual operation and store data in an efficient format in the

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<sup>1</sup>Research Associate and Associate Professor of Forestry, respectively.

<sup>2</sup>Schroering, J.D. and B.L. Lanford. 1985. Performance of the Franklin 105 Feller Buncher in a Fifth Row Thinning Application. *S. Jour. of Appl. For.* 9(2):110-113.

<sup>3</sup>Schroering, J.D. and B.L. Lanford. 1985. Timber Cruising with the Hewlett-Packard 41CV Hand-held Programmable Calculator. *Ala. Agr. Exp. Stn. Bull.* 564.

<sup>4</sup>Stokes, B.J. and B.L. Lanford. 1983. Evaluation of Timbco Hydro-buncher in Southern Plantation Thinning. *ASAE Pap. No.* 83-1600.

<sup>5</sup>The use or mention of trade names is for the reader's information and convenience and is not necessarily an endorsement by the Alabama Agricultural Experiment Station, Auburn University, or the USDA Forest Service.

calculator's extended memory was written for the HP-41CV. Support programs were also written to transfer data from the calculator to a cassette tape for temporary storage, and to permanently store data on a magnetic disc for future use in editing and analysis on the HP-87XM microcomputer.

## **COMPUTERIZED TIME STUDIES**

### **Hand-Held Calculators**

One approach used to address the problems associated with field time studies has been the development and use of electronic timing and mass storage devices. Programmable calculators are one specific type of data acquisition and storage device applicable for collecting time study data. The HP-41CV programmable calculator was chosen for this project because it is both a powerful programmable calculator and a data acquisition and storage device. Use of the HP-41CV and HP peripheral hardware in a timber cruising application was described in an earlier publication.<sup>6</sup> Except for the actual data acquisition programs, most of the documentation on hardware and software is similar and is repeated in this bulletin for clarity and reference to elemental time study applications.

Sturdy construction, extended battery life, overall lightweight (0.47 pound, including batteries and modules), and a well defined and easily read keyboard enhance the usefulness of the HP-41CV in field situations. After installing a time module with an internal clock in the HP-41CV, the user is able to time elements of an operation. By depressing a user-defined element code key, the elapsed time from the last function and a numeric value identifying the element code are automatically stored, eliminating the need for tally sheets. The HP-41CV, with a time module, an extended functions module, and an extended memory module, can store up to 362 individual time records.

By combining the timing and storage functions into one device, considerable time, labor, and expense can be saved, while maintaining data accuracy. One person can collect field data and concentrate on the actual operation being timed, without having to manually record the time for each element code. Storing data in a format which can be quickly transferred, stored, and analyzed on a computer also reduces the cost of the project by eliminating manual reformatting and keypunching.

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<sup>6</sup>See footnote 3, p. 3.

### Peripheral Hardware

Eventually, data from the calculator must be transferred to other storage mediums for error checking, analysis, and storage. The versatility of Hewlett-Packard hardware enables users to add compatible HP devices to the HP-41CV calculator, table 1. Features of the peripheral devices include increased programming and data storage functions, timing capabilities, additional data/program memory registers, and powerful communications and compatibility features with cassette and disc drives, printers, plotters, and microcomputers. All transfer and storage functions are controlled by the user, and elimi-

TABLE 1. HEWLETT-PACKARD HARDWARE REQUIRED FOR TIME STUDY DATA ACQUISITION AND STORAGE

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HP-41CV Calculator, with:  
 Time Module  
 X Functions Module  
 X Memory Module  
 HP-IL (interface loop) Module  
 HP-IL cables  
 HP-82161A Digital Cassette Drive  
 HP mini cassette tapes  
 HP-87XM Microcomputer with:  
 HP-82938A Interface  
 HP-10833A 1B (interface bus) cable  
 HP-9121D Disc Drive  
 HP magnetic discs

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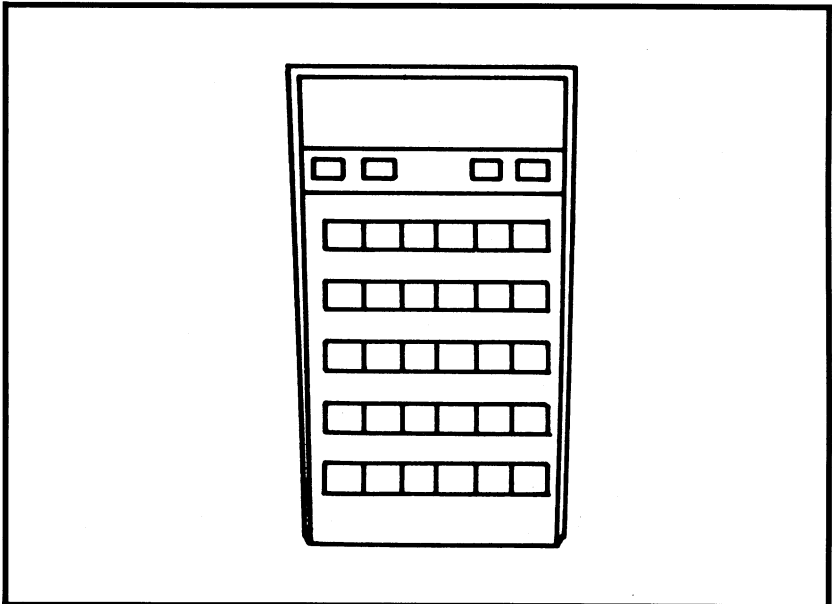


FIG. 1. Hewlett-Packard 41CV calculator.

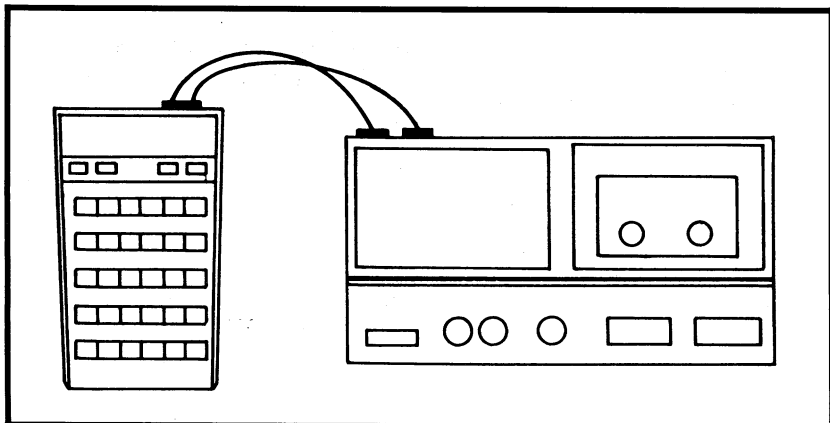


FIG. 2. HP-41CV and HP digital cassette drive, connected with an HP-IL (interconnecting loop) module.

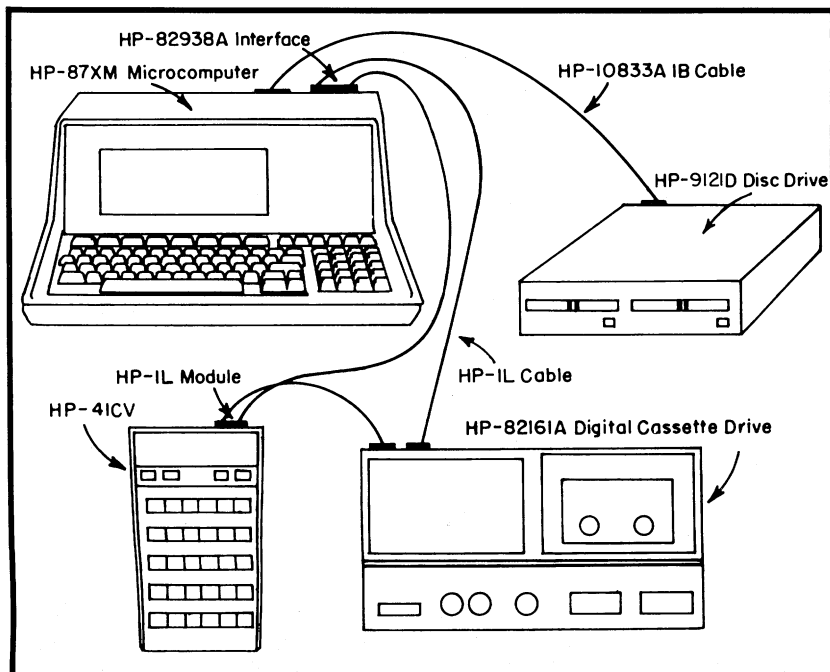


FIG. 3. Configuration for data transfer from digital cassette drive to magnetic disc.

nate the slow and error-prone process of manually transferring data from tally sheets to a computer. Cassette tapes and discs provide efficient storage and retrieval of large amounts of data.

Table 1 contains a listing of the hardware required for the data acquisition and storage programs discussed in this bulletin. Three basic configurations are described: (1) data acquisition; (2) data transfer from the HP-41CV to cassette tape; and (3) permanent data storage on magnetic discs. The HP-41CV calculator, used for data acquisition, is diagrammed in figure 1. Figure 2 depicts the data transfer process between the calculator and a mini cassette tape drive. The cassette drive is lightweight and battery powered, allowing the user to transfer data at any convenient time. A single mini cassette tape can store up to 16,000 time records. The configuration of the final data transfer process from cassette tapes to magnetic discs, where data can be accessed by a microcomputer for final editing and analysis, is diagrammed in figure 3. A 3.5-inch magnetic disc has the capacity to store 32,000 time or load description records. Complete documentation from Hewlett-Packard, including instructions for installation, illustrations, and examples, is provided with each device.

### Software

The three programs described in this bulletin were written for specific time study data acquisition and storage objectives, yet are adaptable for other applications.<sup>7</sup> Complete documentation for each program, including storage registers, labels, flags, program procedures, and program listings, can be found in the appendices. A general knowledge of BASIC programming and a thorough understanding of the proper installation and use of Hewlett-Packard microcomputers, disc drives, hand-held calculators, and peripherals are required.

Program ETIME is an elemental time study data acquisition program written for use on the HP-41CV hand-held calculator. Program TRNSFR, also written for the HP-41CV, is a data transferring program, designed to transfer data from the HP-41CV to a mini cassette tape when the extended memory registers within the calculator are full. The third program written for the HP-41CV, STORE, controls the permanent storage of data on a magnetic disc from mini cassettes and calculator memory. All three programs can be stored within the HP-41CV's program memory at the same time. Two additional programs, STORE1 and STORE2, written in BASIC for use on the HP-87XM microcomputer to run in conjunction with program STORE,

<sup>7</sup>See footnote 3, p. 3.

establish compatibility and transfer data between the HP-41CV and the mass storage devices. Once stored on a disc, data can be easily accessed by the HP-87XM microcomputer for error checking and analysis.

### ETIME Program

ETIME is a data acquisition program designed for use in elemental time studies. Alpha keys A through G are used for timing up to seven different elements of an operation, while alpha keys H through J are used to enter load or cycle description data. Elements vary depending on the particular machine or operation being studied, but may include felling, limbing, or bucking for manual operations and shearing, delimiting, moving to a tree, bunch, or pile, grappling, dumping, or loading for mechanical operations. Keys are assigned to a particular time element by the user. Load or cycle description variables include diameter, number of logs, tree, bunch, or pile number, and distance travelled. These keys are designated in the program and can be changed only by program modification.

Data are stored within the calculator's extended memory in an efficient manner so as to minimize the number of storage registers needed for each time or load description record. The formatting of all data is done automatically within the program and for load description variables involves dividing each data entry by a specific power of 10, adding all data for a particular load, and then adding an integer (8,9, or 10) to the number. Time data are stored in a similar fashion, but are formatted by a stopwatch function which converts elemental time to decimal hours. Integers 1 through 7 represent the seven element codes. Due to the design of the program and the use of alpha label keys, elements of an operation occurring for less than 3.0 seconds cannot be accurately timed.

Element times are stored in extended memory in the form:

INTEGER. \_ \_ \_ \_ \_

*Time (hours)*

where the integer (1-7) represents a user designated element code. For example, depressing key A causes the integer "1" to be stored with the associated time for element one. Depressing key B causes the integer "2" to be stored with the associated time for element two.

Load description variables are stored in a similar format but must be entered by the user. These data are used as predictor (independent) variables in regression or production equations. For example,



by knowing the average DBH and number of logs, the weight and volume of a cycle can be determined. Also, if the trees, bunches, or piles have been measured and numbered prior to the study, a number can be stored with the element code which will uniquely identify the tree, bunch, or pile with a known weight or volume.

Load or cycle description variables are stored as:

8.    \_\_\_\_\_    \_\_\_\_\_    \_\_\_\_\_    \_\_\_\_\_
 

Diameter	Number of logs, trees or bolts
----------	-----------------------------------
9.    \_\_\_\_\_    \_\_\_\_\_    \_\_\_\_\_
 

Number of trees, tree number, bunch number, or pile number
---
10.    \_\_\_\_\_    \_\_\_\_\_    \_\_\_\_\_    \_\_\_\_\_
 

Distance travelled
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Average diameter and number of logs or bolts in the accumulator or grapple are important variables affecting the production of feller bunchers, skidders, or loaders. Tree, bunch, or pile numbers are used in place of volume or weight when the trees, bunches, or piles have been previously measured and numbered. Distance travelled is an important variable influencing the production of prehaulers, skidders, and trucks.

For example, assume a grapple skidder is being studied, and that due to favorable logging conditions, bunches were not measured and numbered prior to skidding. While the internal clock is timing the actual skidding operation, the user estimates the average diameter of the logs within the grapple, keys the number into the calculator, and then depresses key H. This number is divided by 100 within the program. The user is then prompted for "NO. LOGS?". After keying in the number of logs and depressing the R/S key, the number is divided by 100,000, added to the coded diameter, and then added to the integer "8". The resulting number is then stored in calculator memory. A similar procedure is used for the two additional sets of load description variables. Entering load description data does not affect the internal timing functions.

Due to the rapid and continuous nature of data acquisition in time studies, errors can occur in data collection. If ETIME is used to time elements of a videorecorded operation, the film can be played until the timing is correct. However, if ETIME is used as a field data ac-

quisition device, previous elements cannot be retimed. If an error is made in entering load description data or in depressing the wrong alpha key, the user must depress an error key "a", which stores a value of "99" in extended memory after the incorrect data. This permits the user to delineate an error in the data set, while continuing the timing of the operation without further loss of data. After data have been transferred to a permanent storage device, incorrect data can either be corrected or removed from the data set.

Example: Program ETIME, occupying 50 program registers in main memory, must be properly loaded into the HP-41CV. In this example, a drive-to-tree feller buncher equipped with an accumulating shear will be studied. Since all trees within the study area have been measured and numbered, the user needs to key in only the tree number when a tree is cut. As an example, one complete cycle, involving the shearing, bunching, and dumping of four trees, will be discussed.

Four elements of the feller buncher's operation will be timed. Elements and their associated storage codes and alpha entry keys are listed in table 2. Data will be stored in file TIME and will require 14 data storage registers. Complete documentation, including procedures, storage registers, labels, flags, and a program listing can be found in Appendix A.

### Procedures

Before proceeding, make sure all files stored in extended memory have been deleted.

1. Execute program ETIME.
2. An audible signal will be executed and "ELEMENTAL TIME STUDY" will be displayed. "DIR EMPTY" will be displayed, notifying the user that no files are currently stored in extended memory. "REGISTERS UNUSED = 362", the number of available storage registers, will also be displayed.
3. An audible signal will be executed and the user will be prompted for "FILE NAME?". Enter TIME and depress the R/S key.

TABLE 2. ELEMENTS OF OPERATION AND ASSOCIATED STORAGE CODES AND ALPHA ENTRY KEYS FOR HYPOTHETICAL TIME STUDY

Element (codes)	Alpha keys
Move-to-tree (1) .....	A
Position-shear-accumulate (2) .....	B
Move-to-dump (3) .....	C
Dump load (4) .....	D
Error (99) .....	a

4. An audible signal will be executed and the user will be prompted for "NO. ENTRIES?". Since the amount of time data to be recorded is usually not known prior to the initiation of the time study, the maximum number of registers should be specified, Appendix A. Unused space at the end of the file can be deleted after data are stored on a magnetic disc. However, for explanatory purposes, enter 14 and depress the R/S key.

5. Since each user will depress the alpha keys at different times, the actual element times will differ each time this hypothetical feller buncher example is executed. The importance of this example lies in following the correct procedures and in familiarizing oneself with the calculator and the time study program. The feller buncher operation is described in the *ELEMENT* column below. The user enters the information in the *ENTER* column, in this case tree number. The user then depresses the key listed in the *KEY* column. Alpha keys A through G are depressed at the *END* of a given element. The timing process is initiated when the R/S key is depressed:

<i>Element</i>	<i>Enter</i>	<i>Key</i>
(initiate timing)		R/S
move-to-tree	39	I
(end)		A
position-shear-accumulate		
(end)		B
move-to-tree	25	I
(end)		A
position-shear-accumulate		
(end)		B
move-to-tree	47	I
(end)		A
position-shear-accumulate		
(end)		B
move-to-tree	8	I
(end)		A
position-shear-accumulate		
(end)		B
move-to-dump		
(end)		C
dump		
(end)		D

6. After the storage registers in file TIME are full, an audible sig-

nal is executed and "STORAGE FULL" is displayed.

7. Current files and allocated space in extended memory are displayed at "TIME D014". TIME is the file name, D designates a data file and 014 represents the number of registers in the file.

8. "REGISTERS UNUSED = 346", the number of registers available in extended memory, is displayed. Two additional registers per file are automatically allocated as an address label.

9. Depress the USER key to end program execution and to restore the calculator to NORMAL mode.

Sample data were stored in extended memory in file TIME in the following format:

```

9.039000000
1.001594444
2.001583333
9.047000000
1.003644444
2.001411111
9.047000000
1.002925000
2.001716667
9.008000000
1.002941667
2.001258333
3.002122222
4.001641667

```

Recall that the integer portion of the number designates either a time record (1-7) or a load description record (8-10).

## TRNSFR

TRNSFR is a data transfer program used to transfer and store data from extended memory in the HP-41CV calculator to a mini cassette tape. The HP-41CV, with an extended function (X Function) module and an extended memory (X Memory) module, has the capacity to store up to a maximum of 362 time or load description records (approximately 30 to 40 cycles, depending on the operation) in extended memory. However, a single, mini cassette tape has the capacity to store 16,000 records. The HP-41CV and the HP-82161A digital cassette drive are lightweight, portable, and battery powered, allowing the user to transfer and store data at any convenient time.

Data stored in extended memory must be copied into the calculator's main memory before being transferred to tape. TRNSFR cop-

ies and transfers data in blocks of 94 records or less, depending on the file size and the number of records remaining to be copied and transferred. Although data are stored on tape in the same format as in extended memory, the user has the option of renaming the file on tape before data are transferred. Approximate time needed to transfer and store a 362-record file from extended memory to tape is 2.3 minutes, and will vary, depending on the number and size of the files currently on tape.

Example: The following example assumes the user has properly loaded program TRNSFR into the HP-41CV and that the magnetic tape has been previously initialized using the NEWM (new medium) command. A general knowledge of the Hewlett-Packard peripherals and their proper installation and use is required. TRNSFR occupies 34 program registers in main memory. Complete documentation can be found in Appendix B. The following extended memory file was created with program ETIME.

File Name (extended memory): TIME

Registers: 14

File Name (tape): TIME

### *Procedures*

1. All hardware must be in the OFF mode. Properly connect the HP-41CV calculator and the HP-82161A digital cassette drive with the HP-IL module. Turn the calculator and the cassette drive ON and insert an initialized tape into the cassette drive.

2. Execute Program TRNSFR.

3. "TRANSFER ROUTINE" will be displayed.

4. An audible signal will be executed and the user will be prompted for "OLD FILE?". Enter TIME and depress the R/S key.

5. An audible signal will be executed and the user will be prompted for "REGISTERS?". Enter 14 and depress the R/S key.

6. An audible signal will be executed and the user will be prompted for "NEW FILE?". Enter TIME and depress the R/S key.

7. After the successful transfer and storage of all data, an audible signal will be executed and "TRANSFER COMPLETE" will be displayed. Approximate time needed to transfer file TIME is 40 seconds, and will vary, depending on the size and number of files currently on the tape.

8. All hardware must be in the OFF mode before disconnecting any of the peripheral devices.

## Store Program

Program STORE transfers data from a mini cassette tape to the HP-87XM microcomputer, where data are then stored on a magnetic disc for editing, analysis, and permanent storage. Data are stored on the disc in the same format as on tape. Each disc has a 256K byte capacity. A general knowledge of BASIC programming and a thorough understanding of the proper installation and use of Hewlett-Packard microcomputers, disc drives, hand-held calculators, and peripherals are required. The HP-41CV calculator controls the entire information loop and regulates the digital cassette drive, the microcomputer, and the disc drive. Two BASIC programs, STORE1 and STORE2, must be loaded and run on the HP-87XM during the execution of program STORE.

Data to be stored on the disc are initially copied from tape to extended memory in the calculator. Data are then copied to the calculator's main memory in blocks of 96 registers or less, and finally transferred, a register at a time, to the HP-87XM. Complete documentation, including procedures, storage registers, labels, flags, and a program listing can be found in Appendix C.

Programs STORE1 and STORE2 are BASIC programs written for use on the HP-87XM microcomputer to run in conjunction with program STORE. STORE1 establishes data compatibility between the HP-87XM and the HP-41CV, via the HP-IL (interface loop) module. STORE2 creates a data file on the disc, where data from the tape will be stored. Each time a record is copied to the disc, the register number and data value are displayed on the HP-87XM screen. Complete documentation and program listings for STORE1 and STORE2 can be found in appendices D and E, respectively. Procedures for STORE1 and STORE2 are discussed in the following example and can be found in Appendix C.

Example. The following example assumes the user has properly loaded program STORE into the HP-41CV and that programs STORE1 and STORE2 are stored on the disc. STORE occupies 61 program registers in main memory. The following file was created with program ETIME and was transferred and stored on tape with program TRNSFR.

File Name (tape): TIME  
Registers: 14  
File Name (disc): TIME

### *Procedures*

1. All hardware must be in the OFF mode. Connect the HP-87XM microcomputer to the magnetic disc drive with the HP-IB (interface bus) cable. Next, attach the HP-1L module to the unused port on the HP-41CV and then connect the cassette drive to the loop, so that the output Plug from the IL module is inserted into the input port of the cassette drive. Complete the loop by connecting the cassette drive to the HP-IL interface on the microcomputer with an 1L cable, and then connect the HP-87XM to the calculator with the remaining input cable from the HP-1L module, figure 3.

2. Turn on the disc drive *FIRST* and then turn on the HP-87XM, the HP-41CV, and the cassette drive.

3. Insert an initialized disc into the disc drive and insert the tape that contains file *TIME* into the cassette drive.

4. Execute program *STORE* on the HP-41CV.

5. An audible signal will be executed and the user will be instructed to load and run (L-R *STORE1*) the first BASIC storage program on the HP-87XM.

6. Load and run program *STORE1* on the HP-87XM.

7. "WAITING" will be displayed on the HP-87XM screen. Depress the R/S key on the HP-41CV. "READY TO STORE" will be displayed on the HP-87XM screen.

8. "STORAGE ROUTINE" will be briefly displayed on the HP-41CV. User will be prompted for "FILE?". Enter *TIME* on the HP-41CV and depress the R/S key.

9. User will be prompted for "REGISTERS?". Enter 14 on the HP-41CV and depress the R/S key.

10. Data are now being copied from the tape to extended memory in the calculator. Approximate time needed to copy file *TIME* is 15 seconds, and will vary, depending on the number and size of the files on the tape. After the entire file is copied, an audible signal is executed and the user is instructed to load and run (L-R *STORE2*) the second BASIC storage program on the HP-87XM.

11. Load and run program *STORE2* on the HP-87XM. User will be prompted for "FILE NAME?". Enter *TIME* and depress the END LINE key on the HP-87XM.

12. User will be prompted for "NUMBER OF REGISTERS?". Enter 14 and depress the END LINE key on the HP-87XM. The screen on the HP-87XM will be cleared.

13. Depress the R/S key on the HP-41CV. "TRANSFERRING" will be displayed on the HP-41CV while data are being transferred to the microcomputer and copied to the disc. The following will be displayed on the HP-87XM screen:

---

REGISTER	1	9.039000000
REGISTER	2	1.001594444
REGISTER	3	2.001583333
REGISTER	4	9.025000000
REGISTER	5	1.003644444
REGISTER	6	2.001411111
REGISTER	7	9.047000000
REGISTER	8	1.002925000
REGISTER	9	2.001716667
REGISTER	10	9.008000000
REGISTER	11	1.002941667
REGISTER	12	2.001258333
REGISTER	13	3.002122222
REGISTER	14	4.001641667

Only the actual data will be stored on the disc.

14. After the entire file has been copied to the disc, an audible signal will be executed and "STORAGE COMPLETE" will be displayed on the HP-41CV. Approximate time needed to copy and store file TIME on the disc is 23 seconds.

15. Remove the disc from the disc drive. All hardware must be in the OFF mode before disconnecting any of the peripheral devices.

### SUMMARY

Elemental time study data can be efficiently collected and stored with the HP-41CV programmable hand-held calculator. Programming, stopwatch functions, alphanumeric capabilities, and direct data entry eliminate tally sheets and permit the user to delineate invalid data during data acquisition. Programming versatility allows users to design programs for both general and unique time study applications. Compatible peripheral devices, including cassette drives, microcomputers, and disc drives, increase the power and usefulness of the system by featuring editing, analysis, and unlimited storage capabilities.



## APPENDIX A

Program Name: ETIME

Registers: 50

Authors: J. D. Schroering/B. L. Lanford

Calculator: HP-41CV

Modules: Time module; X functions; X memory

Date: 12/15/83

### A. General comments:

ETIME is an elemental time study program that times and stores up to seven different time element codes and up to three different load description variables. Time codes and the internal stopwatch are activated by the alpha label keys A-G, while keys H-J are used for the load description variables. Due to the design of the program and the use of alpha label keys, elements occurring for less than 3.0 seconds cannot be accurately timed. An audible signal is automatically executed when the designated file in extended memory is full. The user designates the appropriate element code or load description variable for each alpha key:

<i>Alpha Key</i>	<i>Description</i>
A	—Time Element Code 1.
B	—Time Element Code 2.
C	—Time Element Code 3.
D	—Time Element Code 4.
E	—Time Element Code 5.
F	—Time Element Code 6.
G	—Time Element Code 7.
H	—Diameter and number of logs.
I	—Number of trees, bunch number, pile number, OR tree number.
J	—Distance.

### B. Storage assignments:

<i>Register</i>	<i>Description</i>
00	—initial stopwatch time.
01	—storage register counter.
02	—decimal stopwatch time (hours).
03	—element code index (1-7).
04	—extended memory file name.
05	—number of data registers in extended memory file.

### C. Labels:

<i>Label</i>	<i>Description</i>
ETIME	—initiates program execution. Displays file names and allocated space in extended memory. Prompts user for file name and number of entries and creates a file in extended memory. Initializes storage registers and the internal stopwatch.

- 01 —stops, stores, and converts the stopwatch time to elemental time (in hours); adds index code (1-7) to elemental time, depending on the previously depressed alpha label key.
- A-G —time element labels, each having a specific index code (1-7). Depressing an alpha label key (A-G) terminates the timing of a specific element code.
- H —user *initially* enters diameter and is then prompted for the number of logs associated with the given diameter (has no effect on stopwatch).
- I —user enters the number of trees, tree number, pile number *OR* bunch number associated with a given time code (has no effect on stopwatch).
- J —user enters the distance associated with a given time code (has no effect on stopwatch).
- a —error code label. A value of 99 is stored in the data file after an error has been made in keying in an alpha label key or an incorrect load description variable.
- 02 —signal to user that data file in extended memory is full.
- 03 —stores element index code and associated elemental time or load description variables in extended memory data file.
- 04 —displays the names and associated space of allocated files in extended memory; calculates and displays the remaining amount of available space.

#### D. Flags used:

<i>Flag</i>	<i>Description</i>
27	—activates user mode.

#### E. Program procedure:

1. Set calculator to NORMAL mode.
2. Execute program ETIME.
3. An audible signal will be executed and "ELEMENTAL TIME STUDY" will be displayed. File names and associated space currently allocated in extended memory will be displayed. The amount of unused space in extended memory will be displayed as "REGISTERS UNUSED = XXX".
4. After approximately 2 seconds, an audible signal will be executed and the user will be prompted for "FILE NAME?". Enter the desired file name (≤6 characters) and depress the R/S key.
5. An audible signal will be executed and the user will be prompted for "NO. ENTRIES?". Enter the number of registers needed and depress the R/S key. The file name and number of registers are used to name a file and allocate space in extended memory. One register is needed for each element time and/or load description variable that is stored. The maximum number of registers available to the user depends on the type and number of modules in use. Assuming no other data or programs are stored in extended memory, the following values can be used as a guide in space allocation:

<i>Module</i>	<i>Number</i>	<i>Maximum registers available</i>
X Functions	1	124
X Memory	1	362

6. After the space in extended memory has been allocated and the internal stopwatch initialized, the message "\*\*\*READY\*\*" will be displayed. To start the stopwatch at the *initiation* of the first element code, depress the R/S key.
7. Depress the specific alpha label key (A-G) *after* each function has been completed.
8. During the timing of specific element codes, enter the necessary load description data and depress the specific load description label keys (H-J).
9. After an incorrect number or label key has been entered, depress the shift A (a) key. "\*\*\*ERROR\*\*" will be displayed.
10. After the storage registers are full, an audible signal will be executed and the message "STORAGE FULL" will be displayed.
11. The name and number of registers for each file in extended memory will be displayed. "REGISTERS UNUSED = XXX" will be displayed.
12. Depress the USER key to end the program and restore the calculator to NORMAL mode.

#### F. Program listing:

01	LBL "ETIME"	33	1 E3
02	TONE 7	34	/
03	TONE 8	35	STO 01
04	"ELEMENTL"	36	"***READY**"
05	AVIEW	37	PROMPT
06	PSE	38	0
07	"TIME STUDY"	39	SETSW
08	AVIEW	40	RUNSW
09	PSE	41	RTN
10	PSE	42	LBL 01
11	TONE 7	43	STO 03
12	XEQ 04	44	RCLSW
13	CLRG	45	HR
14	TONE 7	46	STO 02
15	AON	47	RCL 00
16	"FILE NAME?"	48	-
17	PROMPT	49	RCL 02
18	ASTO 04	50	STO 00
19	AOFF	51	X<>Y
20	TONE7	52	RCL 03
21	"NO. ENTRIES?"	53	+
22	PROMPT	54	ISG 01
23	STO 05	55	GTO 03
24	CLA	56	XEQ 02
25	ARCL 04	57	LBL A
26	CRFLD	58	1
27	SF 27	59	GTO 01
28	0	60	LBL B
29	STO 00	61	2
30	RCL 05	62	GTO 01
31	1	63	LBL C
32	-	64	3

65	GTO 01	107	XEQ 02
66	LBL D	108	LBL a
67	4	109	TONE 7
68	GTO 01	110	"**ERROR**"
69	LBL E	111	AVIEW
70	5	112	99
71	GTO 01	113	ISG 01
72	LBL F	114	GTO 03
73	6	115	LBL 02
74	GTO 01	116	XEQ 03
75	LBL G	117	"STORAGE FULL"
76	7	118	AVIEW
77	GTO 01	119	BEEP
78	LBL H	120	PSE
79	800	121	XEQ 04
80	+	122	STOP
81	TONE 7	123	LBL 03
82	"NO. LOGS?"	124	SAVEX
83	PROMPT	125	RTN
84	1 E3	126	LBL 04
85	/	127	"FILES IN"
86	+	128	AVIEW
87	1 E2	129	PSE
88	/	130	"X-MEMORY"
89	ISG 01	131	AVIEW
90	GTO 03	132	PSE
91	XEQ 02	133	PSE
92	LBL I	134	EMDIR
93	1 E3	135	PSE
94	/	136	PSE
95	9	137	"REGISTERS"
96	+	138	AVIEW
97	ISG 01	139	PSE
98	GTO 03	140	"UNUSED ="
99	XEQ 02	141	FIX 0
100	LBL J	142	ARCL X
101	1 E4	143	AVIEW
102	/	144	PSE
103	10	145	PSE
104	+	146	RTN
105	ISG 01	147	END
106	GOT 03		

## APPENDIX B

Program Name: TRNSFR

Program Registers: 34

Author: J.D. Schroering

Calculator: HP-41CV

Modules: X Functions; X Memory (2); HP-IL Module

Peripherals: HP-82161A Digital Cassette Drive

Date: 3/1/84

### A. General comments:

Program TRNSFR transfers and stores data from extended memory in the HP-41CV calculator to magnetic tape. The HP-41CV calculator, with an extended functions module and two X Memory modules, has the capacity to store up to a maximum of 600 records, whereas a single, mini data cassette tape has the capacity to store 16,000 records. The user has the option of renaming the file before the transfer is initiated. After the file is transferred, an audible signal is executed and the user is notified that the transfer is complete.

### B. Storage assignments:

<i>Register</i>	<i>Description</i>
00-93	—temporary data storage registers. Data is transferred from extended memory to registers 00-93 in blocks of 94 records or less, for subsequent transfer to tape.
94	—number of registers in file.
95	—old file name (extended memory).
96	—new file name (tape).
97	—number of registers remaining to be transferred to tape.
98	—storage register counter for registers 00-93.
99	—current value of data pointer in extended memory.

### C. Labels:

<i>Label</i>	<i>Description</i>
TRNSFR	—initiates program execution. Initializes storage registers. Prompts user for old file name, number of registers, and new file name. Creates and initializes space on tape. Sets flag 01.
01	—determines current value of data pointer in extended memory. Stores value in register 99. If this is the first block of data to be transferred, flag 01 is set.
02	—initializes data pointer in extended memory.
03	—retrieves a block of 94 records from the file in extended memory; temporarily stores the values in registers 00-93; transfers the 94 records to tape. If the entire file has been transferred, program control is sent to label 08.
04	—determines the current data pointer value. The number of registers remaining to be transferred is calculated. If 94 records or less remain to be transferred, program control is sent to label 06. If not, program control is sent to label 05.

- 05 —stores the number of registers remaining to be transferred; sends program control to label 01.
- 06 —determines number of registers remaining to be transferred (<94); sets flag 02.
- 07 —initializes storage register counter for files containing 94 or less registers; sets flag 02.
- 08 —displays "TRANSFER COMPLETE" after the entire file has been transferred.

**D. Flags used:**

<i>Flag</i>	<i>Description</i>
01	—initializes the file on tape (if set).
02	—last block of data, or a block of data containing 94 or fewer registers, is being transferred (if set).

**E. Program procedure:**

1. All hardware must be in the OFF mode. Properly connect the calculator and the digital cassette drive with the HP-IL module. Turn the calculator and the cassette drive ON and insert an initialized tape into the cassette drive.
2. Execute program TRNSFR.
3. "TRANSFER ROUTINE" will be displayed.
4. An audible signal will be executed and the user will be prompted for "OLD FILE?". Enter old file name (6 characters) and depress the R/S key.
5. An audible signal will be executed and the user will be prompted for "REGISTERS?". Enter the number of registers in the file and depress the R/S key.
6. An audible signal will be executed and the user will be prompted for "NEW FILE?". Enter new file name ( $\leq 6$  characters) and depress the R/S key.
7. An audible signal will be executed and "TRANSFER COMPLETE" will be displayed after all the registers in the file in extended memory have been transferred and stored on tape. Approximate time needed to transfer a 600 record file is 3.6 minutes.
8. All hardware must be in the OFF mode before disconnecting any of the peripheral devices.

**F. Program listing:**

01	LBL	15	ASTO 95
02	CLRG	16	AOFF
03	0.093	17	94
04	STO 98	18	TONE 7
05	"TRANSFER"	19	"REGISTERS?"
06	AVIEW	20	PROMPT
07	PSE	21	STO 97
08	"ROUTINE"	22	STO 94
09	AVIEW	23	X<Y?
10	PSE	24	XEQ 07
11	AON	25	AON
12	TONE 7	26	TONE 7
13	"OLD FILE?"	27	"NEW FILE?"
14	PROMPT	28	PROMPT

29	ASTO 96	64	X<>Y 65	X<=Y
30	AOFF	66	GTO 06	
31	RCL 94	67	LBL 05	
32	XEQ "CREATE"	68	RCL X	
33	SF 01	69	STO 97	
34	LBL 01	70	GTO 01	
35	CLA	71	LBL 06	
36	ARCL 95	72	RCL X	
37	FS?C 01	73	STO 97	
38	GTO 02	74	1	
39	RCLPTA	75	-	
40	STO 99	76	1 E3	
41	GTO 03	77	/	
42	LBL 02	78	STO 98	
43	0	79	SF 02	
44	LBL 03	80	GTO 01	
45	SEEKPTA	81	LBL 07	
46	RCL 98	82	SF 02	
47	GETRX	83	1	
48	CLA	84	-	
49	ARCL 96	85	1 E3	
50	RCL 99	86	/	
51	XEQ "SEEKR"	87	STO 98	
52	RCL 98	88	RTN	
53	XEQ "WRTRX"	89	LBL 08	
54	FS?C 02	90	BEEP	
55	GTO 08	91	"TRANSFER"	
56	LBL 04	92	AVIEW	
57	CLA	93	PSE	
58	ARCL 95	94	"COMPLETE"	
59	RCLPTA	95	AVIEW	
60	RCL 94	96	PSE	
61	-	97	END	
62	CHS			
63	94			

## APPENDIX C

Program Name: STORE  
 Program Size: 61 registers  
 Author: J. D. Schroering  
 Calculator: HP-41CV  
 Modules: X Functions; X Memory (2); HP-IL Module  
 Peripherals: Digital Cassette Drive; Magnetic Disc Drive  
 Microcomputer: HP-87XM with HP-IL Interface and HP-IB (interface bus) cable  
 Date: 3/21/84

### A. General comments:

Program STORE transfers data from a mini cassette tape to the HP-87XM microcomputer, where the data are then stored on a magnetic disc for editing, analysis, and permanent storage. Each disc has a 256K byte capacity. A general knowledge of BASIC programming and a thorough understanding of the proper installation and use of Hewlett-Packard microcomputers, disc drives, handheld calculators and peripherals are required. The HP-41CV calculator controls the entire information loop and regulates the digital cassette drive, the microcomputer, and the disc drive. Two BASIC storage programs (STORE1 and STORE2) must be loaded and run on the HP-87XM during the execution of program STORE.

### B. Storage assignments:

<i>Register</i>	<i>Description</i>
00-95	—temporary data storage registers. Data are copied in blocks of 96 records or less from tape to extended memory and then to main memory in the calculator.
96	—file name (tape).
97	—number of registers in file.
98	—number of registers remaining to be copied from either tape to extended memory or from main memory to the disc.
99	—storage register counter.

### C. Labels:

<i>Label</i>	<i>Description</i>
STORE	—initiates program execution. Executes an audible signal and instructs user to load and run the first BASIC storage program (STORE1) on the HP-87XM. Selects the HP-87XM as the primary device in the interface loop.
01	—initializes storage register counter. Prompts user for name and associated number of registers for the file on tape. Creates the necessary file space in extended memory. Sets flag 01.
02	—recalls file name; if no data have been copied from extended memory, control is sent to label 03.
03	—initializes the data pointers for the given file on tape and in extended memory.



04	—reads a block of data from tape; executes subroutine 08. If all the data have been copied to extended memory, control is sent to label 09.
05	—calculates the remaining number of registers to be copied to extended memory. If 96 or fewer registers remain, control is sent to label 06.
06	—stores the number of registers remaining to be copied from tape to extended memory.
07	—resets the storage register counter; sets flag 02.
08	—subroutine that copies a block of data ( $\leq 96$ registers) from main to extended memory within the calculator.
09	—disc storage portion of program STORE. Initializes storage register counter. Executes subroutine 18. Sets flag 03.
10	—recalls file name. If no data have been stored on the disc, control is sent to label 11.
11	—initializes data pointer of file in extended memory.
12	—transfers a block of data from extended memory to main memory within the calculator; executes subroutine 16. If all the data have been stored on the disc, control is sent to label 'END'. Reinitializes the storage register counter.
13	—calculates the remaining number of registers to be transferred from extended memory to main memory and stored on the disc. If 96 or fewer registers remain, control is sent to label 15.
14	—stores the number of registers remaining to be stored on the disc.
15	—resets the storage register counter; sets flag 04.
16	—subroutine that executes an audible signal and instructs user to load and run the second BASIC program (STORE2) on the HP-87XM. Selects the HP-87XM as the primary device in the interface loop. Notifies user that the data are being transferred from the calculator to the microcomputer. Sets flag 05.
17	—recalls an individual record to the alpha register in the calculator and then transfers the value, via the HP-IL module and interface, to the HP-87XM.
18	—subroutine that initializes storage register counter for files containing 96 or fewer registers. Sets flags 02, 04, and 06.
END	—clears flags 02, 05, and 06. An audible signal is executed and "STORAGE COMPLETE" is displayed after the successful completion of all the programs.

#### D. Flags used:

*Flag*

*Description*

01

—initializes the data pointer of the file on tape and in extended memory (if set).

- 02 —last block of data, or a block of data containing 96 or fewer registers, is being copied from tape to extended memory (if set).
- 03 —initializes the data pointer of the file in extended memory (if set).
- 04 —last block of data, or a block of data containing 96 or fewer registers, is being transferred from main memory in the calculator to the HP-87XM (if set).
- 05 —data are being transferred from main memory to the HP-87XM (if set).
- 06 —file contains fewer than 96 registers (if set).

#### E. Program procedure:

1. Connect the HP-87XM microcomputer to the magnetic disc drive with the HP-IB (interface bus) cable. Next, attach the HP-IL module to a port on the HP-41CV and then connect the cassette drive to the loop, so that the output plug from the IL module is inserted into the input port of the cassette drive. Complete the loop by connecting the cassette drive to the HP-IL interface on the microcomputer with an IL cable, and then connect the HP-87XM to the calculator with the remaining input cable from the HP-IL module.
2. Turn on the disc drive *FIRST* and then turn on the HP-87XM, the HP-41CV, and the cassette drive.
3. Insert an initialized disc into the disc drive and insert the tape that contains the necessary data into the cassette drive.
4. Execute program STORE on the HP-41CV.
5. An audible signal will be executed and the user will be instructed to load and run (L-R STORE1) the first BASIC storage program on the HP-87XM.
6. Load and run program STORE1 on the HP-87XM.
7. "WAITING" will be displayed on the HP-87XM screen. The HP-87XM power light will flash, indicating that the microcomputer is ready to receive a command from the calculator. Depress the R/S key on the HP-41CV. "READY TO STORE" will be displayed on the HP-87XM screen.
8. "STORAGE ROUTINE" will be briefly displayed on the HP-41CV. User will be prompted for "FILE?" Enter the name of the file on tape that is to be copied to disc and depress the R/S key.
9. User will be prompted for "REGISTERS?" Enter the number of registers associated with the file on tape and depress the R/S key.
10. Data are now being copied from the tape to extended memory in the calculator. Approximate time needed to transfer 600 records is 2.0 minutes. After the entire file is copied, an audible signal is executed and the user is instructed to load and run (L-R STORE2) the second BASIC storage program on the HP-87XM.
11. Load and run program STORE2 on the HP-87XM. User will be prompted for "FILE NAME?" Enter name of file to be created on the disc and depress the END LINE key on the HP-87XM.
12. User will be prompted for "NUMBER OF REGISTERS?" Enter the number of registers needed for the disc file and depress the END LINE key on the HP-87XM. The power light will flash, indicating that the microcomputer is ready to receive data from the calculator.

13. Depress the R/S key on the HP-41CV. "TRANSFERRING" will be displayed on the HP-41CV while the file is being copied to the microcomputer. Each time a record is copied to the disc, the register number and the data value will be displayed on the HP-87XM screen. Approximate time needed to copy and store 600 records is 13.8 minutes.
14. After the entire file has been copied to the disc, an audible signal will be executed and "STORAGE COMPLETE" will be displayed on the HP-41CV.
15. Remove the disc from the disc drive. All hardware must be in the OFF mode before disconnecting any of the peripheral devices.

#### F. Program listing:

01	LBL "STORE"	40	CRFLD
02	FIX 9	41	SF 01
03	CLRG	42	LBL 02
04	TONE 7	43	CLA
05	"L-R STORE!"	44	ARCL 96
06	AVIEW	45	FS?C 01
07	STOP	46	GTO 03
08	CLRG	47	GTO 04
09	2	48	LBL 03
10	XEQ "SELECT"	49	0
11	AON	50	SEEKR
12	"READY TO STORE"	51	SEEKPTA
13	AOFF	52	LBL 04
14	XEQ "OUTA"	53	RCL 99
15	LBL 01	54	XEQ "READRX"
16	CLRG	55	XEQ 08
17	0.095	56	FS?C 02
18	STO 99	57	GTO 09
19	"STORAGE"	58	LBL 05
20	AVIEW	59	96
21	PSE	60	RCL 98
22	"ROUTINE"	61	-
23	AVIEW	62	CHS
24	PSE	63	96
25	AON	64	X<>Y
26	"FILE?"	65	X<=Y
27	PROMPT	66	GTO 07
28	ASTO 96	67	LBL 06
29	AOFF	68	RCL X
30	96	69	STO 98
31	"REGISTERS?"	70	GTO 02
32	PROMPT	71	LBL 07
33	STO 97	72	RCL X
34	STO 98	73	STO 98
35	X<Y?	74	1
36	XEQ 18	75	-
37	RCL 97	76	1 E3
38	CLA	77	/
39	ARCL 96	78	STO 99

79	SF 02	127	-
80	GTO 02	128	1 E3
81	LBL 08	129	/
82	RCL 99	130	STO 99
83	SAVERX	131	SF 04
84	RTN	132	GTO 10
85	LBL 09	133	LBL 16
86	0.095	134	FS? 05
87	STO 99	135	GTO 17
88	RCL 97	136	TONE 7
89	STO 98	137	"L-R STORE2"
90	FS? 06	138	AVIEW
91	XEQ 18	139	STOP
92	SF 03	140	"TRANSFERRING"
93	LBL 10	141	AVIEW
94	CLA	142	2
95	ARCL 96	143	XEQ "SELECT"
96	FS?C 03	144	SF 05
97	GTO 11	145	LBL 17
98	GTO 12	146	CLA
99	LBL 11	147	ARCL IND 99
100	0	148	XEQ "OUTA"
101	SEEKPTA	149	ISG 99
102	LBL 12	150	GTO 17
103	RCL 99	151	RTN
104	GETRX	152	LBL 18
105	XEQ 16	153	SF 02
106	FS?C 04	154	SF 04
107	GTO "END"	155	SF 06
108	0.095	156	1
109	STO 99	157	-
110	LBL 13	158	1 E3
111	96	159	/
112	RCL 98	160	STO 99
113	-	161	RTN
114	CHS	162	LBL "END"
115	96	163	CF 02
116	X<>Y	164	CF 05
117	X<=Y	165	CF 06
118	GTO 15	166	BEEP
119	LBL 14	167	"STORAGE"
120	RCL X	168	AVIEW
121	STO 98	169	PSE
122	GTO 10	170	"COMPLETE"
123	LBL 15	171	AVIEW
124	RCL X	172	PSE
125	STO 98	173	END
126	1		

## APPENDIX D

Microcomputer: HP-87XM

Program Name: STORE1

Author: Hewlett-Packard

Date: 3/23/84

**A. General comments:**

Program STORE1 is a BASIC program written for use on the HP-87XM microcomputer. STORE1 establishes data compatibility between the HP-87XM microcomputer and the HP-41CV hand-held calculator, via the HP interface loop (IL) module. STORE1 is run in conjunction with the main operating program STORE which instructs the user to load and run STORE1 (L-R STORE1) on the HP-87XM at the proper time. STORE1 will notify the user when the microcomputer is ready to receive data by displaying "READY TO STORE" on the HP-87XM screen.

**B. Program listing:**

```
10  ! ESTABLISHES DATA COMPATIBILITY IN THE INTERFACE
    LOOP
20  CLEAR
30  DISP "WAITING"
40  ENTER 9; A$
50  DISP A$
60  END
```

**APPENDIX E**

Microcomputer: HP-87XM

Program Name: STORE2

Author: J. D. Schroering

Date: 4/3/84

**A. General comments:**

Program STORE2 is a BASIC program written for use on the HP-87XM micro-computer. STORE2 prompts the user for a file name and number of registers, and creates a data file on the disc, where the data from the tape will be stored. STORE2 is run in conjunction with the main operating program STORE, which instructs the user to load and run STORE2 (L-R STORE2) on the HP-87XM at the proper time. Each time a record is copied to the disc, the register number and the data value are displayed on the HP-87XM screen.

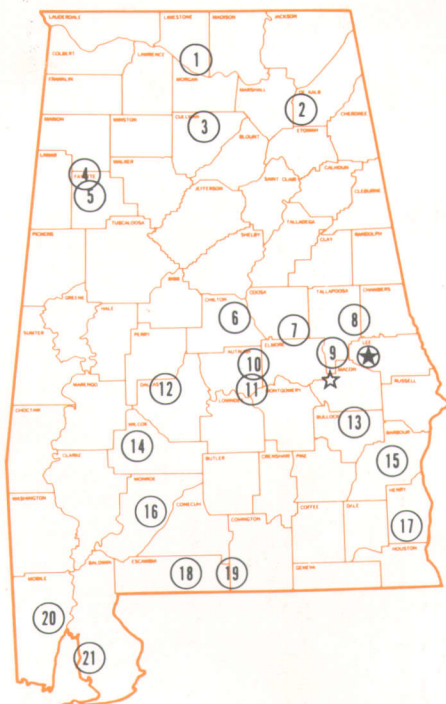
**B. Program listing:**

```
10  DISP "FILE NAME?"
20  INPUT NAME$
30  DISP "NUMBER OF REGISTERS?"
40  INPUT NUMBER
50  CREATE NAME$, NUMBER + 3, 8
60  ! OPEN FILE
70  ASSIGN# 1 TO NAME$
80  FOR I = 1 TO NUMBER
90  ! INPUT EACH REGISTER VALUE FROM THE HP-41CV
100 ENTER 9; X
110 ! WRITE VALUE TO FILE ON DISC
120 PRINT# 1; X
130 PRINT USING "8A, 4D, M3D.9D" ; "REGISTER", I, X
140 NEXT I
150 END
```



## Alabama's Agricultural Experiment Station System AUBURN UNIVERSITY

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- ★ Main Agricultural Experiment Station, Auburn.
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1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
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