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TIMBER CRUISING WITH THE HEWLETT-PACKARD 41CV HAND-HELD PROGRAMMABLE CALCULATOR

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TIMBER CRUISING WITH THE HEWLETT-PACKARD 41CV HAND-HELD PROGRAMMABLE CALCULATOR

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INTRODUCTION

ADVANCES in computer technology have implications to forestry in general and to forest inventory in particular. Powerful computer capabilities, including programming, alphanumeric features, and continuous memory, have been built into sturdy, compact, and relatively inexpensive hand-held calculators. Magnetic tapes and discs, fully compatible with hand-held calculators and microcomputers, are able to efficiently store large amounts of data.

Timber cruising, characterized by repetitive procedures and large amounts of data, warrants the use of a standardized method of data acquisition and storage. The objective of this bulletin is to present a collection of computer hardware and software for computerizing data acquisition and storage during timber cruising. To simplify and standardize the collection of cruise data, a data acquisition program was written for the Hewlett-Packard 41CV[2] hand-held calculator. Support programs were also written to transfer data from the hand-held 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 Hewlett-Packard 87XM microcomputer.

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[1] Research Associate and Associate Professor of Forestry, respectively.

[2] 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.

BACKGROUND

Cruising involves following a standardized set of procedures, usually delegated by management objectives, physical attributes of the stand, and the resources available to conduct the cruise. Acquisition and storage procedures can be generalized, whether the cruise involves fixed or variable radius plots, low sampling intensities, or 100 percent inventories. Information pertaining to both plot and tree attributes is typically recorded. General cruising procedures are referenced in most mensuration texts; specific or unique procedures are usually described in industry, government, or university publications.

After field work has been completed, data are usually transferred to a computer, error checked, summarized, and stored in some type of organized filing system for future use. Data may be analyzed and summarized in different ways depending on the objectives of the cruise. The underlying consideration is that data were collected and stored in an orderly manner and can be easily accessed when necessary.

Customary methods of cruising have several drawbacks. One major obstacle is the use of field tally sheets. Data must be manually transferred to a computer before analyses can be performed. This process is time-consuming and serves as an additional source of errors in the data set. Lost or destroyed tally sheets reduce both the amount and validity of the data.

Another problem lies in cruising procedures. Proper procedures must be thoroughly learned and understood in order to ensure data validity. Crews must be trained to measure and record necessary information, depending on management objectives and the sampling scheme. Missing data and errors made in recording data are often not detected in the field and are very expensive to correct or replace once the cruise is completed.

COMPUTERIZED CRUISING

Hand-Held Calculators

One approach used to address the problems associated with standard methods of cruising has been the development and use of electronic data acquisition and mass storage devices. Programmable calculators are one type of data acquisition and storage device that is applicable to timber cruising. The Hew-

lett-Packard 41CV programmable calculator was chosen for this project because of its many desirable features as both a powerful programmable calculator and as a data acquisition and storage device.

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 applications. Since data are entered directly into the calculator, the need for tally sheets is eliminated. The HP-41CV can store up to 600 plot or tree records. Continuous memory allows the cruiser to turn off the calculator while travelling to the site or between plots with no loss of programs or data. The feature enables the user to enter some data, such as stand characteristics or sampling intensities, into the calculator at the office, where permanent stand records or aerial photographs can be easily accessed.

Programming of detailed cruising procedures and automatic data storage features eliminate the need to memorize complex procedures. Because of the alphanumeric capabilities of the calculator, messages and procedures can be displayed to the user with English-like commands, such as PLOT NO?, SITE INDEX?, STAND AGE?, or DBH?. Error check routines can also be programmed. When data outside a predetermined range are entered, an error message, specifying the incorrect data, can be displayed to the user. This "in-the-field" data check not only reduces the possibility of entering incorrect values into the data set but also reduces the cost of correcting erroneous data.

Peripheral Hardware

Eventually, data from the calculator must be transferred to other storage mediums for final error checking, analysis, and storage. The versatility of Hewlett-Packard hardware enables users to add compatible HP devices, table 1, to the HP-41CV calculator. Features of the peripheral devices include increased programming and data storage functions, 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 eliminate the slow and

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

HP-41CV Calculator with:
X Functions module
X Memory modules (2)
HP-IL (interface loop) Module
HP-IL Cables
HP-82161A Digital cassette drive
HP Minicassette tapes
HP-87XM Microcomputer with:
HP-82938A Interface
HP-10833A IB (interface bus) Cable
HP-9121D Disc drive
HP Magnetic discs

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 diagrams the data transfer process between the calculator and a minicassette tape drive. The cassette drive is lightweight and battery powered, allowing the user to transfer data in the field at any time. A single minicassette tape can store up to 16,000 plot or tree 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 plot or tree 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 cruising and data storage objectives. 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.

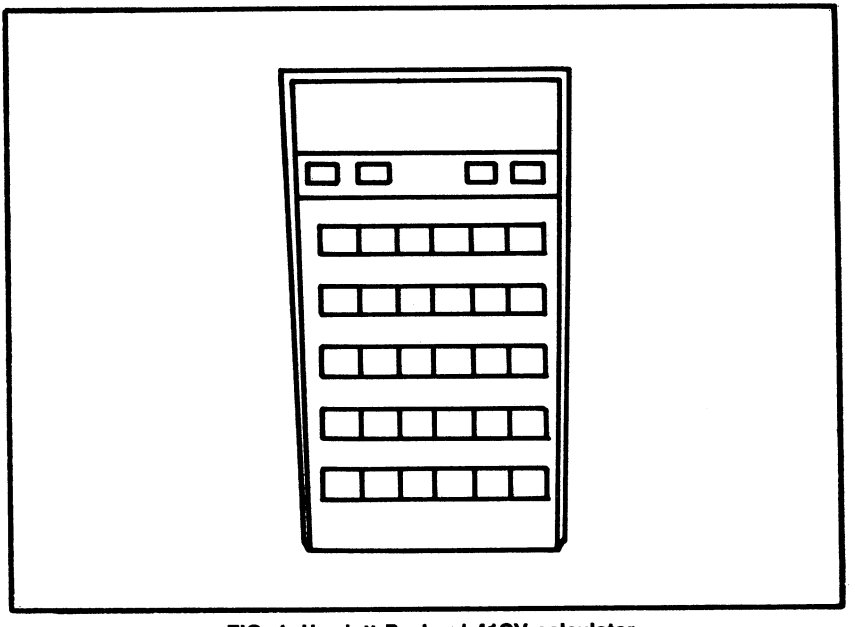


FIG. 1. Hewlett-Packard 41CV calculator.

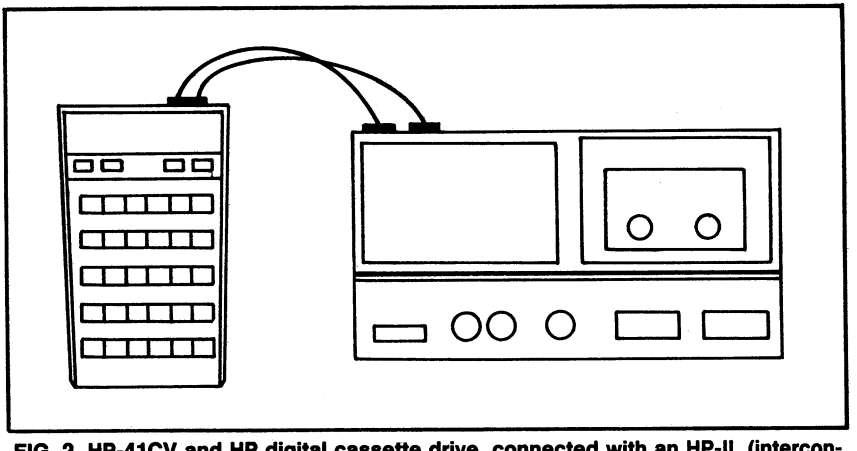


FIG. 2. HP-41CV and HP digital cassette drive, connected with an HP-IL (interconnecting loop) module.

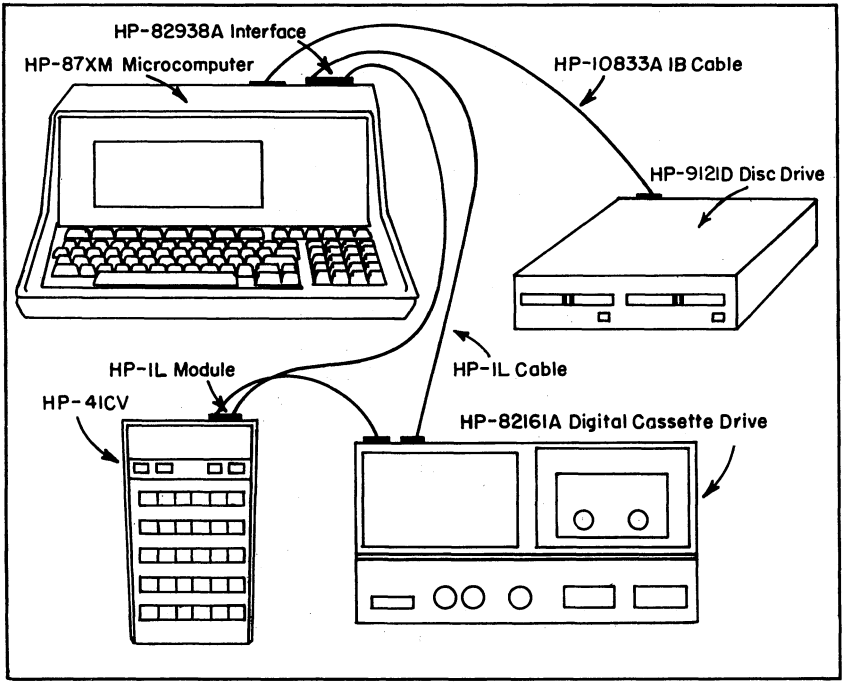


FIG. 3. Configuration for data transfer from digital cassette drive to magnetic disc.

Program CRUISE is a 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 minicassette 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. 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, establish compatibility and transfer data between the HP-41CV and the mass storage devices. By establishing compatibility among the HP-41CV, the cassette drive, the HP-87XM microcomputer, and the disc drive, data can be transferred among the devices and permanently stored on a magnetic disc, where data can then be easily accessed by the HP-87XM microcomputer for error checking and analysis.

CRUISE

CRUISE is a data acquisition program designed to computerize the storage of timber cruise information. Field data may be collected on fixed or variable radius plots. It is assumed that each plot will have some descriptive information such as plot number, site index, stand age, and a numerical forest type. Each tree in the plot is designated by species/product group and DBH. In order to calculate volume, a user designated sample of trees from each species/product group will be measured for height.

Data are stored within the calculator's extended memory in a unique way that minimizes the number of storage registers needed for each plot and tree record. The formatting of plot and tree records is performed within the program. The process involves dividing each data entry by a specific power of 10, adding all coded data for a particular plot or tree record, and then adding an integer (either a 1 or a 2) to the number. The integer portion of the number designates either a plot record "1" or a tree record "2", and the decimal portion is the actual data in coded form. Plot data are stored in extended memory in the form:

1. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
   Plot Number Site Index Stand Age For. Type

and tree data are stored as:

2. ___ ___ ___ ___ ___ ___ ___
   SP/PR Group DBH Height

For example, PLOT NUMBER, a three digit entry, is divided by 1,000. SITE INDEX, a two digit entry which is stored to the right of PLOT NUMBER, is divided by 100,000. This process is repeated for STAND AGE and FOREST TYPE. Similar procedures are also executed for all tree entries. This method of storing the entire plot or tree record in a single storage register eliminates the need for four separate registers for each plot record and three separate registers for each tree record.

Tree data include species/product group, DBH, and height. CRUISE is designed to store data on a maximum of 63 trees per plot. If more than 63 trees are located on a plot, the remaining trees can be tallied under a similar plot number.

Species/product groups are designated by the user and include categories such as pine pulpwood, pine sawtimber, hardwood sawtimber, hardwood veneer, etc. Ten separate species/product groups are available. Each tree is assigned only one species/product group, the highest valued group for the tree. Label keys 0 through 9 are user entry keys for the 10 species/product groups.

To develop a local volume table for each species/product group, heights for a given species/product group are sampled at a user designated frequency. The user designates a separate sampling frequency for each species/product group. Distribution of species/product groups within the stand, desired accuracy, and management objectives delegate the height sampling frequencies. After a species/product group is identified for each tree, the sampling frequency for that particular species/product group is compared to a random number. If the random number is less than or equal to the sampling frequency, the tree is measured for height. Different height sampling procedures can be adapted if the user desires to sample heights based on probabilities proportional to size. A detailed description of the actual cruising process for plot and tree records can be found in the procedures section.

Program CRUISE contains an error checking routine for DBH and height. Prior to data acquisition, the user is prompted for the expected minimum and maximum DBH and height values expected in the particular stand. During tree data collection, DBH and height entries are compared to the minimum and maximum values. If an error occurs, an audible signal is automatically executed, and an error message, specifying the variable to be remeasured, is displayed to the user. This monitoring process reduces the number of height and diameter errors in the data set.

Due to the design of program CRUISE and the continuous memory features of the HP-41CV, data used for initialization of file space and storage registers can be entered into the calculator prior to the actual cruise. Species/product group abbreviations, height sampling frequencies, and minimum and maximum DBH and height values for the error check routine

should be entered prior to the field procedures. Continuous memory features allow the user to enter critical information, which will be used throughout the entire program, at any convenient location where aerial photographs and stand records are available.

Example

Program CRUISE, occupying 111 program registers in main memory, must be properly loaded into the HP-41CV. Preliminary cruise information, entered into the calculator prior to the cruise, is summarized in tables 2 and 3, and includes species/product abbreviations, height sampling frequencies, and minimum and maximum height and DBH values for the error check routine. Plot and tree data are summarized in table 4.

In an actual cruise, it is assumed that the preliminary cruise information will be entered in the office, and that the plots will be physically separated. In this example, data will be stored in extended memory in file EXMPL and will require 13 data storage registers. Complete documentation, including procedures, storage registers, labels, flags, and a program listing, can be found in appendix A.

TABLE 2. PRELIMINARY CRUISE INFORMATION

SP/PR Name	Abbreviation	Height sampling frequency	Keyboard label
Pine pulpwood	PPW	.5[1]	1
Pine sawtimber	PST	.4	2
Hrdwd pulpwood	HPW	.8	3
Hrdwd sawtimber	HST	.8	4

[1] 50 percent of trees in this SP/PR group will be measured for height.

TABLE 3. MINIMUM AND MAXIMUM VALUES FOR ERROR CHECK ROUTINE

Minimum DBH:	6 inches
Maximum DBH:	24 inches
Minimum height:	30 feet
Maximum height:	80 feet

TABLE 4. HYPOTHETICAL PLOT AND TREE DATA

Plot data	Tree data		
	SP/PR group	DBH	Height
Plot number: 1	1	9	45
Site index: 85	2	16	
Stand age: 16	1	8	
Forest type: 8	4	8	
	3	20	78
	1	10	50
Plot data	Tree data		
	SP/PR group	DBH	Height
Plot number: 2	1	6	
Site index: 70	1	8	
Stand age: 13	2	16	68
Forest type: 6	2	14	
	1	9	42

PROCEDURES. Steps 1-6 should be completed at the office or vehicle prior to starting the timber cruise. Abbreviations for the species/product group names will depend on user preference. Information pertaining to height sampling frequencies and minimum and maximum height and DBH values can be obtained from previous cruise information or from aerial photographs of the stand.

1) Execute program CRUISE.

2) An audible signal will be executed and the user will be prompted for "FILE NAME?". Enter EXMPL and depress the R/S key.

3) An audible signal will be executed and the user will be prompted for "NO. ENTRIES?". Since the number of trees to be recorded is usually unknown prior to the initiation of the cruise, the maximum number of registers should be specified, see 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 13 and depress the R/S key.

4) The species/product name and the height sampling inquiry routine will be automatically executed. During this routine, the user enters the species/product abbreviation and the height sampling frequency for each species/product group. One question is displayed at a time. The user enters the information and data listed in the Enter column below and depresses the specific key listed in the Key column:

Display	*Enter*	*Key*
SP/PR GR = 1		R/S
NAME?	PPW	R/S
HT SMP FREQ?[1]	.5	R/S
SP/PR GR = 2		R/S
NAME?	PST	R/S
HT SMP FREQ?	.4	R/S
SP/PR GR = 3		R/S
NAME?	HPW	R/S
HT SMP FREQ?	.8	R/S
SP/PR GR = 4		R/S
NAME?	HST	R/S
HT SMP FREQ?	.8	R/S
SP/PR GR = 5		A

[1] HT SMP FREQ = height sampling frequency.

5) Depressing the 'A' key ends the inquiry routine. The user will now be prompted for the expected minimum and maximum values, one value at a time:

Display	*Enter*	*Key*
MIN DBH?	6	R/S
MAX DBH?	24	R/S
MIN HT?	30	R/S
MAX HT?	80	R/S

6) "**READY**" will be displayed. Turn off the calculator and proceed to the first plot. Since the calculator has continuous memory, it can be turned off with no loss of data.

7) Once at plot one, turn on the calculator and depress key 'B'.

8) "**READY**" will be displayed. Depress the R/S key. "REGISTERS UNUSED = 13" will be displayed.

9) After a pause of approximately 15 seconds, the user will be prompted for the following plot information, one value at a time:

Display	*Enter*	*Key*
PLOT NUMBER?	1	R/S
SITE INDEX?	85	R/S
STAND AGE?	16	R/S
FOR. TYPE?	8	R/S

10) The program is now ready to tally individual trees from plot one. When the user is prompted for "SP/PR?", the user has the option of displaying the number of unused registers in the file by depressing key 'D'. If key 'D' is depressed at this point in the program, "REGISTERS UNUSED = 12" will be displayed. After the number of unused registers is displayed, depress the R/S key. The user will once again be prompted for "SP/PR?" and the tree acquisition routine will continue. The following prompts will be displayed, one line at a time:

Display	*Enter*	*Key*
SP/PR?	1	R/S
DBH?	9	R/S
SP/PR?	2	R/S
DBH?	16	R/S
•	•	•
•	•	•
•	•	•
•	•	•
SP/PR?	1	R/S
DBH?	10	R/S
SP/PR?		C

11) After all the trees within a plot have been graded and measured for DBH, key 'C' is depressed to terminate the tree data acquisition routine and to initiate the height acquisition routine. If a tree height is required, the abbreviated species/product name and the DBH of the particular tree will be displayed, and the user will be prompted for tree height in the following format: "Name-DBH-HT?". If a height measurement is not required, tree data for that particular tree will be displayed for approximately 4 seconds in the following format: "Name-DBH". This display process will be repeated for all trees on the plot so that it will be clear to the user which trees require a height measurement. In this example, the following statements will be displayed, one line at a time:

Display	*Enter*	*Key*
PPW-9-HT?	45	R/S
PST-16		
PPW-8		
HST-8		
HPW-20-HT?	78	R/S
PPW-10-HT?	50	R/S

12) "**READY**" will be displayed. Turn off the calculator and proceed to plot two.

13) Once at plot two, turn on the calculator and depress key 'B'.

(14) "**READY**" will be displayed. Depress the R/S key. "REGISTERS UNUSED = 6" will be displayed.

15) The same procedures from step nine are repeated for plot two:

Display	*Enter*	*Key*
PLOT NO?	2	R/S
SITE INDEX?	70	R/S
STAND AGE?	13	R/S
FOR. TYPE?	6	R/S

16) The program is now ready to tally trees from plot two. The same procedures from step 10 are repeated:

Display	*Enter*	*Key*
SP/PR?	1	R/S
DBH?	6	R/S
•	•	•
•	•	•
•	•	•
•	•	•
SP/PR?	1	R/S
DBH?	9	R/S
SP/PR?		C

17) Key 'C' is depressed to terminate the tree data acquisition routine and to initiate the height acquisition routine. The same procedures from step 11 are repeated:

Display	*Enter*	*Key*
PPW-6		
PPW-8		
PST-16-HT?	68	R/S
PST-14		
PPW-9-HT?	42	R/S

18) "**READY**" will be displayed. Since all plot and tree data have been entered and stored, depress the USER key to end program execution and to restore the calculator to NORMAL mode.

The sample data were stored in extended memory in file EXMPL in the following format:

```
1.001851608
2.010904500
2.021600000
2.010800000
2.040800000
2.032007800
2.011005000
1.002701306
2.010600000
2.010800000
2.021606800
2.021400000
2.010904200
```

Recall that the integer portion of the number designates either a plot record "1" or a tree record "2".

TRNSFR

TRNSFR is a data transfer program used to transfer and store data from extended memory in the HP-41CV calculator to a minicassette tape. The HP-41CV, with an extended function (X Function) module and two extended memory (X Memory) modules, has the capacity to store a maximum of 600 records (approximately 1/2 day's work) in extended memory.

However, a single minicassette 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 it can be transferred to tape. TRNSFR copies 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 600-record file from extended memory to tape is 3.6 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 CRUISE:

File name (extended memory): EXMPL
Registers: 13
File name (tape): EXMPL

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, figure 2. 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 EXMPL and depress the R/S key.

5) An audible signal will be executed and the user will be prompted for "REGISTERS?". Enter 13 and depress the R/S key.

6) An audible signal will be executed and the user will be prompted for "NEW FILE?". Enter EXMPL 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 EXMPL 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 STORE transfers data from a minicassette 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 the 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 the 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, one 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 and 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 CRUISE and was transferred and stored on tape with program TRNSFR:

File name (tape): EXMPL
Registers: 13
File name (disc): EXMPL

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-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, 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 EXMPL 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 EXMPL on the HP-41CV and depress the R/S key.

9) User will be prompted for "REGISTERS?". Enter 13 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 EXMPL is 14 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 EXMPL and depress the END LINE key on the HP-87XM.

12) User will be prompted for "NUMBER OF REGISTERS?". Enter 13 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  1.001851608
REGISTER  2  2.010904500
REGISTER  3  2.021600000
REGISTER  4  2.010800000
REGISTER  5  2.040800000
REGISTER  6  2.032007800
REGISTER  7  2.011005000
REGISTER  8  1.002701306
REGISTER  9  2.010600000
REGISTER 10  2.010800000
REGISTER 11  2.021606800
REGISTER 12  2.021400000
REGISTER 13  2.010904200
```

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 EXMPL 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

Large amounts of cruise data can be efficiently collected and stored with programmable hand-held calculators. Programming, alphanumeric capabilities, and direct data entry eliminate tally sheets and the need to memorize cruising procedures, and permit error checking during data acquisition. Programming versatility allows users to design programs for both general and unique cruising 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: CRUISE
Program Size: 111 registers
Authors: J. D. Schroering/B. L. Lanford
Calculator: HP-41CV
Modules: X Functions; X Memory (2)
Date: 5/8/84

A. General Comments

CRUISE is a data acquisition program used to standardize and simplify timber cruising. Plot data (plot number, site index, stand age, and forest type) are recorded initially, followed by individual tree data (species/product group, DBH, and height). Users can name up to 10 separate species/product groups. DBH is recorded for every tree, whereas height (for a given species/product group) is recorded only on randomly selected trees, depending on a user selected height sampling frequency and the results of a random number generator.

B. Storage Assignments

Register	*Description*
00	—file name (≤ 6 characters).
01-10	—abbreviated alpha names (≤ 4 characters each) for species/product groups 1-10.
11-20	—individual height sampling frequencies for species/product groups 1-10.
21-83	—temporary storage registers used to store tree data.
84	—tree data storage register currently in use.
85	—increment counter for temporary data storage registers.
86	—current species/product group.
87	—current DBH.
88	—storage register counter for tree data clearing subroutine.
89	—storage register counter for initialization of species/product names and associated height sampling frequencies.
90	—current random number; used as a seed for the next random number.
91	—alpha characters "SP/PR?".
92	—minimum DBH.
93	—maximum DBH.
94	—minimum height.
95	—maximum height.
96	—storage register counter for height sampling frequencies.
97	—alpha character "-".
98	—alpha characters "-HT?".
99	—number of unused registers within the given file.

C. Labels

Label	*Description*
CRUISE	—initiates program execution; clears all storage registers. Stores initial data required by the random number generator and special alpha characters used in displaying tree data. Prompts user for file name and number of registers and allocates space in extended memory.
10	—initializes the height sampling frequency registers by storing a value of "1" in each of the 10 registers.
11	—user is prompted for the species/product name and the associated height sampling frequency.
A	—terminates the species/product name and the height sampling frequency routines. User will be prompted for minimum and maximum values that will be used in an error check routine.
B	—"**READY**" will be displayed to notify the user that the office procedures are complete and that the calculator can be turned off or the plot data acquisition routine can be activated.
12	—plot data acquisition routine. Data from previous plots are cleared from temporary storage. User is prompted for plot number, site index, stand age, and forest type. Program control is sent to label 15.
13	—transfers control to the appropriate species/product label (00-09) after user keys in a species/product group.
00-09	—species/product group labels. Depressing the appropriate label key (00-09) initiates the tree data acquisition routine.
C	—initiates the height acquisition routine.
14	—prompts user for DBH; checks for errors. Stores value and increments the necessary storage register counters.
15	—stores plot data in extended memory; decrements the necessary storage register counters.
16	—recalls "SP/PR?" to the X register and sends control to label 13.
17	—executes an audible signal and notifies user to "STORE DATA".
D	—displays the number of unused registers in the file.
18	—displays tree data (species/product abbreviation and DBH).
19	—stores tree data in extended memory; increments register counters; sets flag 03. If all height data have been collected, program control is sent to label 12. Otherwise, control is sent to label 23.

20	—initiates the storage register clearing subroutine.
21	—initializes storage registers 21 to 83.
22	—stores proper register counter in storage register 85.
23	—decodes tree data into a numeric code and sends program control to label 'RANDOM'.
24	—error check routine for height data. If an error occurs, program control is sent to label 'ERROR'. Otherwise, control is sent to label 19. Sets flag 02.
RANDOM	—random number generator. A random number is generated for each tree and compared with the height sampling frequency for a given species/product group. If a height measurement is required, program control is sent to label 24. Otherwise, program control is sent to label 18.
ERROR	—error message display routine. An audible signal is automatically executed when an incorrect DBH or height has been entered. Depending on the type of error, program control is sent back to a data acquisition (either DBH or height) routine.

D. Flags Used

Flag	*Description*
01	—designates an error in DBH (if set).
02	—designates an error in height (if set).
03	—displays "**READY**", signifying that the calculator can be turned off and the cruiser can proceed to the next plot (if set).
27	—activates user mode (if set).
29	—clears the decimal point from the display (if set).

E. Program Procedure

1) Set calculator to NORMAL mode.
2) Execute program CRUISE.
3) An audible signal will be executed and the user will be prompted for "FILE NAME?". Enter the desired file name ($\leq$ 6 characters) and depress the R/S key.
4) 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 plot or tree record 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:

Module	*Number*	*Maximum Registers Available*
X Functions	1	124
X Memory	1	362
X Memory	2	600

5) The species/product name and the height sampling frequency inquiry routine will be automatically executed. The number of the species/product group will be displayed. Depress the R/S key to continue. The user will be prompted for the species/product abbreviation ($\leq$ 4 characters) and the desired height sampling frequency. Depress the R/S key after entering the desired species/product abbreviation and after entering the height sampling percent. Enter the sampling percent as ".XX". A height sampling percent of 1.0 is automatically entered for each species/product group at the initiation of this step.
6) Depress key 'A' to terminate the species/product name and the height sampling frequency inquiry routine.
7) User will be prompted for minimum DBH, maximum DBH, minimum height, and maximum height. Depress the R/S key after each entry.
8) "**READY**" will be displayed. Turn off the calculator and proceed to a plot.
9) Once at the desired plot, turn on the calculator and depress key 'B'.
10) "**READY**" will be displayed. Depress the R/S key. "REGISTERS UNUSED = XXX" will be displayed.
11) After a pause of approximately 15 seconds, during which data registers in main memory are being cleared and initialized, the user is prompted for "PLOT NO. ?".
12) Enter plot number (up to 3 digits) and depress the R/S key.
13) User is prompted for "SITE INDEX?". Enter site index (up to 2 digits) and depress the R/S key.
14) User is prompted for "STAND AGE?". Enter stand age (up to 2 digits) and depress the R/S key.
15) User is prompted for "FOR. TYPE?". Enter forest type (up to 2 digits) and depress the R/S key.
16) After the successful completion of step 15, the program is ready to store individual tree data. "SP/PR?" will be displayed.
17) Enter the appropriate numeric label key (1 digit), depending on the particular species/product group of the first tree in the plot and then depress the R/S key.
18) User will be prompted for "DBH?". Enter DBH (up to 2 digits) and depress the R/S key. "SP/PR?" will be displayed to notify the user that the next tree in the plot can be tallied. When the user is prompted for "SP/PR?", the user has the *option* of displaying the number of unused registers in the file by depressing key 'D'. If key 'D' is depressed, "REGISTERS UNUSED = XXX" will be displayed. After the number of unused registers is displayed, depress the R/S key. The user will once again be prompted for "SP/PR?" and the tree acquisition routine will continue.
19) Repeat steps 17-18 until all trees in the plot have been recorded.
20) Depress key 'C' to initiate the height sampling routine.
21) If a tree height is required, the species/product name and DBH of the particular tree will be displayed and the user will be prompted for tree height in the following format: "Name-DBH-HT?". If

height is not needed, tree data will be *momentarily* displayed in the following format: "Name-DBH". This display process will be repeated for all trees on the plot.

22) Enter the height (up to 3 digits) and depress the R/S key.
23) Repeat steps 21-22 until prompted for plot number.
24) Repeat steps 8-23 until all plots and trees have been tallied.
25) Depress the USER key to end program execution and to restore the calculator to NORMAL mode.

F. Program Listing

```
01 LBL "CRUISE"
02 CLRG
03 AON
04 "SP/PR?"
05 ASTO 91
06 "-"
07 ASTO 97
08 "-HT?"
09 ASTO 98
10 CLA
11 TONE 7
12 "FILE NAME?"
13 PROMPT
14 ASTO 00
15 AOFF
16 TONE 7
17 "NO. ENTRIES?"
18 PROMPT
19 CLA
20 ARCL 00
21 CRFLD
22 STO 99
23 SF 27
24 11.02001
25 STO 96
26 LBL 10
27 1
28 STO IND 96
29 ISG 96
30 GTO 10
31 1.01001
32 STO 89
33 LBL 11
34 CLA
35 FIX 0
36 AON
37 "SP/PR GR ="
38 ARCL 89
39 AVIEW
40 AOFF
41 STOP
42 AON
43 CLA
44 "NAME?"
45 PROMPT
46 ASTO IND 89
47 AOFF
48 RCL 89
49 10
50 +
51 "HT SMP FREQ?"
52 PROMPT
53 STO IND Y
54 ISG 89
55 GTO 11
56 LBL A
57 "MIN DBH?"
58 PROMPT
59 STO 92
60 "MAX DBH?"
61 PROMPT
62 STO 93
63 "MIN HT?"
64 PROMPT
65 STO 94
66 "MAX HT?"
67 PROMPT
68 STO 95
69 LBL B
70 "**READY**"
71 PROMPT
72 LBL 12
73 FS?C 03
74 GTO B
75 XEQ D
76 XEQ 20
77 21
78 STO 84
79 1
80 "PLOT NO. ?"
```

```
 81  PROMPT
 82  1 E3
 83  /
 84  +
 85  "SITE INDEX?"
 86  PROMPT
 87  1 E5
 88  /
 89  +
 90  "STAND AGE?"
 91  PROMPT
 92  1 E7
 93  /
 94  +
 95  "FOR. TYPE?"
 96  PROMPT
 97  1 E9
 98  /
 99  +
100  GTO 15
101  LBL 13
102  RTN
103  GTO IND X
104  LBL 00
105  2.10
106  GTO 14
107  LBL 01
108  2.01
109  GTO 14
110  LBL 02
111  2.02
112  GTO 14
113  LBL 03
114  2.03
115  GTO 14
116  LBL 04
117  2.04
118  GTO 14
119  LBL 05
120  2.05
121  GTO 14
122  LBL 06
123  2.06
124  GTO 14
125  LBL 07
126  2.07
127  GTO 14
128  LBL 08
129  2.08
130  GTO 14
131  LBL 09
132  2.09
133  GTO 14
134  LBL C
135  GTO 22
136  LBL 14
137  CLA
138  SF 01
139  "DBH?"
140  PROMPT
141  RCL 92
142  X>Y?
143  GTO "ERROR"
144  RDN
145  RCL 93
146  X<Y?
147  GTO "ERROR"
148  RDN
149  1 E4
150  /
151  +
152  STO IND 84
153  83
154  RCL 84
155  X=Y?
156  XEQ 17
157  1
158  ST+ 84
159  ST+ 85
160  ST- 99
161  CF 01
162  RCL 91
163  GTO 13
164  LBL 15
165  SAVEX
166  1
167  ST- 99
168  LBL 16
169  RCL 91
170  GTO 13
171  LBL 17
172  BEEP
173  "STORE DATA"
174  AVIEW
175  PSE
176  RTN
177  LBL D
178  "REGISTERS"
179  AVIEW
180  PSE
```

```
181  "UNUSED = "
182  FIX 0
183  ARCL 99
184  AVIEW
185  PSE
186  RTN
187  GTO 16
188  LBL 18
189  AVIEW
190  PSE
191  RCL IND 85
192  LBL 19
193  SAVEX
194  ISG 85
195  GTO 23
196  SF 03
197  GTO 12
198  LBL 20
199  21.083
200  STO 88
201  LBL 21
202  0
203  STO IND 88
204  ISG 88
205  GTO 21
206  RTN
207  LBL 22
208  RCL 84
209  1
210  -
211  1 E3
212  /
213  21
214  +
215  STO 85
216  LBL 23
217  RCL IND 85
218  CLA
219  2
220  -
221  1 E2
222  *
223  INT
224  STO 86
225  FIX 0
226  CF 29
227  ARCL IND X
228  ARCL 97
229  RCL IND 85
230  1 E2
231  *
232  FRC
233  1 E2
234  *
235  STO 87
236  ARCL X
237  FS? 02
238  GTO 24
239  GTO "RANDOM"
240  LBL 24
241  SF 02
242  ARCL 98
243  AVIEW
244  PROMPT
245  RCL 94
246  X>Y?
247  GTO "ERROR"
248  RDN
249  RCL 95
250  X<Y?
251  GTO "ERROR"
252  RDN
253  1 E7
254  /
255  RCL 87
256  1 E4
257  /
258  +
259  RCL 86
260  1 E2
261  /
262  +
263  2
264  +
265  SF 29
266  CF 02
267  GTO 19
268  LBL "RANDOM"
269  RCL IND 85
270  RCL 90
271  FRC
272  PI
273  +
274  5
275  Y^x
276  FRC
277  STO 90
278  X< >Y
279  2
280  -
```

```
281  1 E2
282  *
283  INT
284  10
285  +
286  RCL IND X
287  RCL 90
288  X>Y?
289  GTO 18
290  GTO 24
291  LBL "ERROR"
292  TONE 9
293  "**ERROR**"
294  AVIEW
295  PSE
296  "*REMEASURE*"
297  AVIEW
298  PSE
299  RDN
300  RDN
301  FS? 01
302  GTO 14
303  FS? 02
304  GTO 23
305  GTO 24
306  END
```

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 a maximum of 600 records, whereas a single minicassette 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

Register	*Description*
00-93	—temporary data storage registers. Data are 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

Label	*Description*
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 ($\leq$ 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

Flag	*Description*
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 ($\leq$ 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 (≤ 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 "TRNSFR"
02 CLRG
03 0.093
04 STO 98
05 "TRANSFER"
06 AVIEW
07 PSE
08 "ROUTINE"
09 AVIEW
10 PSE
11 AON
12 TONE 7
13 "OLD FILE?"
14 PROMPT
15 ASTO 95
16 AOFF
17 94
18 TONE 7
19 "REGISTERS?"
20 PROMPT
21 STO 97
22 STO 94
23 X<Y?
24 XEQ 07
25 AON
26 TONE 7
27 "NEW FILE?"
28 PROMPT
29 ASTO 96
30 AOFF
31 RCL 94
32 XEQ "CREATE"
33 SF 01
34 LBL 01
35 CLA
36 ARCL 95
37 FS?C 01
38 GTO 02
39 RCLPTA
40 STO 99
41 GTO 03
42 LBL 02
43 0
44 LBL 03
45 SEEKPTA
46 RCL 98
47 GETRX
48 CLA
49 ARCL 96
50 RCL 99
51 XEQ "SEEKR"
52 RCL 98
53 XEQ "WRTRX"
54 FS?C 02
55 GTO 08
56 LBL 04
57 CLA
58 ARCL 95
59 RCLPTA
60 RCL 94
61 -
62 CHS
63 94
64 X< >Y
65 X<=Y?
66 GTO 06
67 LBL 05
68 RCL X
69 STO 97
70 GTO 01
71 LBL 06
72 RCL X
73 STO 97
74 1
75 -
76 1 E3
77 /
78 STO 98
79 SF 02
80 GTO 01
```

```
81  LBL 07
82  SF 02
83  1
84  -
85  1 E3
86  /
87  STO 98
88  RTN
89  LBL 08
90  BEEP
91  "TRANSFER"
92  AVIEW
93  PSE
94  "COMPLETE"
95  AVIEW
96  PSE
97  END
```

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 minicassette tape to the HP-87XM microcomputer, where 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, 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 storage programs (STORE1 and STORE2) must be loaded and run on the HP-87XM during the execution of program STORE.

B. Storage Assignments

Register	*Description*
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

Label	*Description*
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 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 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 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 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 STORE2 (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 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"
02 FIX 9
03 CLRG
04 TONE 7
05 "L-R STORE1"
06 AVIEW
07 STOP
08 CLRG
09 2
10 XEQ "SELECT"
11 AON
12 "READY TO STORE"
13 AOFF
14 XEQ "OUTA"
15 LBL 01
16 CLRG
17 0.095
18 STO 99
19 "STORAGE"
20 AVIEW
21 PSE
22 "ROUTINE"
23 AVIEW
24 PSE
```

```
25  AON
26  "FILE?"
27  PROMPT
28  ASTO 96
29  AOFF
30  96
31  "REGISTERS?"
32  PROMPT
33  STO 97
34  STO 98
35  X<Y?
36  XEQ 18
37  RCL 97
38  CLA
39  ARCL 96
40  CRFLD
41  SF 01
42  LBL 02
43  CLA
44  ARCL 96
45  FS?C 01
46  GTO 03
47  GTO 04
48  LBL 03
49  0
50  SEEKR
51  SEEKPTA
52  LBL 04
53  RCL 99
54  XEQ "READRX"
55  XEQ 08
56  FS?C 02
57  GTO 09
58  LBL 05
59  96
60  RCL 98
61  -
62  CHS
63  96
64  X< >Y
65  X<=Y?
66  GTO 07
67  LBL 06
68  RCL X
69  STO 98
70  GTO 02
71  LBL 07
72  RCL X
73  STO 98
74  1
75  -
76  1 E3
77  /
78  STO 99
79  SF 02
80  GTO 02
81  LBL 08
82  RCL 99
83  SAVERX
84  RTN
85  LBL 09
86  0.095
87  STO 99
88  RCL 97
89  STO 98
90  FS? 06
91  XEQ 18
92  SF 03
93  LBL 10
94  CLA
95  ARCL 96
96  FS?C 03
97  GTO 11
98  GTO 12
99  LBL 11
100 0
101 SEEKPTA
102 LBL 12
103 RCL 99
104 GETRX
105 XEQ 16
106 FS?C 04
107 GTO "END"
108 0.095
109 STO 99
110 LBL 13
111 96
112 RCL 98
113 -
114 CHS
115 96
116 X< >Y
117 X<=Y?
118 GTO 15
119 LBL 14
120 RCL X
121 STO 98
122 GTO 10
123 LBL 15
124 RCL X
```

```
125  STO 98
126  1
127  -
128  1 E3
129  /
130  STO 99
131  SF 04
132  GTO 10
133  LBL 16
134  FS? 05
135  GTO 17
136  TONE 7
137  "L-R STORE2"
138  AVIEW
139  STOP
140  "TRANSFERRING"
141  AVIEW
142  2
143  XEQ "SELECT"
144  SF 05
145  LBL 17
146  CLA
147  ARCL IND 99
148  XEQ "OUTA"
149  ISG 99
150  GTO 17
151  RTN
152  LBL 18
153  SF 02
154  SF 04
155  SF 06
156  1
157  -
158  1 E3
159  /
160  STO 99
161  RTN
162  LBL "END"
163  CF 02
164  CF 05
165  CF 06
166  BEEP
167  "STORAGE"
168  AVIEW
169  PSE
170  "COMPLETE"
171  AVIEW
172  PSE
173  END
```

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, see Appendix C, 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 INTER-
    FACE 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

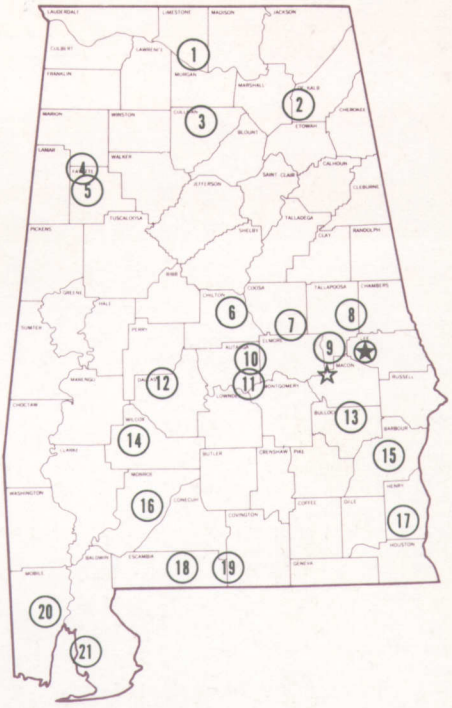
Program STORE2 is a BASIC program written for use on the HP-87XM microcomputer. STORE2 prompts the user for a file name and number of registers, and creates a data file on the disc, where data from the tape will be stored. STORE2 is run in conjunction with the main operating program STORE, see Appendix C, 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 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

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

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.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Substation, Spring Hill.
21. Gulf Coast Substation, Fairhope.