HEATHKIT® MANUAL

for the

MEMORY AND INPUT/OUTPUT ACCESSORY

for the ET-3400 Trainer

Model ETA-3400

595-2271-01

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SOFTWARE REFERENCE MANUAL

for the

MEMORY AND INPUT/OUTPUT ACCESSORY

for the ET-3400 Trainer

Model ETA-3400

595-2271-01

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

TABLE OF CONTENTS

INTRODUCTION

This Manual describes the operation of your ET-3400/ETA-3400 microcomputer system. The major operational features of the system are explained in the sections titled "Heath/Wintek FANTOM II Monitor" and "Heath/Pittman Tiny BASIC." The keyboard commands, "Monitor Listing," sample programs, and memory maps are also included, as well as several article reprints from "Kilobaud" magazine that will help you more fully enjoy your ET-3400/ETA-3400 Microcomputer System.

The Microcomputer system easily interfaces to a video terminal and a cassette recorder. The increase in memory size and software support gives you a more flexible, general-purpose computer system, while the trainer itself still remains functional and useful. The following list summarizes the main features.

- The ETA-3400 uses an independent power supply.
- The system supports 1024 (1K) bytes of read/write random-access memory. This is expandable to 4K.
- A 2K ROM MONITOR.
- A 2K ROM Tiny BASIC interpreter.
- Expanded I/O support:
  - Audio cassette mass storage;
  - Video terminal.

HEATH/WINTEK FANTOM II MONITOR

This Monitor consists of a group of individual computer programs linked together that operate as a single supervisory systems controller. These programs are permanently located in a 2K ROM (2048 bytes of Read-Only-Memory) on the ETA-3400 circuit board. FANTOM II schedules and verifies the operation of peripheral computer components. You use the Monitor to build, test, execute, store, and retrieve computer programs written in machine code.

The Monitor provides you with a means of communicating between the microprocessor, the terminal, and a cassette. You select a Monitor command by pressing a key on the console terminal associated with the particular command. This information is processed by the Monitor, which then directs the computer to the routine that performs the operation. Control is returned to the Monitor after the operation is completed.

This section of the Manual describes the function, operation and features of FANTOM II. Some of the major features are:

- Display/Alter register contents.
- Display/Alter memory contents.
- Display Program Instructions
- Program Execution Control.
- Program Storage and Retrieval.

NOTE: A knowledge of the Motorola 6800 microprocessor and common programming techniques is essential for understanding the FANTOM II Monitor. The HEATH EE-3401 microprocessor course provides this knowledge.

SYMBOLS

This Manual uses symbols to describe some terms. Frequently used symbols and their meaning are listed below. In examples of keyboard dialogue, monitor and program output are underlined.

MICROPROCESSOR

A Accumulator or register A. The 8-bit arithmetical or logical section of the computer that processes data.

B Accumulator or register B. An 8-bit register similar to register A.

C The condition code register. A 6-bit register that indicates the nature or result of an instruction.

P The program counter. A 16-bit register that sequentially counts each program instruction.

S The stack pointer. A 16-bit register that records the last address of an entry onto the stack.

X The index register. This 16-bit register permits automatic program modification of an instruction address without destroying the address contained in memory. The index register is frequently used as a memory pointer.

TERMINAL

ESC The ESCape key. Press this key to return control to the Monitor.

BRK The BReaK key. Press this key once to return control to the Monitor. Press it twice to return control to the ET-3400 trainer.

CTRL The control key. When it is used in conjunction with another key, it creates a special function. For instance, if you hold CTRL and press P, the contents of the program counter will be displayed.

CR The carriage return, or return key, on your video terminal.

PROMPT CHARACTERS

MON> The FANTOM II Monitor prompt character. It indicates that your system is functioning and ready to accept a Command.

: Tiny BASIC prompt character.

USING THE MONITOR

POWER UP and MASTER RESET

When power is first applied to the ET-3400/ETA-3400 Microcomputer System, you should press the RESET key on the ET-3400 keypad. The display will then show CPU UP, and the next keypad entry will be interpreted as a command. Use the RESET key to initialize the system or escape from a malfunctioning program.

When you wish to use FANTOM II, after pressing the RESET key, press the DO (D) key on your trainer and enter the hexadecimal starting address 1400. This command causes FANTOM II to print the prompt characters (MON>)* on the video terminal. This tells you that the system Monitor is functioning and is waiting for a command. For instance, the following sequence will initialize the Monitor, examine the contents of several memory locations, and return control to the ET-3400 microcomputer.

- Apply power to the microcomputer system.
- Press RESET on the ET-3400 keypad.
- Press DO on the keypad and enter hexadecimal address 1400.
- Look for the prompt character (MON>) on your terminal.
- Type M (Memory) on the terminal keyboard and enter the address 1400 followed by a carriage return.
- The video display responds by printing the address and the memory contents. (1400 0F)
- Enter several carriage returns and observe the display. You will notice that, for each carriage return, a sequential memory location and its corresponding data is shown.
- Press the ESCape or BReaK key on your terminal. The prompt character reappears and control is returned to the monitor.
- Press the BReaK key a second time and control is returned to the Trainer.

*Throughout this Manual, the computer output has been underlined to set it off from the user response.

DISPLAY/ALTER REGISTER CONTENTS

DISPLAY REGISTERS

The ET-3400/ETA-3400 Microcomputer System manipulates all data through its registers. You can examine the contents of a single register or all the registers by selecting the appropriate command. When you use the correct format, displaying the contents of a selected register is simple. For instance, pressing R after the prompt character displays the contents of all microprocessor registers. In this and subsequent examples, unless specified, the data shown is only given as an example. You should expect to get different displays.

```
MON> R C=DB B=0B A=0B X=0B0B P=1401 S=00D2 CE 1000
MON>
```

In this example, you can see that the condition code register was set to hexadecimal integer DB. The A and B registers equal 0B, while the index register X was set to 0B0B. The program counter (P) displays the address of the next instruction to be executed and S is the current address of the stack pointer. Finally, the next instruction that would be executed if the program were run is CE 1000. This information, when displayed on the video screen, is useful for correcting program errors.

The two most significant bits of the 8-bit RAM location that hold the condition code are neglected by the system hardware. In the example, DB (1101 1011) shows the status of the condition codes. By pressing CTRL/C and entering a different value, you can change the status of register C.

DISPLAY/ALTER REGISTERS

The Monitor also lets you display or change the contents of individual registers, except the stack pointer. To display the contents of a register (other than the stack pointer), press the CTRL key on the terminal, and then select and press the key that corresponds to the register name. When you wish to change the contents of a register, enter the new value after displaying the original contents. The following examples show you how to display and alter the contents of each microprocessor register.

For instance, to display the program counter, simultaneously press the CTRL and the P keys. A return causes the Monitor to complete the command and display the prompts.

```
MON> CTRL/P P=1401 CR
MON>
```

In the next example, the contents of register A are first displayed and then altered. Press CTRL/A to display the current contents of register A. Enter a new hexadecimal value, for instance 1B, and a carriage return. The return signals the Monitor to execute the command, and the displayed prompt character indicates a successful completion of the command. You can then press CTRL/A and verify that the register contents were changed.

```
MON> CTRL/A A=NN 1B (CR)
MON> CTRL/A A=1B (CR)
MON>
```

The Monitor uses the same format to display or alter the contents of each microprocessor register. In all subsequent examples, NN or NNNN represents a random hexadecimal value. The list summarizes the usage of register commands available to you through the Monitor.

```
MON> CTRL/A A=1B (CR)           (Display A)
MON> CTRL/B B=NN 12 (CR)        (Alter B to read 12)
MON> CTRL/C C=NN 00 (CR)        (Alter C to read 00)
MON> CTRL/P P=NNNN 1234 (CR)     ( P = 1234 )
MON> CTRL/X X=NNNN 5678 (CR)     ( X = 5678 )
MON> R C=00 B=12 A=1B X=5678 P=1234 S=NNNN ☆
MON>
```

☆You can neither alter the stack pointer, nor predict its value, with the FANTOM II Monitor. Also, machine instructions or data will be output after the stack pointer address is printed.

DISPLAY/ALTER MEMORY CONTENTS

DISPLAY MEMORY

The FANTOM II Monitor can access individual or sequential memory locations. This feature allows you to rapidly examine and correct program instructions or data. To display an area of memory on the video terminal, type D (display) and specify the range of the memory locations. The following example shows you how to display the contents of 16 sequential memory cells from address 1400 thru 140F. Because the area shown in the example is part of the Monitor, you should obtain the same results.

```
MON> D 1400,140F (CR)
1400 0F CE 10 00 6F 01 6F 03 86 01 A7 00 86 7F A7 02
MON>
```

The Monitor responds to the carriage return by typing the starting address and listing the memory contents. The address of each line displayed is always the first four-digit number, followed by the contents of the next sixteen sequential memory locations.

DISPLAY/ALTER MEMORY

Use the M (Memory) command when you wish to examine or alter the contents of an individual or a sequence of memory locations. For instance, as shown below, type an M after the prompt character and the address 1400. FANTOM II responds by printing the address and the memory contents (0F) after you press the carriage return. To proceed to the next location, press the carriage return again. FANTOM II responds by printing an address and its contents. To exit the display mode and return to the Monitor, press ESC or BRK.

The following example shows you how to examine the contents of ROM memory locations. You can compare the data with the "Heath/Wintek Monitor Listing," ("Appendix C," Page 37) and/or examine additional locations. This feature provides a quick method of searching for useful Monitor or Tiny BASIC subroutines.

```
MON> M 1400 (CR)
1400 0F (CR)
1401 CE (CR)
1402 10 (CR)
1403 00 (CR)
1404 6F ESC
MON>
```

You may use the same procedure to modify memory contents that you use to change register contents. In the next example, use the M command to alter the contents of several hexadecimal locations between 100 and 105. The procedure always gives you an option of changing or not changing the program data. You will not alter memory contents if you press a carriage return after the data is displayed.

```
MON> M 100 CR
0100 NN A CR
0101 NN OB CR
0102 NN C CR
0103 NN OD CR
0104 NN E CR
0105 NN BRK
MON>
```

The previous example features free-format hexadecimal input. This means you do not have to enter leading zeros. For example, at location 0104 we entered the value E rather than 0E. Free-format allows you to correct or modify a bad entry simply by typing extra digits. For instance, assume that, in the previous example, you incorrectly entered 109 after the M command. Enter the address 0100 before the carriage return to correct the mistake. For example:

```
MON> M 1090100 CR
0100 NN ESC
MON>
```

Since a maximum of four digits is all that are needed for an address, only the last four are retained. Similarly, if only two digits are expected, then only two will be retained.

DISPLAY PROGRAM INSTRUCTIONS

The FANTOM II Monitor offers an important extra feature. You may use the Instruction (I) command to display program instructions. The format is similar to the memory display instruction except that the Monitor prints a single microprocessor instruction per line rather than the contents of each memory cell. An instruction can be one, two, or three bytes. A carriage return, as with the M command, causes FANTOM II to display the next sequential instruction. The I command allows data changes using the same procedure as the M command. However, only the last byte of an instruction can be altered.

The next example displays the first four Monitor program instructions.

```
MON> I 1400 (CR)
1400 0F (CR)
1401 CE 1000 (CR)
1404 6F 01 (CR)
1406 6F 03 BRK
MON>
```

When the data in the first byte of an instruction address memory location is not a machine instruction, the Monitor prints a DATA=NN message. The next instruction following the DATA=NN statement is printed after the carriage return. For instance, the command sequence:

```
MON> I 1A0D (CR)
1A0D DATA=45 (CR)
1A0E DATA=15 (CR)
1A0F 39 ESC
MON>
```

produces the DATA = NN message until the Monitor encounters a valid machine instruction. In this example, the Monitor recognizes the integer (39_H) as a machine instruction.

BLOCK MEMORY TRANSFER

The Monitor features a command that allows you to move the contents of a block of memory from one location to another. The SLIDE memory command simply copies one section of memory to another.

To use the SLIDE memory command, you must determine the parameters of the block of memory to be moved. These parameters include a hexadecimal starting address of both the source and destination of the memory block to be moved. In addition, a hexadecimal count of the number of memory cells to be transferred is also required. Press and hold the CTRL key on the keyboard while pressing the S key to initiate the SLIDE command after you determine the program parameters. FANTOM II prompts you with the keyword SLIDE. You respond to this keyword by typing the starting address of the origin and destination, followed by the count and a carriage return.

The SLIDE command in the next example transfers thirty-two (decimal) bytes of data from ROM into low memory. The starting address of data to be moved is 1400 and the data will be moved to an area of memory starting at location 200. The display (D) command only verifies the data manipulation before and after the SLIDE command is executed.

```
MON> D 200,21F CR
0200 NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN
0210 NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN NN
MON> D 1400,141F CR
1400 0F CE 10 00 6F 01 6F 03 86 01 A7 00 86 7F A7 02
1410 C6 04 E7 01 E7 03 A7 00 09 A6 00 63 00 43 01 00
MON> CTRL/S SLIDE 1400,200,20 CR
MON> D 200,21F CR
0200 0F CE 10 00 6F 01 6F 03 86 01 A7 00 86 7F A7 02
0210 C6 04 E7 01 E7 03 A7 00 09 A6 00 63 00 43 A1 00
```

PROGRAM EXECUTION CONTROL

FANTOM II gives you two options when you execute a machine language program. With the first option, you execute the complete program by entering the GO (G) command and a starting address. The second option allows you to execute a program segment with the S or E command. It is primarily used for detecting errors in program logic.

EXECUTING A PROGRAM

The ETA-3400 Microcomputer Accessory contains a machine language program (Tiny BASIC). We will use this routine to show program execution with the GO command, G. The G command and a program starting address causes the system to fetch the operational code in the memory location specified. Program execution begins from this location and continues until your program returns control to the FANTOM II Monitor, or the RESET key is pressed on the ET-3400. To run Tiny BASIC, enter:

```
MON> G 1C00 (CR)
HTB1 G 1C00
:10 REM HTB1 IS PRINTED OVER MON> (CR)
:20 PRINT "HEATH TINY BASIC IS RUNNING" (CR)
:30 END (CR)
:RUN (CR)
HEATH TINY BASIC IS RUNNING

:BYE (CR)
MON>
```

NOTE: Tiny BASIC writes over the MON> prompt with the HTB1 letters and then issues a carriage return. The prompt character (:) signifies that Tiny BASIC is in the command mode and waiting for an instruction.

Using the Tiny BASIC firmware is only one example of program execution. For another example, you should enter the program shown at the top of Page 14 using the M command. This routine prints a message on your video terminal. The format is similar to the listing printed in "Appendix C," and it illustrates a format that you might encounter in some computer magazines. The JSR (Jump to SubRoutine) mnemonic at hexadecimal location 100 is translated to machine code instructions BD 1618. BD is the machine equivalent of JSR and 1618 is the starting address of a Monitor subroutine that prints a character string. Likewise, FCB is a pseudo-mnemonic that reserves a block of memory for your character string (i.e. the message).

```
0100 BD 1618   MSG JSR   OUTIS       ;OUTPUT CHARACTERS
0103 0D0A48        FCB   0D,0A,48    ;INSERT ASCII MSG.
0106 454C4C        FCB   45,4C,4C    ;CR,LF,HELLO,0
0109 4F00          FCB   4F,00
010B BD 1400       JSR   MAIN        ;RETURN TO MONITOR
```

Machine language program to print a message on your video terminal.

The following operational sequence uses the Monitor to enter the machine code, check the accuracy of the instructions, and execute the program.

```
MON> M 100 (CR)          ( . . . Enter machine code. . .)
0100 NN BD (CR)          ( . . . JSR . . .)
0101 NN 16 (CR)          ( . . . High byte address . . . .)
0102 NN 18 (CR)          ( . . . Low byte address . . . . .)
0103 NN 0D (CR)          ( . . . Sequentially enter      )
     •                           data from the
     •                           machine code
     •                           until complete.
010D NN 00 (CR)          ( . . . JSR MAIN . . . . . . . . . . .)
010E NN ESC
MON>
```

The display instruction (I) lets you sequentially verify the accuracy of your work.

```
MON> I 100 (CR)
0100 BD 1618 (CR)
 •
 •
 •
010B BD 1400 ESC
MON>
```

The program is ready for execution. Use the Go (G) instruction to run your program from address 100.

```
MON> G 100 (CR)
MON>
```

The computer prints a friendly greeting on the display when you execute the program.

WARNING

Always originate your programs at or above hexadecimal location 100 because Tiny BASIC and FANTOM II frequently use the low memory as a buffer. "Appendix A" contains a memory map of the RAM locations that the firmware uses.

EXECUTING A PROGRAM SEGMENT

Isolating and correcting program errors is another function of program execution control. This function is commonly referred to as breakpointing. For a more complete discussion on breakpointing, refer to the operation section of the ET-3400 Microprocessor Trainer Manual. The Monitor supports breakpointing techniques by providing you with both single STEP (S) and multiple step EXECUTE (E) commands. A third technique lets you enter breakpoint addresses into a table and then use the GO command to execute a program segment.

Assume that, in the previous example, machine instruction BD 1618 was incorrectly entered to read BD 160D. The simple method to detect this error is to set the program counter to address 100 and step through each instruction, comparing the computer activity with the results expected from your algorithm.

The single STEP command requires that you define the initial program parameters and preset any registers to their initial status. For this example, only the program counter is affected and must be preset to the starting address of the program (i.e. 100). Use the command to display/alter the program counter to read hexadecimal integer 100. Type S after presetting the initial parameters to execute a single instruction. The Monitor responds by executing the instruction located at the program address contained in the program counter, and then printing the contents of each CPU register on the terminal.

```
MON> CTRL/P P=NNNN 100 (CR)
MON> R C=NN B=NN A=NN X=NNNN P=0100 S=NNNN
MON> S C=NN B=NN A=NN X=NNNN P=160D S=NNNN
MON>
```

Analysis of the program data displayed on your terminal, when compared with the algorithm (i.e. see Chart 1), shows an incorrect address for the JSR mnemonic. Once the initial parameters have been defined, you may continuously single step through a program by typing S.

A better technique for debugging large programs is to use the EXECUTE (E) multiple step command. The EXECUTE command is similar to the STEP command, except control is returned to the Monitor only after a specified number of steps have been executed. The step count is a hexadecimal integer. For example, the following sequence would execute 18 program steps, and then display the registers in the same format as the STEP command.

```
MON> CTRL/P P=NNNN 100 (CR)
MON> E 12 (CR)
C=NN B=NN A=NN X=NNNN P=NNNN S=NNNN NN NN ☆
MON>
```

Breakpointing is another technique for isolating errors in your program. A breakpoint in your program interrupts the normal program execution and lets you test or analyze program parameters. Type H to set a breakpoint (Haltpoint), followed by the address and a carriage return.

For instance,

```
MON> H 10B (CR)
MON>
```

would set a breakpoint in the table that would halt your program at address 10B.

☆ NOTE: Be extremely careful when you are using ROM subroutines and the S, E, and H commands. In this example, it is not possible to accurately predict the program results because the FANTOM II Monitor and the ET-3400 Monitor share RAM locations. Occasionally, this sharing causes unpredictable results.

When you wish to examine the status of the breakpoint table, simply type CTRL/H. This command displays the contents of the breakpoint table. The Monitor forbids the entering of additional breakpoints into the table until one of the entries is cleared. A cleared table entry is displayed as FFFF.

```
MON> CTRL/H 010B FFFF FFFF FFFF
MON>
```

The only way to delete a breakpoint from the table is to use the CLEAR (C) command. To remove a breakpoint, type C and the address. For instance:

```
MON> C 10B (CR)
MON>
```

would remove the breakpoint 10B from the table.

A maximum of four breakpoints (Haltpoints) is permissible in the table. An attempt to set more than four breakpoints would return the following message:

```
ERROR!
```

Always place a haltpoint at a RAM location containing an operation code. Use the G command to execute the program until the haltpoint is reached. After it encounters a haltpoint address, the Monitor prints the current status of the microprocessor registers. You may examine or alter the contents of memory or registers before proceeding with program execution.

PROGRAM STORAGE AND RETRIEVAL

The ETA-3400 Microcomputer Accessory lets you choose either of two different methods for controlling a cassette magnetic tape recorder. The simpler method allows you to use a recorder and the ET-3400 keypad. The other method lets you use a recorder and console terminal to store data. The advantage to the second method is the optional increase in speed with which you can LOAD or DUMP your routine. Either method lets you create and use an inexpensive library of computer routines. The information you store on cassette tape uses the Kansas City Standard (KCS) format with a five second leader and trailer.

The method you choose to LOAD or DUMP a magnetic tape is optional. However, using a console lets you select different baud rates to transfer data between cassette tape and computer memory. A baud rate is the measure (bits per second) of the speed of transmission of data pulses. We recommend that you use 300 baud. The important thing about baud rates is that they be the same for each device when you are reading or writing information between devices. For your convenience, always write the baud rate on the cassette label next to the program name.

CASSETTE USAGE WITH A CONSOLE TERMINAL

To use the Tape (T) command, press CTRL/T after the Monitor prompt character. This command causes the terminal to print a T after which you specify the baud rate* (1 to 8). A colon (:) separates the baud rate from the program starting address, and a comma is used between the starting and ending address of the memory block to be recorded. Prepare the cassette by installing and rewinding a tape before typing a carriage return. Always allow the recorder to attain a normal operating speed by waiting several seconds before hitting the return key. For instance, assume you wish to save sample program number one on Page (22).

```
MON> CTRL/T T1:100,126 (CR)
MON>
```

This command writes the data from memory locations 100 through 126 to cassette tape at 2400 baud. When the data is completely written, program control is returned to the Monitor and the FANTOM II prompt character reappears. To specify 300 baud, type 8 rather than 1.

*Any integer can be used to specify a baud rate. However, the common rates use: 300 for T8; 600 for T4; 1200 for T2; and 2400 for T1.

Because 300 baud is the recommended rate, the Monitor lets you select and type T rather than CTRL/T when writing data. With this feature, you may standardize all your tapes at 300 baud and, in so doing, be able to use either the keypad or the terminal to LOAD your tapes. For example, the following two commands are equivalent:

```
MON> CTRL/T T8:100,126 (CR)
        or
MON> T 100,126 (CR)
```

The LOAD (L) command allows you to read data from a cassette tape into memory. The baud rate with which the tape was written must agree with the baud rate at which you wish to read the data. If the baud rates do not agree or you find a tape error, possibly due to dirt on the recorder heads, a tape error message will be generated. To use the load command, type L followed by the integer code (1 to 8) that indicates the selected baud rate. For example:

```
MON> L 1 (CR)
MON>
```

would load a tape written at 2400 baud. A tape written at 300 baud can be read by either an "L8" or "L" command.

ET-3400 CASSETTE USAGE

You may use the ET-3400 keypad to save a block of memory on cassette tape. This routine prompts you for the first and last address of the memory block to be recorded. To execute the cassette dump routine from the keypad, use the DO function to transfer control to address 1A8F. The following two prompts are printed on the ET-3400 displays:

```
_ _ _ _ Fr.

_ _ _ _ La.
```

You respond to the prompts by entering the first (Fr.) and last (La.) address of the block of memory to be saved on cassette tape. Before you enter the last digit, activate the cassette recorder by pressing the record button on the cassette. For instance, assume you wish to save sample program number one on Page 22.

- Press DO (D) on the ET-3400 keypad and enter address 1A8F.
- Enter the first address (0100) of the memory block to be transferred after the _ _ _ _ Fr. prompt.

- Enter the first three digits of the last address (012) after the _ _ _ _ La. prompt.

- Install and rewind a magnetic tape. Then press the Record button. Be sure the leader passes the recording head.

- Enter the last digit (6) of the address. When the memory block is recorded, the ET-3400 displays will print CPU UP.

The ET-3400 cassette LOAD routine, located in the Monitor from address 1ABC through 1AD4, reads a block of memory data from cassette tape into computer memory. The routine proceeds until the last record is found or until a tape error occurs. An error can be caused by many diverse problems such as, dirt on the tape or tape heads, an incorrect baud rate, etc. If an error is found the ET-3400 display prints:

```
Error
```

If no error is found, the CPU UP message is printed after the data is completely loaded. Don't forget to turn off the recorder at this point. The following procedure transfers binary data from a cassette tape into computer memory:

- Press the DO (D) key on the trainer and enter the first three digits of the cassette loader routine, 1AB_ .

- Install and rewind the cassette tape.

- Press the PLAY button on the recorder and enter the last digit (C) on the keypad.

- Wait for the message (CPU UP or Error) to be printed on the displays.

USING A TELETYPEWRITER

Two commands let you Punch/List formatted absolute binary tapes using the Motorola MIKBUG* format. The tape format is shown in Figure 1. When you want to load or store binary data from a teletypewriter, use the L or P monitor commands. For instance, to transfer binary data from a paper tape to memory, enter the following command from your console:

```
MON> LO
```

NOTE: Always activate the teletypewriter before you enter any monitor commands.

*Registered Trademark, Motorola Inc.

To Print/Punch a formatted binary tape, enter the P command followed by a beginning and ending address. FANTOM II responds by outputting the data. The next example displays the sixteen bytes of memory from hexadecimal location 1400 to 140 F.

```
MON> P 1400,140F(CR)
S11314000FCE10006F016F03861A700867FA7022D
S9
MON>
```

Figure 1 is a breakdown of the Motorola MIKBUG* format. Use the information only to decode programs stored in the MIKBUG* format.

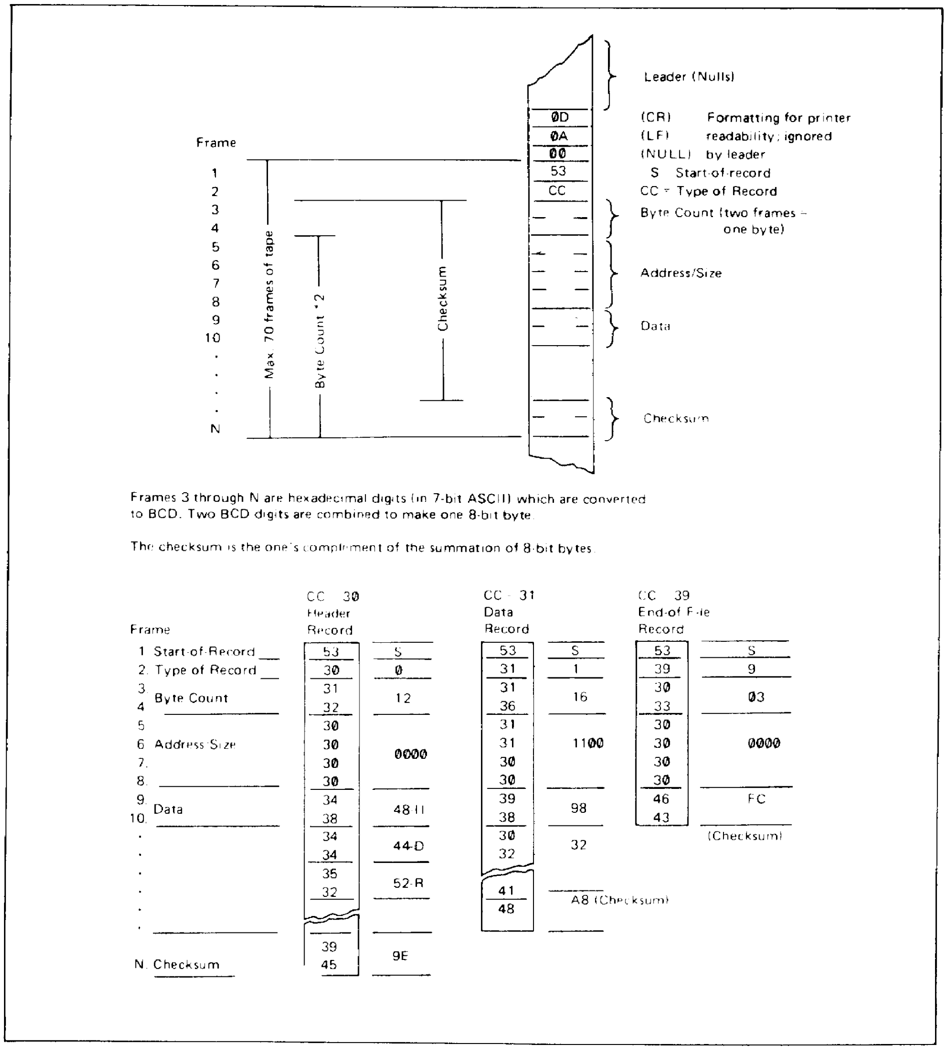

Figure 1
Courtesy of Motorola Semiconductor Products Inc.

A SAMPLE PROGRAM

The sample program provides you with a routine to test the operation of your ETA-3400 Microcomputer Accessory. You can use the routine to gain proficiency with the FANTOM II Monitor. The routine is a duplicate (with minor changes) of a program listed in the ET-3400 Manual.

```
0100 BD FCBC START  JSR     REDIS
0103 86 01          LDA A    $01
0105 20 07          BRA     OUT
0107 D6 F1   SAME   LDA B   DIGADD+1
0109 CB 10          ADD B    $10
010B D7 F1          STA B   DIGADD+1
010D 48             ASL A
010E BD FE3A OUT    JSR     OUTCH
0111 CE 2F00        LDX      $2F00
0114 09      WAIT   DEX
0115 26 FD          BNE     WAIT
0117 16             TAB
0118 5D             TST B
0119 26 EC          BNE     SAME
011B 86 01          LDA A    $01
011D DE F0          LDX     DIGADD
011F 8C C10F        CPX      $C10F
0122 26 EA          BNE     OUT
0124 BD 1400        JSR     MAIN
```

Use FANTOM II when you enter, verify, and execute the sample program. When the program is running, the LED display on the ET-3400 Trainer will sequentially turn each segment on and off and then return to the monitor.

MONITOR COMMAND SUMMARY

REGISTER

COMMAND	FUNCTION
R	Display all the registers.
CTRL/P	Display/alter the program counter.
CTRL/X	Display/alter the index register.
CTRL/A	Display/alter accumulator A
CTRL/B	Display/alter accumulator B
CTRL/C	Display/alter the condition codes.

MEMORY

COMMAND	FUNCTION
D addr1, . . .,addrN	Display an area of memory on your console starting from location addr1 through addrN.
M addr1	Display/Alter sequential memory location starting from addr1.
I addr1	Display sequential program instructions starting from memory location addr1.
CTRL/S addr1, addr2,cnt	Transfer a block of memory contents starting from location addr1 to the memory location starting at addr2. The hexadecimal integer count (cnt<=FF) is the number of bytes to be transferred.

PROGRAM EXECUTION CONTROL

COMMAND	FUNCTION
G addr1	Run the program starting from location addr1.
S addr1	Execute a single program instruction from location addr1.
E cnt	Using the present value of the program counter as a starting value, execute a series of instructions. (cnt<=FF)
H addr1	Insert a single haltpoint address into the breakpoint table.
C addr1	Remove a single haltpoint address from the breakpoint table.
CTRL/H	Examine the status of the breakpoint table.

INPUT/OUTPUT OPERATIONS

COMMAND	FUNCTION
T addr1, . . . ,addrN	Write the memory contents from location addr1 through addrN to a cassette tape at 300 baud.
CTRL/T #,addr1,addrN	Write the memory contents from location addr1 through addrN to a cassette tape. The symbol "#" refers to an integer value representing the desired output baud rate.
L	Read a cassette tape into memory at 300 baud.
L #	Read a cassette tape into memory. The symbol "#" refers to an integer value representing the desired output baud rate.

ET-3400 USAGE

COMMAND	FUNCTION
D 1A8F	Start the cassette and:
— — — — Fr	enter the first address
— — — — La	enter the last address
D 1ABC	Start the cassette and the monitor routine that reads a cassette tape.

TELETYPEWRITER

COMMAND	FUNCTION
P addr1,addrN	Punches a tape using the MIKBUG☆ format.
L 0	Reads a paper tape that was created with the MIKBUG format.

HEATH/PITTMAN TINY BASIC

Tiny BASIC is a subset of BASIC* that allows you to easily create your own computer programs. For instance, a program to balance your checkbook is easy to write using Tiny BASIC. The People's Computer Company (PCC), a nonprofit corporation in Menlo Park, Ca., conceived the idea of a compact computer language designed to teach programming skills. The implementation of Tiny BASIC follows the philosophy of the original idea.

In keeping with the "small is good" philosophy, Heath/Pittman Tiny BASIC employs a two-level interpreter approach with its consequent reduction in speed. The Heath Tiny BASIC firmware is permanently located in your computer system. The obvious advantage to this arrangement is the protection from a runaway program given to the Tiny BASIC interpreter. Also, you do not need to load the interpreter from cassette every time BASIC is used.

The following pages describe the function, operation, and features of Tiny BASIC. Some of the major features are:

- Integer Arithmetic (16-bit)
- Twenty six Variables (A, B, . . . ,Z)
- Fifteen BASIC statements:

LET	LOAD	INPUT	REM
RUN	SAVE	PRINT	IF (THEN)
END	GOTO	GOSUB	RETURN
BYE	LIST	CLEAR	

- FUNCTIONS: Random (RND)
User (USR)

*BASIC is a registered trademark of the Trustees of Dartmouth College.

EDITING COMMANDS

Tiny BASIC lets you modify a program by inserting, changing, or deleting lines in the program. You can insert lines by typing a line with a line number that is not currently in the program. You can change lines by typing a new line with the same line number, and you can delete lines by typing a line number followed immediately by a carriage return.

Two control characters also permit you to edit a line as you enter it. Hold the control (CTRL) key down and then press a U or H to delete either a complete line of text or a single character, respectively.

CTRL/U This command deletes the current line.

CTRL/H This command deletes the previous character.

USING TINY BASIC

Heath Tiny BASIC employs several FANTOM II Monitor subroutines. Therefore, you must always initialize the Monitor and use the Monitor command (G) to start BASIC. This causes Tiny BASIC to execute a CLEAR command. BASIC then prints a prompt character (:) on your terminal, indicating that the system firmware is functioning and awaiting a command. The entry to Tiny BASIC is at 1C00, so you must use "G 1C00" to start it.

For example, the following program prints a message on your terminal several times. The procedure to implement this program requires that you initialize the FANTOM II Monitor, start the Tiny BASIC interpreter, create and execute a BASIC program, and finally return control to the monitor.

- Initialize the FANTOM II monitor by entering "DO 1400 (CR)".
- Type "G 1C00 (CR)" on your console. This is the Tiny BASIC starting address.
- Enter the following program statements after the prompt (:) character.

```
:100 LET I=0
:200 PRINT "HEATH TINY BASIC"
:300 I=I+1
:400 IF I<5 GOTO 200
:500 END
```

- Type "RUN (CR)". The program prints
  `HEATH TINY BASIC`
  five times on your display, and then outputs a prompt character.
- Type "BYE (CR)". System control is then returned to the monitor.

The BReaK key is used to interrupt the execution of a Tiny BASIC program. This is particularly valuable if a program is in an infinite loop. You may stop it by pressing the BReaK key and holding it until Tiny BASIC responds "!0 AT NNN". Thes error message tells you that the BreaK key was pressed and line NNN is the next line to be executed. To continue running your program, you may type "GOTO NNN".

NOTE: When your program is at an INPUT statement, the BreaK key is disabled. You must either respond to the INPUT request with data or use a "MASTER RESET" from the ET-3400 keypad to regain system control.

MODES OF OPERATION

You can use either the COMMAND mode or the PROGRAM mode when working with Tiny BASIC. An instruction in the COMMAND mode does not have a line number and is immediately executed after the carriage return. An instruction in the PROGRAM mode has a line number and will not execute until a RUN command is given. For example, the following two statements perform the same operation. However, the second statement will not be executed until you type RUN (CR) on the keyboard.

```
:PRINT "TESTING THE ETA-3400 ACCESSORY" (CR)

:10 PRINT "TESTING THE ETA-3400 ACCESSORY" (CR)
```

The important thing to remember about the modes of operation is: The COMMAND mode primarily assists you in detecting and debugging program errors, whereas the PROGRAM mode collects statements that will eventually become your finished computer program.

All Tiny BASIC instructions are valid in either mode. However, some of the instructions only make sense in one of the modes. For this reason, RUN and LIST should not be used in the PROGRAM mode. Also, END and RETURN should not be used in the COMMAND mode.

All instructions function the same in either mode except for INPUT and GOTO. In COMMAND mode, the data that is to be INPUTted must be on the same line. Thus,

```
:INPUT X,5,Y,7
```

will cause the variable X to be set to 5 and Y to be set to 7. In addition, in the COMMAND mode, a GOTO will not be accepted until the program has been started with a RUN command at least once.

INSTRUCTIONS

A list of the instructions that Tiny BASIC recognizes is given below. It assumes that you are familiar with programming in the BASIC language. If you are not comfortable using BASIC, a course such as "BASIC Programming," Heath Model EC-1100, will help you to become proficient with BASIC.

INSTRUCTION FORM	DESCRIPTION
REM (text)	The remark (REM) is a nonexecutable statement, used only for commentary.
LET Var = Exp or Var = Exp	This instruction assigns the value of the expresion to the variable. Variable values are not preset. Therefore, always assign an initial value to a variable before using it.
INPUT Var1,...,VarN	This instruction allows you to read data from the keyboard and assign values to the variables.
PRINT "message";Arg or PR Arg1,...,ArgN	The message or value of the argument is printed on the console terminal. Messages may be numbers or letters and are enclosed within quotations. If a comma is used between items in the PRINT list, items are printed in fields that start in columns 1, 8, 16, 32, and so on. If semicolons are used between the items, no space is left between them when they are printed.
GOTO NNN	The program is unconditionally transferred to the statement numbered NNN and execution continues.
GOSUB NNN	The go-to-subroutine (GOSUB) instruction transfers program execution to the statement number. When the RETURN instruction is encountered in the subroutine, program execution returns to the statement following GOSUB.
RETURN	Once program control is transferred to a subroutine, program execution continues until program control encounters a RETURN statement. A subroutine must always be terminated with a RETURN statement.

IF Exp1 rel Exp2 THEN Stmt	If the test "Exp1 rel Exp2" is true, the statement after the "THEN" is executed. This statement can be any Tiny BASIC statement. The "THEN Stmt" part can be replaced by GOTO NNN Tiny BASIC recognizes the relational operators: = < > <= >= <> ><
RUN	This instruction starts the program at the statement with the lowest statement number.
END	When the interpreter encounters an END statement in your program, it stops program execution and returns control to the command mode.
LIST LIST NNN LIST NNN1,NNN2	The LIST instruction writes the entire buffer contents to your terminal. The LIST instruction followed by an argument writes either a single program statement or the range of statements between the arguments. ((NNN1 < NNN2))
CLEAR	The interpreter removes all program statements from the buffer when it encounters a CLEAR instruction.
BYE	Executing a BYE instruction causes the interpreter to exit BASIC and return to the FANTOM II Monitor. The exit does not clear the buffer and you can return to BASIC with the buffer contents intact by using a warm start (see Page 33).
SAVE	The SAVE instruction directs Tiny BASIC to write the buffer contents at 300 baud to a cassette tape.
LOAD	The LOAD instruction reads a cassette tape at 300 baud and transfers a previously saved computer program into the buffer.

MATHEMATICAL EXPRESSIONS

A mathematical expression is the combination of one or more constants, variables, and functions connected by arithmetical operators. For instance, the Tiny BASIC statement: LET A = 5+6/3−2*2 contains a mathematical expression.

NUMERICAL CONSTANTS

All constants in Tiny BASIC are evaluated as 16-bit signed integers. An integer constant is written without a decimal point, using the decimal digits zero through nine. Unless they are preceded by a negative sign, integer constants are assumed to be positive.

VARIABLES

A variable is any capital letter (A-Z). The letter is a symbol for a numeric value capable of changing during program execution. The value of this variable can range from −32768 to 32767. "Appendix A" contains the address of each of the 26 variables used by Tiny BASIC.

OPERATORS

Tiny BASIC uses four arithmetical operators; addition (+), subtraction (−), multiplication (*), and division (/). The statement LET A = 5+6/3−2*2 is an example of a mathematical expression using these operators. Tiny BASIC processes these operators in the same fashion that you would use to solve an algebraic expression. For example, Tiny BASIC first evaluates 6/3 and 2*2 and then evaluates the expression to A=5+2−4 and sets the variable A equal to 3. Because Tiny BASIC evaluates multiplication and division before addition and subtraction, you must be careful when writing any mathematical expression. If you are not certain of the order of operations, use parentheses to force the order you wish. Evaluation always proceeds from left to right, except that arguments enclosed within parentheses are evaluated first.

Tiny BASIC also uses two unary (+ or −) operators. These operators denote whether an expression is positive or negative. The expression LET A = 5− (−3) causes the variable A to equal eight.

TINY BASIC RE-INITIALIZATION (Warm Start)

Tiny BASIC, in conjunction with the FANTOM II Monitor, allows you to exit Tiny BASIC and then re-enter it without clearing program statements and variables. In particular, the warm start re-entry preserves any remaining program and sets your memory limits. You can also reserve a block of memory by changing the high or low memory address ("Appendix A, Tiny BASIC Memory Map") and combine a BASIC program with a routine written in machine code.

The warm start is used after you have left Tiny BASIC by typing "BYE" or by pressing RESET on the ET-3400 Trainer. From the FANTOM II Monitor, when you have the "MON>" prompt, type "B" to do a warm start of Tiny BASIC.

FUNCTIONS

You may use either of two intrinsic functions in Tiny BASIC. The random (RND) function allows you to generate a positive pseudo-random integer. The user (USR) function is actually a call to a machine language subroutine that you have previously written. You can use either function in the COMMAND or PROGRAM mode.

THE RND FUNCTION

The RaNDom function selects a positive pseudo-random integer between zero and one less than the argument. The argument is an integer or variable between 1 and 32767. For instance, the following statement, when inserted in the sample program, causes the computer to store a random integer between zero and eight in the variable J.

```
LET J = RND(9)
```

THE USR FUNCTION

If a subroutine is written in Tiny BASIC, you simply use the GOSUB and RETURN commands to call and return from the subroutine. This is no problem. But suppose you wish to call a machine language subroutine from a program written in Tiny BASIC. This is the purpose of the USR function.

The USR function also permits you to call two routines in the Tiny BASIC interpreter. These two are commonly called PEEK and POKE, but they are not part of Tiny BASIC's vocabulary. You must implement the USR function to call the PEEK and POKE interpreter subroutines. These two routines let you get at nearly every feature of your microcomputer. As the name implies, you can examine the contents of selected memory locations with the PEEK routine. The POKE routine lets you enter data into memory locations.

First, how do machine language subroutines work? A subroutine is called with a JSR instruction. This pushes the return address onto the stack and jumps to the subroutine whose address is in the JSR instruction. When the subroutine has finished its operation, it executes the RTS instruction, which retrieves that address from the stack, returning control to the program that called it.

Depending on what function the subroutine is to perform, data may be passed to the subroutine by the calling program in one or more of the CPU registers and results may be passed back from the subroutine to the main program in the same way. The registers contain either addresses or more data. In some cases, the subroutine has no need to pass data back and forth, so the contents of the registers may be ignored.

The USR function may be called with one, two, or three arguments. These arguments are enclosed by parentheses, separated by a comma, and may be constants, variables, or expressions. The first of these is always the address of the subroutine to be called. The second and third arguments allow you to pass data through the CPU registers. The value of the second argument is placed in the index register while registers A and B contain the third argument. The forms of the USR statement are:

```
A = USR (sa)
A = USR (sa, x)
A = USR (sa, x, r)
```

The starting address (sa) and the index register (x) are 16-bit arguments. The third argument (r) is also 16 bits, but must be split between two registers. The most significant 8 bits of the third argument go into the B register, while the least significant bits are placed in the A register. However, it is important to realize that the three arguments in the USR function are decimal expressions and not the hexadecimal expressions that are normally associated with machine language programs. Any valid combination of numbers, variables, or expressions can be used as arguments.

The value returned by a USR function is a 16-bit number that is split between the A and B registers. The most significant byte is in the B register, and the least significant byte is in the A register. If your BASIC program does not use a returned value (such as POKE), the USR does not have to set up one. However, if the USR is supposed to return a value (such as PEEK), you must set up the value in the machine language of the USR.

The sample program on the next page shows you how to implement the USR function. The program accesses the Tiny BASIC interpreter subroutines "POKE" and "PEEK", which permit you to alter or examine the contents of memory locations. The program lets you store fifteen integer variables into an array that occupies the lowest memory in your computer system.

The program uses a simple loop to input and store data in memory locations zero through fourteen. After running the program, use the BYE command to exit Tiny BASIC and return to the Monitor. You can then examine the memory locations and verify that the program stores data in memory. By using a warm start, you can return to your Tiny BASIC program without deleting program statements.

The program accesses two machine language subroutines. PEEK and POKE. PEEK is permanently programmed into ROM starting at hexadecimal memory locations 1C14 (7188) and POKE is at location 1C18 (7192).

SAMPLE USR PROGRAMS

```
10 REM  THIS PROGRAM IS AN ADAPTATION OF A ROUTINE
11 REM  PUBLISHED BY TOM PITTMAN FOR KILOBAUD MAGAZINE.
12 REM  HEATH HAS OBTAINED PERMISSION FROM KILOBAUD TO
13 REM  REPRINT SEVERAL ARTICLES AT THE END OF THIS
14 REM  MANUAL ABOUT TINY BASIC. THESE ARTICLES PRESENT
15 REM  AN INFORMATIVE DISCUSSION ON TINY BASIC.
16 REM
17 REM
18 REM
20 REM  LET "L" REPRESENT THE VARIABLE FOR THE
21 REM  ADDRESS OF THE INDEX REGISTER.
22 REM
23 LET L=0
24 REM
30 REM  LET "J" REPRESENT THE VARIABLE DATA THAT
31 REM  WILL BE STORED IN ARRAY MEMORY LOCATIONS 0-15.
32 REM
33 INPUT J
34 REM
40 REM  "POKE" THE VARIABLE "J" INTO LOCATION "L" .
41 REM
42 LET J=USR(7192,L,J)
43 REM
50 REM  USE THE "PEEK"COMMAND TO WRITE DATA FROM
51 REM  ARRAY LOCATION "L" INTO VARIABLE "N", THEN
52 REM  USE A PRINT STATEMENT TO VERIFY THAT THE DATA
53 REM  WAS CORRECTLY STORED.
54 REM
55 LET N=USR(7188,L)
56 REM
57 PRINT "INTEGER ",N," IS LOCATED AT ADDRESS ",L
58 REM
60 REM  INCREMENT INDEX REGISTER AND TEST FOR END OF ARRAY.
62 LET L=L+1
64 IF L<15 GOTO 30
70 END
```

In the next example, the USR function lets you call two separate machine language subroutines. A listing of these routines is provided in Figures 1A and 1B. The first routine, "LEDOFF", turns off the ET-3400 LED display, while the other routine, "LEDON", lights various LED segments. Both routines use accumulators A and B to pass a value from the USR function to the BASIC program.

```
0000 BD FE50    LEDOFF   JSR   OUTST1
0003 000000              FCB   0,0,0
0006 000000              FCB   0,0,0
0009 80                  FCB   80
000A 86 44               LDAA  #$44
000C 5F                  CLRB
000D 39                  RTS
```

Figure 1A

```
0100 CE C16F    LEDON    LDX   DG6ADD
0103 BD FE50             JSR   OUTST1
0106 3E5B05              FCB   3E,5B,05
0109 47158D              FCB   47,15,8D
010C 86 AA               LDAA  #/AA
010E 5F                  CLRB
010F 39                  RTS
```

Figure 1B

The USR function requires that you either reserve an area of memory for machine code by adjusting the low memory address of BASIC user space upward, or you use the available bytes in low memory.☆ Both methods are featured in this example.

☆NOTE: See "Appendix A" for a complete memory map. Always use caution when you are working in memory locations below 100_H for subroutines. This area is generally used by BASIC and the Monitors to store program variables. This example only shows you that areas of memory are available. However, the accepted procedure is to reserve an area of memory above address 100_H for your programs.

Use the following procedure to adjust BASIC's low memory limit. For example, the "LEDON" subroutine requires sixteen bytes of memory. Therefore, add the number of program bytes to the constant 0100_H and insert the result in memory locations 20_H and 21_H. Replacing these values changes the low memory limit in BASIC.

0100	Tiny BASIC low memory address.
+ 10	Number of program bytes needed.
0110	New low memory address.

Reserve memory locations 0100_H through $010F_H$ for the program by using the following procedure. First, enter BASIC from the monitor. This will initialize the interpreter, and you will be able to set the new low memory limit by exiting BASIC and replacing the value with your new low memory limit. For example:

```
MON> G 1C00
HTB1:  BYE
MON> M 20 CR
0020 01 CR
0021 00 10 CR
0022 NN ECS
MON>
```

Now use the Phantom II Monitor to enter the machine code from Figure 1A and 1B. The two subroutines are almost identical because they call another subroutine (OUTST1) located in the ET-3400 monitor. This routine outputs data to the LED displays. The major difference between the routines is in the program data. Changing this data changes the display.

Observe that the program statement, LDX DG5ADD, is missing from the LEDOFF routine. The operand, DG6ADD, corresponds to Hexadecimal value C16F, which is the address of the left-most digit on your ET-3400 Trainer. This value must be in the index register before the USR program inserts this value ($49519_{10} = C16F_h$) into the index register for the second program.

The machine language subroutines performs one additional operation before returning to BASIC. The hexadecimal value entered into accumulators A and B is returned to the USR variable (i.e. A=USR(0)). When the return from subroutine instruction is executed, these values are converted to a decimal equivalent and stored in variable A. The value stored in this variable determines the on/off delay time of the LED display. Changing the value in the accumulators lets you alter this delay time.

Always use a warm start to reenter BASIC after you adjust the memory limits and enter the machine code. If you do not use a warm start, BASIC will reinitialize the available memory and write over any program that you may have in memory. That is:

```
MON> B (CR)
:
```

Enter the following BASIC program statements after you adjust the low memory boundry and enter your machine language subroutines.

```
10 K=5
20 PR " OBSERVE ET-3400 DISPLAY"
30 A=USR(256)
40 GOSUB 100
50 A=USR(0,49519)
60 GOSUB 100
70 K=K-1
80 IF K>0 GOTO 30
90 END
100 A=A-1
110 IF A>0 GOTO 100
120 RETURN
```

The LED display on the ET-3400 will display a message when you run the program. Program statement 30 calls the machine language routine that prints the "USr Fnc." message. After lighting the display, the program returns to BASIC and enters the time delay subroutine.

Program statement 50 calls the routine that turns off the LED display. Note that the decimal value, 49519, is equivalent to the hexadecimal value C16F. Setting the index register in the calling program reduces the memory requirements in the subroutine.

The starting address of each routine is supplied in decimal as the first argument in the USR function. If the address is not included, the program will never be executed. If the address is wrong, the jump will be to the wrong place in memory and unpredictable results will occur.

APPENDIXES

APPENDIX A

Tiny Basic Memory Map

LOCATION	SIGNIFICANCE
0000-000F	Not used by Tiny BASIC.
0010-001F	Temporaries.
0020-0021	Lowest address of user program space.
0022-0023	Highest address of user program space.
0024-0025	Program end + stack reserve.
0026-0027	Top of GOSUB stack.
0028-002F	Interpreter parameters.
0030-007F	Input line buffer and Computation stack.
0080-0081	Random Number generator workspace.
0082-00B5	Variables: A,B,...,Z
00B6-00C7	Interpreter temporaries.
0100-0FFF	Tiny BASIC user program space.

1C00	Cold start entry point.
1C03	Warm start entry point.
1C06	Character input routine.
1C09	Character output routine.
1C0C	Break test.
1C0F	Backspace code.
1C10	Line cancel code.
1C11	Pad character.
1C12	Tape mode enable flag. (HEX 80 = enabled)
1C13	Spare stack size.
1C14	Subroutine (PEEK) to read one byte from RAM to B and A. (address in X)
1C18	Subroutine (POKE) to store A and B into RAM at address in X.

APPENDIX B

Tiny Basic Error Message Summary

NUMBER	MEANING
0	Break during execution.
8	Memory overflow; line not inserted.
9	Line number 0 is not allowed.
13	RUN with no program in memory.
18	LET is missing a variable name.
20	LET is missing an =.
23	Improper syntax in LET.
25	LET is not followed by END.
34	Improper syntax in GOTO.
37	No line to GOTO.
39	Misspelled GOTO.
40	Misspelled GOSUB.
41	Misspelled GOSUB.
46	GOSUB invalid. Subroutine does not exist.
59	PRINT not followed by END.
62	Missing close quote in PRINT string.
73	Colon in PRINT is not at end of statement.
75	PRINT not followed by END.
95	IF not followed by END.
104	INPUT syntax bad — expects variable name.
123	INPUT syntax bad — expects comma.
124	INPUT not followed by END.
132	RETURN syntax is bad.
133	RETURN has no matching GOSUB.
134	GOSUB not followed by END.

139	END syntax bad.
154	Cannot list line number 0.
158	LIST not followed by END statement.
164	LIST syntax error — expects comma.
183	REM not followed by END.
188	Memory overflow, too many GOSUB'S.
211	Expression too complex.
224	Divide by zero.
226	Memory overflow.
232	Expression too complex.
233	Expression too complex using RND.
234	Expression too complex in direct evaluation.
253	Expression too complex — simplify.
259	RND(0) not allowed.
266	Expression too complex.
267	Expression too complex for RND.
275	USR expects (before argument.
284	USR expects) after argument.
287	Expression too complex.
288	Expression too complex for USR.
290	Expression too complex.
293	Syntax error in expression — expects value.
296	Syntax error — missing) .
298	Memory overflow — CHECK USR function.
303	Expression too complex in USR.
304	Memory overflow.
306	Syntax error.
330	Syntax error — check IF/THEN.
363	Missing statement. Type keyword.
365	Misspelled statement. Type keyword.

APPENDIX C

Heath/Wintek Monitor Listing

```
HEATH KEYBOARD MONITOR
RAM AND CHARACTERS DEFINED

                    ***     HEATH/WINTEK TERMINAL MONITOR SYSTEM
                    *
                    *       BY JIM WILSON FOR WINTEK CORPORATION
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                    **      CONDITIONAL ASSEMBLIES

    0000            DEBUG   EQU     0               DEBUG CODE OFF

                    **      CHARACTER DEFINITIONS

    000D            CR      EQU     0DH
    000A            LF      EQU     0AH
    0020            SPACE   EQU     ' '


                    **      PIA DEFINITION

    1000                    ORG     $1000
    1000            TERM    RMB     1
    1001            TERM.C  RMB     1
    1002            TAPE    RMB     1
    1003            TAPE.C  RMB     1

                    **      EXTERNALS

    FE6B            SSTEP   EQU     0FE6BH
    FEFC            SWIVE1  EQU     0FEFCH
    FF76            OPTAB   EQU     0FF76H
    FCBC            REDIS   EQU     0FCBCH
    FD7B            DISPLAY EQU     0FD7BH
    FE20            OUTBYT  EQU     0FE20H
    FD43            BKSP    EQU     0FD43H
    FD25            PROMPT  EQU     0FD25H
    FC86            OUTSTA  EQU     0FC86H
    FE52            OUTSTR  EQU     0FE52H

                    **      RAM TEMPORARIES

    00CC                    ORG     0CCH
    00CC            USERC   RMB     1               CONDX CODES
    00CD            USERB   RMB     1
    00CE            USERA   RMB     1               ACCUMULATORS
    00CF            USERX   RMB     2               INDEX
    00D1            USERP   RMB     2               P.C.
    00E4                    ORG     0E4H
    0004            NBR     EQU     4               FOUR BREAKPOINTS ALLOWED
    00E4            BKTBL   RMB     2*NBR
    00EC            T0      RMB     2
    00EE            T1      RMB     2
    00F0            DIGADD  RMB     2
    00F2            USERS   RMB     2
    00F4            T2      EQU     *
    00F4            SYSSWI  RMB     3
    00F7            UIRQ    RMB     3
```

HEATH KEYBOARD MONITOR
RAM AND CHARACTERS DEFINED

```
00FA              USWI    RMB     3
00FD              UNMI    RMB     3

FFFF                      IF      DEBUG-1
                          ELSE
1400                      ORG     $1400
                          ENDIF


                  **      MAIN MONITOR LOOP
                  *
                  *       1)  FEELS OUT MEMORY
                  *       2)  SEARCHES FOR PAST INCARNATIONS
                  *             A) CLEARS BREAKPOINTS IF REINCARNATED
                  *             B) CLEARS BREAKPOINT TABLE OTHERWISE
                  *       3)  SENDS PROMPT 'MON>'
                  *       4)  ACCEPTS COMMAND CHARACTERS AND JUMPS
                  *              TO APPROPRIATE HANDLER

1400  0F          MAIN    SEI
1401  CE 10 00            LDX     #TERM           TERMINAL PIA
1404  6F 01               CLR     1,X             IN CASE IRREGULAR ENTRY
1406  6F 03               CLR     3,X
1408  86 01               LDA A   #1
140A  A7 00               STA A   0,X
140C  86 7F               LDA A   #01111111B
140E  A7 02               STA A   2,X
1410  C6 04               LDA B   #4
1412  E7 01               STA B   1,X
1414  E7 03               STA B   3,X
1416  A7 00               STA A   0,X             IDLE MARKING!!

                  *       NOW FIND MEMORY EXTENT

1418  09          MAIN1   DEX
1419  A6 00               LDA A   0,X
141B  63 00               COM     0,X
141D  43                  COM A
141E  A1 00               CMP A   0,X
1420  26 F6               BNE     MAIN1
1422  63 00               COM     0,X             RESTORE GOOD BYTE
1424  86 15               LDA A   #4*NBR+5
1426  09          MAIN2   DEX                     GO TO MONITOR GRAVEYARD
1427  4A                  DEC A
1428  26 FC               BNE     MAIN2
142A  35                  TXS
142B  86 0C               LDA A   #2*NBR+4
142D  EE 08               LDX     2*NBR,X         RETURN ADDRESS IF ANY
142F  8C 14 4C            CPX     #MAIN5
1432  27 09               BEQ     MAIN4           IS RE-INCARNATION
1434  C6 FF               LDA B   #$FF
1436  30                  TSX
1437  E7 0A       MAIN3   STA B   2*NBR+2,X
1439  08                  INX
143A  4A                  DEC A
143B  26 FA               BNE     MAIN3
```

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HEATH KEYBOARD MONITOR
MAIN - MAIN MONITOR LOOP

      143D  86 04      MAIN4   LDA A  #NBR             CLEAR BREAKPOINTS
      143F  33         MAIN44  PUL B
      1440  33                 PUL B
      1441  30                 TSX
      1442  EE 0C              LDX    2*NBR+4,X
      1444  E7 00              STA B  0,X
      1446  4A                 DEC A
      1447  26 F6              BNE    MAIN44
      1449  0C                 CLC                     NO ERROR MESSAGE
      144A  31                 INS
      144B  31                 INS
      144C  24 0D      MAIN5   BCC    MAIN6            NO ERROR
      144E  BD 16 18           JSR    OUTIS
      1451  0D 0A 45           FCB    CR,LF,'ERROR!',7,0
      145B  BD 16 18   MAIN6   JSR    OUTIS
      145E  0D 0A 4D           FCB    CR,LF,'MON> ',0
      1466  7D 10 00   MAIN66  TST    TERM
      1469  2A FB              BPL    MAIN66
      146B  BD 18 E1           JSR    INCH             INPUT COMMAND
      146E  CE 19 EF           LDX    #CMDTAB-3
      1471  08         MAIN7   INX
      1472  08                 INX
      1473  08                 INX
      1474  A1 00              CMP A  0,X
      1476  25 F9              BCS    MAIN7
      1478  26 D2              BNE    MAIN5            ILLEGAL COMMAND
      147A  36                 PSH A
      147B  BD 18 63           JSR    OUTSP
      147E  32                 PUL A
      147F  C6 4C              LDA B  #-MAIN5/256*256+MAIN5
      1481  37                 PSH B
      1482  C6 14              LDA B  #MAIN5/256
      1484  37                 PSH B
      1485  E6 02              LDA B  2,X
      1487  37                 PSH B
      1488  E6 01              LDA B  1,X
      148A  37                 PSH B
      148B  5F                 CLR B
      148C  DE F2              LDX    USERS
      148E  39                 RTS


                       **      GO - GO TO USER CODE
                       *
                       *       ENTRY:  (X) = USERS
                       *       EXIT:   UPON BREAKPOINT
                       *       USES:   ALL,T0,T1,T2

      148F  BD 16 25   GO      JSR    AHV
      1492  24 04              BCC    GO1              NO OPTIONAL ADDRESS
      1494  A7 07              STA A  7,X
      1496  E7 06              STA B  6,X
      1498  BD FE 6B   GO1     JSR    SSTEP            STEP PAST BKPT
      149B  C6 04              LDA B  #NBR
      149D  30         GO2     TSX                     COPY IN BREAKPOINTS
      149E  EE 0C              LDX    2*NBR+4,X
```

HEATH KEYBOARD MONITOR
GO - GO TO USER CODE

```
14A0   A6 00              LDA A    0,X
14A2   36                 PSH A
14A3   36                 PSH A
14A4   86 3F              LDA A    #$3F
14A6   A7 00              STA A    0,X
14A8   5A                 DEC B
14A9   26 F2              BNE      GO2
14AB   20 3E              BRA      GO7

14AD   30         GO3     TSX
14AE   A6 06              LDA A    6,X
14B0   26 02              BNE      GO33
14B2   6A 05              DEC      5,X
14B4   E6 05      GO33    LDA B    5,X
14B6   4A                 DEC A
14B7   A7 06              STA A    6,X          DECREMENT USER PC
14B9   9F F2              STS      USERS
14BB   9E EC              LDS      TO
14BD   36                 PSH A
14BE   86 04              LDA A    #NBR
14C0   97 EC              STA A    TO
14C2   32                 PUL A
14C3   30                 TSX
14C4   08         GO4     INX                   SEARCH TABLE FOR HIT
14C5   08                 INX
14C6   A1 0D              CMP A    2*NBR+5,X
14C8   26 19              BNE      GO5          NO HIT HERE
14CA   E1 0C              CMP B    2*NBR+4,X
14CC   26 15              BNE      GO5
14CE   BD 16 18           JSR      OUTIS
14D1   0D 0A 00           FCB      CR,LF,0
14D4   86 04              LDA A    #NBR
14D6   33         GO44    PUL B
14D7   33                 PUL B                 OP CODE INTO B
14D8   30                 TSX
14D9   EE 0C              LDX      2*NBR+4,X
14DB   E7 00              STA B    0,X
14DD   4A                 DEC A
14DE   26 F6              BNE      GO44
14E0   7E 15 53           JMP      REGS         DISPLAY REGISTERS

14E3   7A 00 EC   GO5     DEC      TO
14E6   26 DC              BNE      GO4

                  *       SWI NOT MONITORS SO INTERPRET

14E8   BD FE 6B           JSR      SSTEP        STEP PAST SWI
14EB   9F EC      GO7     STS      TO
14ED   CE 14 AD           LDX      #GO3
14F0   7E FE FC           JMP      SWIVE1
```

HEATH KEYBOARD MONITOR
BKPT - INSERT BREAKPOINT

```
                          **      BKPT - INSERT BREAKPOINT INTO TABLE
                          *
                          *       ENTRY:   NONE
                          *       EXIT:    'C' SET IF TABLE FULL
                          *       USES:    ALL,TO

 14F3   30                BKPT    TSX
 14F4   86 FF                     LDA A    #$FF
 14F6   C6 04                     LDA B    #NBR
 14F8   08                BKP1    INX
 14F9   08                        INX               LOOK FOR EMPTY SPOT
 14FA   A1 04                     CMP A    4,X
 14FC   26 04                     BNE      BKP2     NOT EMPTY
 14FE   A1 05                     CMP A    5,X
 1500   27 05                     BEQ      BKP3     IS EMPTY
 1502   5A                BKP2    DEC B
 1503   26 F3                     BNE      BKP1     STILL HOPE
 1505   0D                        SEC
 1506   39                        RTS               FULL!!

 1507   BD 16 25          BKP3    JSR      AHV      GET BREAKPOINT VALUE
 150A   24 04                     BCC      BKP4     NO ENTRY
 150C   A7 05                     STA A    5,X
 150E   E7 04                     STA B    4,X
 1510   0C                BKP4    CLC
 1511   39                        RTS


                          **      CLEAR - CLEAR BREAKPOINT ENTRY
                          *
                          *       ENTRY:   (X) = USERS
                          *       EXIT:    'C' SET IF NOT FOUND
                          *       USES:    ALL,TO

 1512   86 04             CLEAR   LDA A    #NBR
 1514   97 EC                     STA A    TO
 1516   BD 16 25                  JSR      AHV      GET LOCATION
 1519   25 04                     BCS      CLE1     NO VALID HEX
 151B   A6 07                     LDA A    7,X
 151D   E6 06                     LDA B    6,X      USER PC FOR DEFAULT
 151F   30                CLE1    TSX
 1520   08                CLE2    INX
 1521   08                        INX
 1522   A1 05                     CMP A    5,X      SEARCH TABLE
 1524   26 04                     BNE      CLE3     NOT FOUND
 1526   E1 04                     CMP B    4,X
 1528   27 07                     BEQ      CLE4     FOUND
 152A   7A 00 EC          CLE3    DEC      TO
 152D   26 F1                     BNE      CLE2
 152F   0D                        SEC
 1530   39                        RTS

 1531   C6 FF             CLE4    LDA B    #$FF
 1533   E7 04                     STA B    4,X      CLEAR ENTRY
 1535   E7 05                     STA B    5,X
 1537   0C                        CLC
```

HEATH KEYBOARD MONITOR
BKPT - INSERT BREAKPOINT

```
1538  39                 RTS

                   **    EXEC - PROCESS MULTIPLE SINGLE STEP
                   *
                   *     ENTRY:  NONE
                   *     EXIT:   REGISTERS PRINTED
                   *     USES:   ALL,T0,T1,T2

1539  BD 16 25   EXEC    JSR     AHV             GET COUNT
153C  25 09              BCS     EXEC1
153E  86 01              LDA A   #1              DEFAULT COUNT
1540  20 05              BRA     EXEC1

1542  36         EXEC0   PSH A                   SAVE COUNT
1543  BD FE 6B           JSR     SSTEP           STEP CODE
1546  32                 PUL A
1547  4A         EXEC1   DEC A
1548  26 F8              BNE     EXEC0           MORE STEPS
154A  BD 16 18           JSR     OUTIS
154D  0D 0A 00           FCB     CR,LF,0


                   **    STEP - STEP USER CODE
                   *
                   *     ENTRY:  NONE
                   *     EXIT:   REGISTERS PRINTED
                   *     USES: ALL,T0,T1,T2

1550  BD FE 6B   STEP    JSR     SSTEP           STEP USER CODE


                   **    REGS - DISPLAY ALL USER REGISTERS
                   *
                   *     ENTRY:  NONE
                   *     EXIT:   REGISTERS PRINTED
                   *     USES:   ALL,T0

1553  5F         REGS    CLR B
1554  DE F2              LDX     USERS
1556  86 43              LDA A   #'C'
1558  8D 26              BSR     REGS1
155A  86 42              LDA A   #'B'
155C  8D 24              BSR     REGS3
155E  86 41              LDA A   #'A'
1560  8D 20              BSR     REGS3
1562  86 58              LDA A   #'X'
1564  8D 1B              BSR     REGS2
1566  86 50              LDA A   #'P'
1568  8D 18              BSR     REGS3
156A  86 53              LDA A   #'S'
156C  09                 DEX
156D  DF EC              STX     T0
156F  CE 00 EB           LDX     #T0-1
1572  8D 0C              BSR     REGS1
1574  DE F2              LDX     USERS
```

```
HEATH KEYBOARD MONITOR
REGISTER DISPLAY COMMANDS

     1576  EE 06                LDX     6,X             (X) = USERPC
     1578  DF EC                STX     TO
     157A  A6 00                LDA A   0,X
     157C  8D 63                BSR     TYPINO          TYPE INSTRUCTION
     157E  0C                   CLC
     157F  39                   RTS

     1580  08          REGS1    INX
     1581  5C          REGS2    INC B
     1582  BD 18 65    REGS3    JSR     OUTCH           OUTPUT REGISTER NAME
     1585  86 3D                LDA A   #'='
     1587  BD 18 65             JSR     OUTCH
     158A  20 67                BRA     TYPIN2


                       **       REGISTER DISPLAY COMMANDS
                       *
                       *        ENTRY:  (X) = USERSP
                       *                (B) = 0
                       *        EXIT:   OPTIONAL REPLACEMENT VALUE STORED
                       *        USES:   ALL,TO

     158C  08          REGP     INX
     158D  08                   INX
     158E  08          REGX     INX
     158F  5C                   INC B
     1590  08          REGA     INX
     1591  08          REGB     INX
     1592  8B 40       REGC     ADD A   #$40            DISPLACE REG NAME
     1594  8D EA                BSR     REGS1           OUTPUT WITH NAME
     1596  37                   PSH B
     1597  BD 16 25             JSR     AHV
     159A  24 2F                BCC     MEM4
     159C  8D 05                BSR     REG1
     159E  17                   TBA
     159F  33                   PUL B
     15A0  5A                   DEC B
     15A1  27 08                BEQ     REG2
     15A3  09          REG1     DEX
     15A4  A7 00                STA A   0,X
     15A6  A1 00                CMP A   0,X
     15A8  27 01                BEQ     REG2
     15AA  0D                   SEC
     15AB  39          REG2     RTS
                       **       MEM - DISPLAY MEMORY BYTES
                       *
                       *        ENTRY:  (B) = 0
                       *                (X) = USER S.P.
                       *        USES:  ALL,TO

     15AC  5A          MEM      DEC B
```

HEATH KEYBOARD MONITOR
MEM - DISPLAY MEMORY OR INSTRUCTION

```
                    **      INST - DISPLAY INSTRUCTIONS
                    *
                    *       ENTRY:  (B) = 0
                    *               (X) = USER S.P.
                    *       USES:   ALL,TO

15AD  37            INST    PSH B
15AE  EE 06                 LDX     6,X             GET USER P.C.
15B0  8D 73                 BSR     AHV
15B2  24 07                 BCC     MEM1
15B4  36                    PSH A
15B5  37                    PSH B
15B6  30                    TSX
15B7  EE 00                 LDX     0,X
15B9  31                    INS
15BA  31                    INS
15BB  0C            MEM1    CLC
15BC  33            MEM2    PUL B
15BD  24 05                 BCC     MEM3
15BF  8D E2                 BSR     REG1
15C1  25 0A                 BCS     MEM5
15C3  08                    INX
15C4  8D 08         MEM3    BSR     TYPINS          TYPE THE DATA
15C6  37                    PSH B                   SAVE MODE FLAG
15C7  8D 5C                 BSR     AHV             GET REPLACEMENT VALUE
15C9  23 F1                 BLS     MEM2
15CB  0C            MEM4    CLC
15CC  33                    PUL B
15CD  39            MEM5    RTS


                    **      TYPINS - TYPE INSTRUCTION IN HEX
                    *
                    *       ENTRY:  (X) = ADDRESS OF INSTRUCTION
                    *       EXIT:   (X) = ADDRESS OF NEXT INST.
                    *       USES:   ALL

15CE  A6 00         TYPINS  LDA A   0,X             OP CODE
15D0  36                    PSH A                    ONTO STACK
15D1  DF EC                 STX     TO
15D3  8D 43                 BSR     OUTIS
15D5  0D 0A 00              FCB     CR,LF,0
15D8  CE 00 EC              LDX     #TO
15DB  8D 2D                 BSR     OUT4HS
15DD  32                    PUL A
15DE  5D                    TST B
15DF  2B 0E                 BMI     TYPIN1          ONE BYTE ONLY
15E1  8D 66         TYPIN0  BSR     BYTCNT
15E3  5A                    DEC B
15E4  2A 09                 BPL     TYPIN1          IS VALID INST.
15E6  5C                    INC B                   RESTORE (B)
15E7  8D 2F                 BSR     OUTIS
15E9  44 41 54              FCB     'DATA=',0
15EF  DE EC         TYPIN1  LDX     TO
15F1  8D 19                 BSR     OUT2HS
15F3  C1 01         TYPIN2  CMP B   #1
```

HEATH KEYBOARD MONITOR
MEM - DISPLAY MEMORY OR INSTRUCTION

```
15F5   2B 20              BMI     THB1
15F7   27 13              BEQ     OUT2HS
15F9   20 0F              BRA     OUT4HS


                  **      DISB - DISPLAY BREAKPOINTS
                  *
                  *       ENTRY:  NONE
                  *       EXIT:   BREAKPOINT TABLE PRINTED
                  *       USES:   ALL

15FB   C6 06      DISB    LDA B   #6              OFFSET INTO TABLE
15FD   30                 TSX
15FE   08         DISB1   INX
15FF   5A                 DEC B
1600   26 FC              BNE     DISB1
1602   C6 04              LDA B   #NBR
1604   8D 04      DISB2   BSR     OUT4HS
1606   5A                 DEC B
1607   26 FB              BNE     DISB2
1609   39                 RTS


                  **      OUT4HS, OUT2HS - OUTPUT HEX AND SPACES
                  *
                  *       ENTRY:  (X) = ADDRESS
                  *       EXIT:    X UPDATED PAST BYTE(S)
                  *       USES:   X,A,C

160A   8D 05      OUT4HS  BSR     THB             TYPE HEX BYTE
160C   8D 03      OUT2HS  BSR     THB
160E   7E 18 63           JMP     OUTSP


                  **      THB - TYPE HEX BYTE
                  *
                  *       ENTRY:  (X) = ADDRESS OF BYTE
                  *       EXIT:    X INCREMENTED PAST BYTE
                  *       USES:   X,A,C

1611   37         THB     PSH B
1612   5F                 CLR B
1613   BD 17 E4           JSR     OCH
1616   33                 PUL B
1617   39         THB1    RTS


                  **      OUTIS - OUTPUT IMBEDDED STRING
                  *
                  *       CALLING CONVENTION:
                  *               JSR     OUTIS
                  *               FCB     'STRING',0
                  *               <NEXT INST>
                  *       EXIT: TO NEXT INSTRUCTION
                  *       USES:   A,X
```

HEATH KEYBOARD MONITOR
MEM - DISPLAY MEMORY OR INSTRUCTION

```
1618  30          OUTIS   TSX
1619  EE 00               LDX      0,X
161B  31                  INS
161C  31                  INS
161D  37                  PSH B
161E  5F                  CLR B
161F  BD 17 C3            JSR      OAS
1622  33                  PUL B
1623  6E 00               JMP      0,X

                  **      AHV - ACCUMULATE HEX VALUE
                  *
                  *       ENTRY:   NONE
                  *       EXIT:    (BA) = ACCUMULATED HEX VALUE OR
                  *                 (A) = ASCII IF NO HEX
                  *                 'C' SET FOR VALID HEX
                  *                 'Z' SET FOR TERMINATOR = CR
                  *       USES:    B,A,C

1625  5F          AHV     CLR B
1626  BD 18 A3    AHVD    JSR      IHD               GET FIRST DIGIT
1629  24 1D               BCC      AHV3              NOT HEX
162B  36          AHV1    PSH A
162C  37                  PSH B
162D  48                  ASL A
162E  59                  ROL B
162F  48                  ASL A
1630  59                  ROL B
1631  48                  ASL A
1632  59                  ROL B
1633  48                  ASL A
1634  59                  ROL B                      MAKE WAY FOR NEXT DIGIT
1635  37                  PSH B
1636  36                  PSH A
1637  BD 18 A3            JSR      IHD
163A  24 07               BCC      AHV2              THIS NOT HEX
163C  33                  PUL B
163D  1B                  ABA
163E  33                  PUL B
163F  31                  INS
1640  31                  INS                        DISCARD OLD VALUE
1641  20 E8               BRA      AHV1

1643  31          AHV2    INS
1644  31                  INS                        SKIP LATEST VALUE
1645  33                  PUL B
1646  32                  PUL A
1647  0D                  SEC
1648  39          AHV3    RTS
```

HEATH KEYBOARD MONITOR
BYTCNT - COUNT INSTRUCTION BYTES

```
                        **      BYTCNT - COUNT INSTRUCTION BYTES
                        *
                        *       ENTRY: (A) = OPCODE
                        *       EXIT:  (B) = 0,1,2 OR 3
                        *              'C' CLEAR IF RELATIVE ADDRESSING
                        *              'Z' SET IF ILLEGAL

1649  36         BYTCNT  PSH A
164A  16                 TAB
164B  CE FF 75           LDX     #OPTAB-1
164E  08         BYT1    INX
164F  C0 08              SUB B   #8
1651  24 FB              BCC     BYT1
1653  A6 00              LDA A   0,X
1655  46         BYT2    ROR A
1656  5C                 INC B
1657  26 FC              BNE     BYT2
1659  32                 PUL A
165A  25 1E              BCS     BYT7
165C  81 30              CMP A   #$30          CHECK FOR BRANCH
165E  24 04              BCC     BYT3
1660  81 20              CMP A   #$20
1662  24 14              BCC     BYT5          IS BRANCH
1664  81 60      BYT3    CMP A   #$60
1666  25 11              BCS     BYT6          IS ONE BYTE
1668  81 8D              CMP A   #$8D
166A  27 0C              BEQ     BYT5          IS BSR
166C  84 BD              AND A   #$BD
166E  81 8C              CMP A   #$8C
1670  27 04              BEQ     BYT4          IS X OR SP IMM.
1672  84 30              AND A   #$30          CHECK FOR THREE BYTES
1674  81 30              CMP A   #$30
1676  C2 FF      BYT4    SBC B   #$FF
1678  5C         BYT5    INC B
1679  5C         BYT6    INC B
167A  39         BYT7    RTS

                        **      COPY - COPY MEMORY ELSEWHERE
                        *
                        *       ENTRY:  NONE
                        *       EXIT:   BLOCK MOVED
                        *       USES:   ALL
                        *
                        *       COMMAND SYNTAX: (CNTL-)D <FROM>,<TO>,<COUNT>

167B  BD 16 18   COPY    JSR     OUTIS
167E  53 4C 49           FCB     'SLIDE ',0
1685  BD 16 25           JSR     AHV           GET *FROM*
1688  24 19              BCC     COP3          NO HEX
168A  36                 PSH A
168B  37                 PSH B
168C  BD 16 25           JSR     AHV           GET *TO*
168F  24 10              BCC     COP2          NO HEX
1691  36                 PSH A
1692  37                 PSH B
```

```
HEATH KEYBOARD MONITOR
COPY - COPY MEMORY ELSEWHERE

     1693  BD 16 25          JSR    AHV          GET *COUNT*
     1696  24 07             BCC    COP1         NO HEX
     1698  36                PSH A
     1699  37                PSH B
     169A  BD 19 6D          JSR    MOVE         MOVE DATA
     169D  0C                CLC                 NO ERRORS
     169E  39                RTS

     169F  31       COP1     INS
     16A0  31                INS
     16A1  31       COP2     INS
     16A2  31                INS
     16A3  0D       COP3     SEC
     16A4  39                RTS


                    **       LOAD - LOAD DATA INTO MEMORY
                    *
                    *        ENTRY:  NONE
                    *        EXIT:   'C' SET IF ERROR
                    *        USES:   ALL,TO

     16A5  BD 16 25 LOAD     JSR    AHV          GET OPTIONAL PARAMETERS
     16A8  25 02             BCS    LOA00
     16AA  86 08             LDA A  #8           DEFAULT TO CASSETTE
     16AC  16       LOA00    TAB
     16AD  34       LOA0     DES
     16AE  34                DES                 SCRATCHPAD ON STACK
     16AF  BD 18 DE LOA1     JSR    ICT          INPUT CASSETTE/TERM
     16B2  84 7F             AND A  #7FH
     16B4  81 53             CMP A  #'S'
     16B6  26 F7             BNE    LOA1
     16B8  BD 18 DE          JSR    ICT
     16BB  84 7F             AND A  #7FH
     16BD  81 39             CMP A  #'9'
     16BF  27 36             BEQ    LOA4         IS EOF
     16C1  34                DES
     16C2  81 31             CMP A  #'1'
     16C4  26 E9             BNE    LOA1         NOT START-OF-RECORD
     16C6  B7 C1 6F          STA A  0C16FH       TURN ON D.P.
     16C9  4F                CLR A
     16CA  30                TSX
     16CB  BD 18 C2          JSR    IHB          COUNT
     16CE  BD 18 C2          JSR    IHB          ADDRESS (2 BYTES)
     16D1  BD 18 C2          JSR    IHB
     16D4  30                TSX
     16D5  EE 01             LDX    1,X          GET FWA OF BUFFER
     16D7  D7 EC             STA B  TO
     16D9  33                PUL B
     16DA  C0 03             SUB B  #3           ACCOUNT 3 BYTES
     16DC  37       LOA2     PSH B
     16DD  D6 EC             LDA B  TO
     16DF  BD 18 C2          JSR    IHB
     16E2  D7 EC             STA B  TO
     16E4  33                PUL B
     16E5  5A                DEC B
```

HEATH KEYBOARD MONITOR
LOAD - FROM TAPE OR TERMINAL

```
16E6   26 F4              BNE      LOA2
16E8   7F C1 6F           CLR      0C16FH          TURN OFF D.P.
16EB   D6 EC              LDA B    TO
16ED   CE 00 EC           LDX      #TO
16F0   BD 18 C2           JSR      IHB
16F3   4C                 INC A
16F4   27 B9              BEQ      LOA1
16F6   0D         LOA3    SEC
16F7   31         LOA4    INS
16F8   31                 INS
16F9   39                 RTS


                  **      TIME CRITICAL ROUTINES !!!!!
                  *       SINCE CASSETTE I/O IS DONE USING ONLY SOFTWARE
                  *        TIMING LOOPS, THE ROUTINE 'BIT' MUST BE CALLED
                  *        EVERY 208 US.  CRITICAL TIMES IN THESE ROUTINES
                  *        ARE LISTED IN THE COMMENT FIELDS OF CERTAIN
                  *        INSTRUCTIONS IN THE FORM "NNN US".  THESE TIMES
                  *        REPRESENT THE TIME REMAINING BEFORE THE NEXT
                  *        RETURN FROM 'BIT'.  THE TIME INCLUDES THE
                  *        LABELED INSTRUCTION AND INCLUDES THE EXECUTION
                  *        OF THE 'RTS' AT THE END OF 'BIT'.  SOME
                  *        ROUTINES HAVE "NNN US USED" AS A COMMENT
                  *        ON THEIR LAST STATEMENT.  THIS REPRESENTS
                  *        THE TIME EXPIRED SINCE THE LAST RETURN
                  *        FROM 'BIT' INCLUDING THE LABLED INSTRUCTION.


                  **      HIGH SPEED LOAD
                  *
                  *         ACCEPTS ADDITIONAL BIT/CELL PARAMETER
                  *
                  *       ENTRY:  (A) = COMMAND
                  *               (B) = 0
                  *       USES:   ALL,TO,T1,T2

16FA   8B 40      CTLT    ADD A    #$40            DISPLACE TO PRINTING
16FC   BD 18 65           JSR      OUTCH           ECHO TO USER
16FF   BD 16 25           JSR      AHV
1702   16                 TAB
1703   C4 7F              AND B    #$7F
1705   20 03              BRA      PTAP

                  **      RCRD - RECORD MEMORY DATA IN 'KCS' FORMAT
                  *
                  *       ENTRY:  (B) = 0
                  *       USES:   ALL,TO,T1,T2

1707   CB 09      RCRD    ADD B    #9
```

```
                    **      DUMP - RAW MEMORY DUMP 16 BYTES PER LINE
                    *
                    *       ENTRY:  (B) = 0
                    *       USES:   T0,T1,T2

1709   5A           DUMP    DEC B


                    **      PTAP - PUNCH TO TAPE
                    *
                    *       ENTRY:  DEFAULT VALUES ON STACK
                    *                BELOW RETURN ADDRESS
                    *       EXIT:   'C' SET FOR ERROR
                    *       USES:   ALL,T0,T1,T2

170A   30           PTAP    TSX
170B   37                   PSH B                   CASSETTE/TERMINAL FLAG
170C   BD 16 25             JSR     AHV             ACCUMULATE HEX
170F   24 0B                BCC     PTAP1           USE DEFAULT
1711   A7 03                STA A   3,X               STORE FWA
1713   E7 02                STA B   2,X
1715   BD 16 25             JSR     AHV
1718   A7 05                STA A   5,X
171A   E7 04                STA B   4,X
171C   A6 05        PTAP1   LDA A   5,X
171E   E6 04                LDA B   4,X             GET LWA, FWA
1720   EE 02                LDX     2,X
1722   DF EE                STX     T1
1724   97 F5                STA A   T2+1
1726   D7 F4                STA B   T2
1728   33                   PUL B


                    **      PUNCH - WRITE LOADER FILE TO TERMINAL OR CASSETTE
                    *
                    *       ENTRY:  (T1) = FWA BYTES TO PUNCH
                    *               (T2) = LWA BYTES TO PUNCH
                    *               (B) = CASSETTE TERMINAL FLAG:
                    *                  (B) > 0 THEN TO CASSETTE
                    *                      USING (B) CELLS PER BIT
                    *                  (B) = 0 THEN TO TERMINAL
                    *                  (B) < 0 THEN TO TERMINAL WITH
                    *                      IMBEDDED SPACES AND NO S1,ETC.
                    *       USES:   ALL,T0,T1

1729   5D           PUNCH   TST B
172A   2F 07                BLE     PNCH0
172C   BD 18 27             JSR     OLT             OUTPUT LEADER
172F   86 07                LDA A   #7
1731   20 02                BRA     PNCH1

1733   86 04        PNCH0   LDA A   #4              186 US
1735   4A           PNCH1   DEC A
1736   26 FD                BNE     PNCH1
1738   37                   PSH B                   SAVE FLAG;  160 US
1739   D6 F4                LDA B   T2              (BA) = END; 156 US
```

```
HEATH KEYBOARD MONITOR
PUNCH - PUNCH MEMORY

     173B  96 F5             LDA A   T2+1
     173D  90 EF             SUB A   T1+1
     173F  D2 EE             SBC B   T1          (BA) = END - CURRENT
     1741  25 58             BCS     PNCH9       DONE;   144 US
     1743  81 0F             CMP A   #15         140 US
     1745  C2 00             SBC B   #0
     1747  33                PUL B               RESTORE FLAG
     1748  24 02             BCC     PNCH2       AT LEAST FULL RECORD
     174A  20 03             BRA     PNCH3
     174C  86 0F    PNCH2    LDA A   #15
     174E  01                NOP
     174F  97 EC    PNCH3    STA A   T0          COUNTER
     1751  8B 04             ADD A   #4
     1753  97 ED             STA A   T0+1        BYTE COUNT
     1755  CE 17 B6          LDX     #S1STR      114 US
     1758  5D                TST B
     1759  2A 03             BPL     PNCH35
     175B  CE 17 C0          LDX     #CRSTR
     175E  8D 63    PNCH35   BSR     OAS         OUTPUT ASCII STRING
     1760  CE 00 EE          LDX     #T0+2
     1763  4F                CLR A               (A) = CHECKSUM
     1764  01                NOP
     1765  5D                TST B
     1766  2B 03             BMI     PNCH5
     1768  09                DEX
     1769  A5 00             BIT A   0,X         5 CYCLE NUTHIN'
     176B  01       PNCH5    NOP
     176C  01                NOP
     176D  8D 75             BSR     OCH         182 US
     176F  01                NOP
     1770  26 F9             BNE     PNCH5
     1772  DE EE             LDX     T1
     1774  8D 62    PNCH6    BSR     OSH         182 US
     1776  7A 00 EC          DEC     T0
     1779  2A F9             BPL     PNCH6
     177B  43                COM A
     177C  36                PSH A
     177D  01                NOP
     177E  86 07             LDA A   #7
     1780  4A       PNCH7    DEC A
     1781  26 FD             BNE     PNCH7
     1783  32                PUL A
     1784  5D                TST B
     1785  2B 02             BMI     PNCH75      NO CHECKSUM
     1787  8D 6E             BSR     OHB
     1789  B6 10 00 PNCH75   LDA A   TERM
     178C  43                COM A
     178D  49                ROL A
     178E  DF EE             STX     T1
     1790  DF EE             STX     T1
     1792  22 9F             BHI     PNCH0       NOT DONE; NO BREAK
     1794  08                INX
     1795  37                PSH B
     1796  86 06             LDA A   #6
     1798  4A       PNCH8    DEC A
     1799  26 FD             BNE     PNCH8
```

```
HEATH KEYBOARD MONITOR
PUNCH - PUNCH MEMORY

     179B   33          PNCH9    PUL B                    140 US
     179C   01                   NOP
     179D   86 03                LDA A    #3
     179F   4A          PNCHA    DEC A
     17A0   26 FD                BNE      PNCHA
     17A2   CE 17 BB             LDX      #S9STR
     17A5   5D                   TST B
     17A6   2B 0D                BMI      PNCHC           RETURN
     17A8   8D 19                BSR      OAS
     17AA   5D                   TST B
     17AB   27 08                BEQ      PNCHC           NOT CASSETTE
     17AD   86 13                LDA A    #19
     17AF   4A          PNCHB    DEC A
     17B0   26 FD                BNE      PNCHB
     17B2   8D 73                BSR      OLT
     17B4   0C                   CLC                      NO ERRORS
     17B5   39          PNCHC    RTS

     17B6   0D 0A 53    S1STR    FCB      CR,LF,'S1',0
     17BB   0D 0A 53    S9STR    FCB      CR,LF,'S9',0
     17C0   0D 0A 00    CRSTR    FCB      CR,LF,0

                        **       OAS - OUTPUT ASCII STRING
                        *
                        *        ENTRY:   (X) = ADDRESS OF STRING IN FORM:
                        *                   'STRING',0
                        *                 (B) = CASSETTE/TERM FLAG
                        *        EXIT:     X POINTS PAST END OF STRING ZERO
                        *        USES:     X,A,C

     17C3   A6 00       OAS      LDA A    0,X             97 US
     17C5   08                   INX
     17C6   8D 49       OAS1     BSR      OAB             88 US
     17C8   01                   NOP
     17C9   86 10                LDA A    #16            208 US
     17CB   4A          OAS2     DEC A
     17CC   26 FD                BNE      OAS2
     17CE   A6 00                LDA A    0,X
     17D0   08                   INX
     17D1   6D 00                TST      0,X
     17D3   26 F1                BNE      OAS1            NOT LAST BYTE
     17D5   08                   INX
     17D6   20 39                BRA      OAB             OUTPUT LAST AND RETURN

                        **       OSH - OUTPUT OPTIONAL SPACE WITH HEX BYTE
                        *
                        *        ENTRY:   (X) = ADDRESS OF BYTE
                        *                 (A) = CHECKSUM
                        *                 (B) = CASSETTE/TERMINAL FLAG
                        *        EXIT:    (X) INCREMENTED, (A) UPDATED
                        *        USES:    X,A,C

     17D8   AB 00       OSH      ADD A    0,X             174 US
     17DA   36                   PSH A
```

```
HEATH KEYBOARD MONITOR
OUTPUT ROUTINES

     17DB   86 05             LDA A   #5
     17DD   5D                TST B
     17DE   2A 09             BPL     OCHO            NO SPACE
     17E0   BD 18 63          JSR     OUTSP           OUTPUT SPACE
     17E3   32                PUL A

                       **     OCH - OUTPUT AND CHECKSUM HEX BYTE
                       *
                       *      ENTRY:  (X) = ADDRESS OF BYTE
                       *              (A) = CHECKSUM
                       *              (B) = CASSETTE/TERMINAL FLAG
                       *      EXIT:   (X) INCREMENTED, (A) UPDATED
                       *              'Z' SET IF END OF HEADER INFO
                       *      USES:   X,A,C

     17E4   AB 00      OCH    ADD A   0,X             174 US
     17E6   36                PSH A
     17E7   86 06             LDA A   #6
     17E9   01         OCHO   NOP
     17EA   4A         OCH1   DEC A
     17EB   26 FD             BNE     OCH1
     17ED   A6 00             LDA A   0,X
     17EF   8D 06             BSR     OHB
     17F1   32                PUL A
     17F2   08                INX
     17F3   8C 00 F0          CPX     #T1+2
     17F6   39                RTS                     16 US USED

                       **     OHB - OUTPUT HEX BYTE
                       *
                       *      ENTRY:  (A) = BYTE
                       *              (B) = CASSETTE TERMINAL FLAG
                       *      USES: A,C

     17F7   36         OHB    PSH A                   112 US
     17F8   44                LSR A
     17F9   44                LSR A
     17FA   44                LSR A
     17FB   44                LSR A
     17FC   8D 08             BSR     OHB2
     17FE   86 12             LDA A   #18             208 US
     1800   4A         OHB1   DEC A
     1801   26 FD             BNE     OHB1
     1803   32                PUL A
     1804   84 0F             AND A   #$F
     1806   81 0A      OHB2   CMP A   #10
     1808   24 02             BCC     OHB3            IS A - F
     180A   20 03             BRA     OHB4
     180C   01         OHB3   NOP
     180D   8B 07             ADD A   #7
     180F   8B 30      OHB4   ADD A   #$30
```

HEATH KEYBOARD MONITOR
OUTPUT ROUTINES

```
                    **      OAB - OUTPUT ASCII BYTE
                    *
                    *       ENTRY:  (A) = ASCII
                    *               (B) = CASSETTE/TERMINAL FLAG
                    *       EXIT:   (A) PRESERVED
                    *       USES:   C

  1811  5D          OAB     TST B                   80 US
  1812  2F 51               BLE     OUTCH


                    **      OCB - OUTPUT CASSETTE BYTE
                    *
                    *       ENTRY:  (B) = CELLS/BIT COUNT
                    *               (A) = CHARACTER
                    *       USES:   C

  1814  0C          OCB     CLC                     START BIT; 74 US
  1815  8D 27               BSR     BIT1            72 US
  1817  36                  PSH A                   208 US
  1818  0D                  SEC                     STOP BIT
  1819  46                  ROR A
  181A  8D 1B       OCB1    BSR     BIT             200 US
  181C  01                  NOP                     208 US
  181D  44                  LSR A
  181E  26 FA               BNE     OCB1
  1820  8D 15               BSR     BIT
  1822  32                  PUL A
  1823  08                  INX
  1824  09                  DEX                     8 CYCLE PSEUDO-NOP
  1825  20 10               BRA     BIT


                    **      OLT - OUTPUT LEADER TRAILER
                    *
                    *       ENTRY:  NONE
                    *       EXIT:   5 SECONDS MARKING WRITTEN
                    *       USES:   C

  1827  0D          OLT     SEC                     78 US
  1828  36                  PSH A
  1829  8D 13               BSR     BIT1
  182B  37                  PSH B
  182C  C6 6E               LDA B   #110
  182E  17                  TBA
  182F  8D 06       OLT1    BSR     BIT
  1831  01                  NOP
  1832  4A                  DEC A
  1833  26 FA               BNE     OLT1
  1835  33                  PUL B
  1836  32                  PUL A
```

HEATH KEYBOARD MONITOR
OUTPUT ROUTINES

```
                          **      BIT - OUTPUT 'C' TO CASSETTE
                          *
                          *       ENTRY:  (B) = CELL/BIT COUNT
                          *               'C' = BIT
                          *       USES:   C EXCEPT 'C'

  1837   36               BIT     PSH A                         192 US
  1838   86 15                    LDA A   #21
  183A   01                       NOP
  183B   01                       NOP
  183C   20 03                    BRA     BIT3                  182 US

  183E   36               BIT1    PSH A                         64 US
  183F   86 01                    LDA A   #1
  1841   37               BIT3    PSH B
  1842   8C                       FCB     $8C                   3 CYCLE SKIP
  1843   86 1D            BIT4    LDA A   #29
  1845   4A               BIT5    DEC A
  1846   26 FD                    BNE     BIT5
  1848   4C                       INC A
  1849   8D 10                    BSR     FLIP                  43 US
  184B   86 1E                    LDA A   #30
  184D   4A               BIT6    DEC A
  184E   26 FD                    BNE     BIT6
  1850   07                       TPA
  1851   84 01                    AND A   #1                    MASK TO CARRY
  1853   8D 07                    BSR     FLIP1
  1855   5A                       DEC B
  1856   26 EB                    BNE     BIT4
  1858   33                       PUL B
  1859   32                       PUL A
  185A   39                       RTS          ..... ALL TIMES REFERENCED HERE !!!


                          **      FLIP - FLIP CASSETTE BIT
                          *
                          *       ENTRY:  (A) = 0 THEN NO FLIP
                          *               (A) = 1 THEN FLIP
                          *       USES:   A,C EXCEPT 'C'

  185B   01               FLIP    NOP                           35 US
  185C   B8 10 02         FLIP1   EOR A   TAPE
  185F   B7 10 02                 STA A   TAPE
  1862   39                       RTS                           24 US


                          **      OUTSP - OUTPUT SPACE TO TERMINAL
                          *
                          *       ENTRY:  NONE
                          *       EXIT:   (A) = ' '
                          *       USES:   A,C

  1863   86 20            OUTSP   LDA A   #' '
```

HEATH KEYBOARD MONITOR
OUTPUT ROUTINES

```
                    **      OUTCH - OUTPUT CHARACTER TO TERMINAL
                    *
                    *       ENTRY:  (A) = CHARACTER
                    *       EXIT:   (A) PRESERVED UNLESS -LF-
                    *       USES:   C

 1865  36           OUTCH   PSH A
 1866  37                   PSH B
 1867  8D 21                BSR     BRD            BAUD RATE DETERMINE
 1869  0D                   SEC                    STOP BIT
 186A  8D 32                BSR     WOB
 186C  0C                   CLC                    START BIT
 186D  8D 2F                BSR     WOB
 186F  0D                   SEC
 1870  46                   ROR A
 1871  8D 2B        OUTC1   BSR     WOB            WAIT - OUTPUT BIT
 1873  44                   LSR A
 1874  26 FB                BNE     OUTC1
 1876  8D 26                BSR     WOB            WAIT; OUTPUT STOP
 1878  33                   PUL B
 1879  32                   PUL A
 187A  81 0A                CMP A   #LF
 187C  26 0B                BNE     OUTC2
 187E  36                   PSH A
 187F  4F                   CLR A
 1880  8D E3                BSR     OUTCH          OUTPUT FILL CHARACTER
 1882  8D E1                BSR     OUTCH
 1884  8D DF                BSR     OUTCH
 1886  8D DD                BSR     OUTCH
 1888  32                   PUL A
 1889  39           OUTC2   RTS


                    **      BRD - BAUD RATE DETERMINATION
                    *
                    *       ENTRY:  NONE
                    *       EXIT:   (B) = BAUD RATE DIVISOR
                    *                     (COMPENSATED FOR 5*13 EXTRA
                    *                       EXECUTION TIME!!)
                    *       USES:   B,C

 188A  36           BRD     PSH A
 188B  C6 01                LDA B   #1             ASSUME 110 BAUD
 188D  B6 10 00             LDA A   TERM            BAUD SWITCH DATA
 1890  43                   COM A
 1891  84 0E                AND A   #1110B         MASK TO SWITHCES
 1893  44                   LSR A
 1894  27 06                BEQ     BRD2           IS 110
 1896  56           BRD1    ROR B
 1897  4A                   DEC A
 1898  26 FC                BNE     BRD1
 189A  C0 05                SUB B   #5             EXECUTION COMPENSATION
 189C  32           BRD2    PUL A
 189D  39                   RTS
```

```
HEATH KEYBOARD MONITOR
OUTPUT ROUTINES

                        **      WOB - WAIT AND OUTPUT BIT
                        *
                        *       ENTRY:  (B) = DELAY COUNT
                        *               'C' = BIT
                        *       EXIT:   (B), 'C' PRESERVED
                        *       USES:   C

189E   37               WOB     PSH B
189F   8D 72                    BSR     DLB             DELAY ONE BIT
18A1   20 68                    BRA     WIB1

                        **      IHD - INPUT HEX DIGIT FROM TERMINAL
                        *
                        *       ENTRY:  NONE
                        *       EXIT:   (A) = HEX VALUE IF VALID
                        *                     ASCII OTHERWISE
                        *               'C' SET IF HEX
                        *               'Z' SET IF CR
                        *       USES:   A,C

18A3   8D 3C            IHD     BSR     INCH
18A5   81 20                    CMP A   #SPACE
18A7   27 FA                    BEQ     IHD             IGNORE SPACES

                        **      ASH - ASCII TO HEX TRANSLATOR
                        *
                        *       ENTRY:  (A) = ASCII
                        *       EXIT, USES: SEE 'IHD'

18A9   80 30            ASH     SUB A   #'0'
18AB   25 0C                    BCS     ASH1            NOT HEX
18AD   81 0A                    CMP A   #10
18AF   25 10                    BCS     ASH3
18B1   80 11                    SUB A   #'A'-'0'
18B3   81 06                    CMP A   #6
18B5   25 08                    BCS     ASH2            IS HEX
18B7   8B 11                    ADD A   #'A'-'0'        DISPLACE BACK
18B9   8B 30            ASH1    ADD A   #'0'
18BB   81 0D                    CMP A   #CR
18BD   0C                       CLC
18BE   39                       RTS

18BF   80 F6            ASH2    SUB A   #-10
18C1   39               ASH3    RTS

                        **      IHB - INPUT HEX BYTE
                        *
                        *       ENTRY:  (B) = CASSETTE/TERMINAL FLAG
                        *               (X) = ADDRESS
                        *               (A) = CHECKSUM
                        *       EXIT:   A, X UPDATED
                        *               (B) PRESERVED
```

HEATH KEYBOARD MONITOR
INPUT ROUTINES

```
18C2  36        IHB    PSH A              SAVE CHECKSUM
18C3  8D 19            BSR     ICT        INPUT CASSETTE/TERMINAL
18C5  84 7F            AND A   #7FH
18C7  8D E0            BSR     ASH        ASCII - HEX
18C9  48               ASL A
18CA  48               ASL A
18CB  48               ASL A
18CC  48               ASL A
18CD  97 EC            STA A   TO
18CF  8D 0D            BSR     ICT        INPUT CASSETTE/TERMINAL
18D1  84 7F            AND A   #7FH
18D3  8D D4            BSR     ASH        ASCII - HEX
18D5  9B EC            ADD A   TO
18D7  A7 00            STA A   0,X        PLACE IN MEMORY
18D9  32               PUL A
18DA  AB 00            ADD A   0,X
18DC  08               INX
18DD  39        IHB2   RTS

                **     ICT - INPUT FROM CASSETTE OR TERMINAL
                *
                *      ENTRY:  (B) = CASSETTE/TERMINAL FLAG
                *      EXIT:   (A) = CHARACTER
                *      USES:   A,C

18DE  5D        ICT    TST B
18DF  2E 54            BGT     ICC        IS CASSETTE

                **     INCH - INPUT TERMINAL CHARACTER
                *
                *      ENTRY:  NONE
                *      EXIT:   (A) = CHARACTER
                *      USES:   A,C

18E1  37        INCH   PSH B
18E2  8D A6            BSR     BRD        BAUD RATE DETERMINE
18E4  17               TBA
18E5  16        INC1   TAB
18E6  54               LSR B
18E7  5C               INC B
18E8  7D 10 00  INC2   TST     TERM
18EB  2B FB            BMI     INC2       WAIT FOR SPACING
18ED  8D 15            BSR     WIB        WAIT, INPUT START
18EF  25 F7            BCS     INC2       WAS NOISE
18F1  16               TAB
18F2  86 80            LDA A   #80H
18F4  8D 0E     INC3   BSR     WIB        WAIT; INPUT BIT
18F6  46               ROR A
18F7  24 FB            BCC     INC3
18F9  8D 09            BSR     WIB        GET STOP
18FB  25 03            BCS     INC4       NO FRAME ERROR
18FD  7C 10 00         INC     TERM         SEND STOP BIT
1900  84 7F     INC4   AND A   #$7F       MASK TO SEVEN BITS
1902  33               PUL B
```

```
HEATH KEYBOARD MONITOR
INPUT ROUTINES

    1903  39               RTS

                     **    WIB - WAIT AND INPUT BIT
                     *
                     *     ENTRY:  (B) = DELAY COUNT
                     *     EXIT:   'C' = BIT
                     *     USES:   C

    1904  37         WIB   PSH B
    1905  8D 0C            BSR     DLB          WAIT ONE BIT TIME
    1907  CB 80            ADD B   #80H
    1909  C0 80            SUB B   #80H
    190B  C9 00      WIB1  ADC B   #0           COPY BIT INTO LSB
    190D  F7 10 00         STA B   TERM
    1910  56               ROR B                RESTORE SMASHED 'C'
    1911  33               PUL B
    1912  39               RTS

                     **    DLB - DELAY ONE BIT AND RETURN (TERM) IN B
                     *
                     *     ENTRY:  (B) = DELAY CONSTANT
                     *     EXIT:   (B) = (TERM) .AND. 11111110 B
                     *     USES:   C EXCEPT 'C'

    1913  C5 FE      DLB   BIT B   #0FEH
    1915  26 11            BNE     DLB4         NOT 110 BAUD
    1917  5A               DEC B
    1918  27 02            BEQ     DLB1         110 FULL BIT TIME
    191A  C6 38            LDA B   #56
    191C  C8 31      DLB1  EOR B   #49
    191E  36               PSH A
    191F  86 12      DLB2  LDA A   #18
    1921  4A         DLB3  DEC A
    1922  26 FD            BNE     DLB3
    1924  5A               DEC B
    1925  26 F8            BNE     DLB2
    1927  32               PUL A
    1928  BC 19 13   DLB4  CPX     DLB          5 CYCLE NUTHIN'
    192B  01               NOP
    192C  5A               DEC B
    192D  26 F9            BNE     DLB4
    192F  F6 10 00         LDA B   TERM
    1932  C4 FE            AND B   #$FE
    1934  39               RTS

                     **    ICC - INPUT CASSETTE CHARACTER
                     *
                     *     GETS BITS FROM CASSETTE IN SERIAL FASHION
                     *     EACH BIT CONSISTS OF SEVERAL 'CELLS'
                     *     EACH CELL IS EITHER 1/2 CYCLE OF 1200HZ
                     *                         OR   1 CYCLE OF 2400HZ
                     *     AT 8 CELLS/BIT THE ROUTINE IS 'KCS'
                     *       COMPATIBLE
```

HEATH KEYBOARD MONITOR
INPUT ROUTINES

```
                    *
                    *      ENTRY:   (B) = CELLS PER BIT
                    *      EXIT:    (A) = CHARACTER
                    *               'C' = STOP BIT
                    *      USES:    A,C

1935  37            ICC    PSH B
1936  54                   LSR B
1937  8D 1E         ICC1   BSR      TNC              TAKE NEXT CELL
1939  25 FC                BCS      ICC1             NOT START BIT
193B  5A                   DEC B
193C  2A F9                BPL      ICC1             NOT ENOUGH CELLS
193E  33                   PUL B
193F  86 7F                LDA A    #01111111B       PRESET ASSEMBLY
1941  37            ICC2   PSH B
1942  36                   PSH A
1943  8D 12         ICC3   BSR      TNC              TAKE NEXT CELL
1945  5A                   DEC B
1946  26 FB                BNE      ICC3
1948  32                   PUL A
1949  33                   PUL B
194A  46                   ROR A
194B  25 F4                BCS      ICC2
194D  37                   PSH B
194E  36                   PSH A
194F  8D 06         ICC4   BSR      TNC              GET STOP BIT
1951  5A                   DEC B
1952  26 FB                BNE      ICC4
1954  32                   PUL A
1955  33                   PUL B
1956  39                   RTS

                    **     TNC - TAKE NEXT CELL
                    *
                    *      WAITS FOR 1/2 CYCLE OF 1200 HZ OR
                    *               1 CYCLE OF 2400 HZ
                    *      STRUCTURE ASSURES EXIT AT END OF
                    *       ZERO CELL
                    *
                    *      ENTRY:   NONE
                    *      EXIT:    'C' = CELL VALUE
                    *               (A) = NEW CASSETTE DATA
                    *      USES:    A,C

1957  B6 10 02      TNC    LDA A    TAPE
195A  8D 02                BSR      TNC1
195C  24 0E                BCC      TNC3             WAS ZERO
195E  37            TNC1   PSH B
195F  5F                   CLR B
1960  5C            TNC2   INC B
1961  B1 10 02             CMP A    TAPE
1964  27 FA                BEQ      TNC2             NO TRANSITION
1966  B6 10 02             LDA A    TAPE
1969  C1 1D                CMP B    #29
196B  33                   PUL B
```

HEATH KEYBOARD MONITOR
INPUT ROUTINES

```
1960  39          TNC3    RTS

                  **      MOVE - REENTRANT MOVE MEMORY
                  *
                  *       ENTRY:  STACK>  RETURN (0,S)
                  *                       COUNT  (2,S)
                  *                       TO     (4,S)
                  *                       FROM   (6,S)
                  *       EXIT:   STACK CLEANED
                  *       USES:   ALL

196D  30          MOVE    TSX
196E  EE 02               LDX     2,X           CHECK COUNT <> 0
1970  27 74               BEQ     MOV4          NO MOVE
1972  30          MOVEA   TSX                   ** ALTERNATE ENTRY **
1973  A6 05               LDA A   5,X           (BA) = TO
1975  E6 04               LDA B   4,X
1977  A0 07               SUB A   7,X           (BA) = TO - FROM
1979  E2 06               SBC B   6,X
197B  25 24               BCS     MOV2          IS MOVE DOWN
197D  26 03               BNE     MOV1
197F  4D                  TST A
1980  27 64               BEQ     MOV4          DISPLACEMENT = 0

                  *       HAVE MOVE UP - MUST START AT TOP
                  *          TO AVOID CONFLICT

1982  86 FF       MOV1    LDA A   #-1           (BA) = -1
1984  16                  TAB
1985  36                  PSH A                 DELTA = -1
1986  37                  PSH B
1987  AB 03               ADD A   3,X           (BA) = COUNT - 1
1989  E9 02               ADC B   2,X
198B  36                  PSH A
198C  37                  PSH B
198D  AB 05               ADD A   5,X           TO = TO + COUNT - 1
198F  E9 04               ADC B   4,X
1991  A7 05               STA A   5,X
1993  E7 04               STA B   4,X
1995  33                  PUL B
1996  32                  PUL A
1997  AB 07               ADD A   7,X           FROM = FROM
1999  E9 06               ADC B   6,X             + COUNT - 1
199B  A7 07               STA A   7,X
199D  E7 06               STA B   6,X
199F  20 0E               BRA     MOV3

                  *       HAVE MOVE DOWN - MAY START AT TOP

19A1  86 01       MOV2    LDA A   #1            DELTA = 1
19A3  5F                  CLR B
19A4  36                  PSH A
19A5  37                  PSH B
19A6  4F                  CLR A
19A7  A0 03               SUB A   3,X           (BA) = - COUNT
```

HEATH KEYBOARD MONITOR
MOVE - MOVE SUBROUTINE

```
19A9  E2 02          SBC B   2,X
19AB  A7 03          STA A   3,X
19AD  E7 02          STA B   2,X          COUNT = - COUNT

               *     ACTUAL MOVE LOOP FOLLOWS

19AF  30       MOV3  TSX
19B0  EE 08          LDX     8,X
19B2  A6 00          LDA A   0,X
19B4  30             TSX
19B5  EE 06          LDX     6,X
19B7  A7 00          STA A   0,X
19B9  30             TSX
19BA  A6 01          LDA A   1,X          BUMP *FROM*
19BC  E6 00          LDA B   0,X
19BE  AB 09          ADD A   9,X
19C0  E9 08          ADC B   8,X
19C2  A7 09          STA A   9,X
19C4  E7 08          STA B   8,X
19C6  A6 01          LDA A   1,X          BUMP *TO*
19C8  E6 00          LDA B   0,X
19CA  AB 07          ADD A   7,X
19CC  E9 06          ADC B   6,X
19CE  A7 07          STA A   7,X
19D0  E7 06          STA B   6,X
19D2  A6 01          LDA A   1,X          BUMP *COUNT*
19D4  E6 00          LDA B   0,X
19D6  AB 05          ADD A   5,X
19D8  E9 04          ADC B   4,X
19DA  A7 05          STA A   5,X
19DC  E7 04          STA B   4,X
19DE  26 CF          BNE     MOV3         COUNT <> 0
19E0  4D             TST A
19E1  26 CC          BNE     MOV3
19E3  31             INS
19E4  31             INS                  DISCARD DELTA
19E5  30             TSX

19E6  EE 00    MOV4  LDX     0,X
19E8  31             INS
19E9  31             INS
19EA  31             INS
19EB  31             INS
19EC  31             INS
19ED  31             INS
19EE  31             INS
19EF  31             INS
19F0  6E 00          JMP     0,X
```

HEATH KEYBOARD MONITOR
TABLES

```
                        **      COMMAND TABLE

19F2   54               CMDTAB  FCB     'T'         TAPE RECORD DATA
19F3   17 07                    FDB     RCRD

19F5   53                       FCB     'S'         STEP USER CODE
19F6   15 50                    FDB     STEP

19F8   52                       FCB     'R'         DISPLAY USER REGISTERS
19F9   15 53                    FDB     REGS

19FB   50                       FCB     'P'         PUNCH TO PAPER TAPE
19FC   17 0A                    FDB     PTAP

19FE   4D                       FCB     'M'         DISPLAY MEMORY (BYTE)
19FF   15 AC                    FDB     MEM

1A01   4C                       FCB     'L'         LOAD FROM TAPE
1A02   16 A5                    FDB     LOAD

1A04   49                       FCB     'I'         DISPLAY MEMORY (INST)
1A05   15 AD                    FDB     INST

1A07   48                       FCB     'H'         HALTPOINT INSERT
1A08   14 F3                    FDB     BKPT

1A0A   47                       FCB     'G'         GO TO USER CODE
1A0B   14 8F                    FDB     GO

1A0D   45                       FCB     'E'         MULTIPLE STEP
1A0E   15 39                    FDB     EXEC

1A10   44                       FCB     'D'         DUMP MEMORY
1A11   17 09                    FDB     DUMP

1A13   43                       FCB     'C'
1A14   15 12                    FDB     CLEAR       BREAKPOINT CLEAR

1A16   42                       FCB     'B'         GO TO BASIC
1A17   1C 03                    FDB     1C03H       WARM START ENTRY

1A19   18                       FCB     'X'-40H     DISPLAY INDEX
1A1A   15 8E                    FDB     REGX

1A1C   14                       FCB     'T'-40H     HI SPEED TAPE
1A1D   16 FA                    FDB     CTLT

1A1F   13                       FCB     'S'-40H     SLIDE MEMORY!!
1A20   16 7B                    FDB     COPY

1A22   10                       FCB     'P'-40H     DISPLAY P.C.
1A23   15 8C                    FDB     REGP

1A25   08                       FCB     'H'-40H     HALTPOINT LIST
1A26   15 FB                    FDB     DISB
```

HEATH KEYBOARD MONITOR
TABLES

```
1A28  03                  FCB    'C'-40H         DISPLAY CONDX
1A29  15 92               FDB    REGC

1A2B  02                  FCB    'B'-40H         DISPLAY B ACC.
1A2C  15 91               FDB    REGB

1A2E  01                  FCB    'A'-40H         DISPLAY A ACC.
1A2F  15 90               FDB    REGA

1A31  00                  FCB    '@'-40H         EXIT TO OLD MONITOR
1A32  FC 00               FDB    $FC00


                   **     MTST - MEMORY DIAGNOSTIC
                   *
                   *        DISPLAYS LWA IN 'ADDR' FIELD ON LEDS
                   *              CURRENT TEST PATTERN IN 'DATA'
                   *      ENTRY:  NONE
                   *      EXIT:   FAILED ADDRESS/PATTERN DISPLAYED
                   *                PROCESSOR HALTED
                   *      USES: ALL,T0,T1,DIGADD

1A34  0F           MTST   SEI
1A35  8D 49               BSR    FTOP            FIND TOP OF MEMORY
1A37  35                  TXS                    STACK AT TOP
1A38  31                  INS
1A39  6F 00        MTS2   CLR    0,X
1A3B  09                  DEX
1A3C  26 FB               BNE    MTS2            CLEAR ALL MEMORY
1A3E  6F 00               CLR    0,X
1A40  9F EE               STS    T1              HOPE THIS IS GOOD!!
1A42  8E 00 EB            LDS    #T0-1
1A45  BD FC BC            JSR    REDIS           RESET DISPLAYS
1A48  CE 00 EE            LDX    #T1
1A4B  C6 02               LDA B  #2
1A4D  BD FD 7B            JSR    DISPLAY         OUTPUT LWA FOUND
1A50  4F                  CLR A
1A51  5A                  DEC B
1A52  BD FE 20     MTS3   JSR    OUTBYT          OUTPUT PATTERN
1A55  36                  PSH A
1A56  BD FD 43            JSR    BKSP            BACKSPACE DISPLAYS
1A59  32                  PUL A
1A5A  DE EE               LDX    T1
1A5C  A1 00        MTS4   CMP A  0,X
1A5E  26 13               BNE    MTS6            FAILURE!
1A60  6C 00               INC    0,X
1A62  09                  DEX
1A63  8C 00 F1            CPX    #DIGADD+1       SKIP CONTAMINATED AREA
1A66  26 03               BNE    MTS5
1A68  CE 00 DF            LDX    #T0-13
1A6B  8C FF FF     MTS5   CPX    #-1
1A6E  26 EC               BNE    MTS4
1A70  4C                  INC A
1A71  20 DF               BRA    MTS3

1A73  DF EE        MTS6   STX    T1
```

```
HEATH KEYBOARD MONITOR
MEMORY DIAGNOSTIC

     1A75  BD FC BC          JSR      REDIS             RESET DISPLAYS
     1A78  CE 00 EE          LDX      #T1
     1A7B  5C                INC B
     1A7C  BD FD 7B          JSR      DISPLAY
     1A7F  3E                WAI

                       **    FTOP - FIND MEMORY TOP
                       *
                       *     SEARCHES DOWN FROM 1000H UNTIL FINDS
                       *       GOOD MEMORY
                       *
                       *     ENTRY:   NONE
                       *     EXIT:    (X) = LWA MEMORY
                       *     USES:    X

     1A80  36          FTOP  PSH A
     1A81  CE 10 00          LDX      #TERM             TOP OF MEMORY+1
     FFFF                    IF       DEBUG-1
                             ENDIF
     1A84  86 55             LDA A    #55H              TEST PATTERN
     1A86  09          FT01  DEX
     1A87  A7 00             STA A    0,X
     1A89  A1 00             CMP A    0,X
     1A8B  26 F9             BNE      FT01
     1A8D  32                PUL A
     1A8E  39                RTS

                       **    CCD - CONSOLE CASSETTE DUMP
                       *
                       *     ENTRY: NONE
                       *     EXIT:  TO LED MONITOR
                       *     USES:  ALL,T0,T1,T2

     1A8F  C6 08       CCD   LDA B    #8
     1A91  8D 42             BSR      IN.PIA            INITALIZE PIA
     1A93  8E 00 EB          LDS      #T0-1
     1A96  37                PSH B
     1A97  BD FC 86          JSR      OUTSTA
     1A9A  47 85             FCB      47H,05H+80H       'FR'
     1A9C  CE 00 EE          LDX      #T1
     1A9F  C6 02             LDA B    #2
     1AA1  BD FC BC          JSR      REDIS             RESET DISPLAYS
     1AA4  BD FD 25          JSR      PROMPT            PROMPT FWA
     1AA7  BD FC 86          JSR      OUTSTA
     1AAA  0E FD             FCB      0EH,7DH+80H       'LA'
     1AAC  BD FC BC          JSR      REDIS             RESET DISPLAYS
     1AAF  CE 00 F4          LDX      #T2
     1AB2  BD FD 25          JSR      PROMPT            PROMPT LWA
     1AB5  33                PUL B
     1AB6  BD 17 29          JSR      PUNCH
     1AB9  7E FC 00    CCD1  JMP      $FC00             EXIT TO MONITOR
```

HEATH KEYBOARD MONITOR
LED MONITOR TAPE PROCESSORS

```
                        **      CCL - CONSOLE CASSETTE LOAD
                        *
                        *       ENTRY:  NONE
                        *       EXIT:   TO CONSOLE MONITOR IF SUCESS
                        *       USES:   ALL,TO,HIGHEST MEMORY

1ABC  C6 08             CCL     LDA B   #8
1ABE  8D 15                     BSR     IN.PIA          INITIALIZE PIA
1AC0  8D BE                     BSR     FTOP            FIND MEMORY TOP
1AC2  35                        TXS
1AC3  31                        INS
1AC4  BD 16 AD                  JSR     LOAO            LOAD MEMORY
1AC7  24 F0                     BCC     CCD1            NORMAL RETURN
1AC9  BD FC BC                  JSR     REDIS             PRINT ERROR MESSAGE
1ACC  BD FE 52                  JSR     OUTSTR
1ACF  4F 05 05                  FCB     4FH,05H,05H,1DH,05H+80H
1AD4  3E                        WAI

                        **      IN.PIA - INITIALIZE PIA FOR LED MONITOR
                        *
                        *       INITIALIZE CASSETTE SIDE FOR LOAD OR DUMP
                        *        AND SET (TERM) SO THAT A BREAK IS NOT
                        *         SENSED.
                        *
                        *       ENTRY:  NONE
                        *       EXIT:   NONE
                        *       USES:   A,X

1AD5  CE 10 00          IN.PIA  LDX     #TERM
1AD8  6F 01                     CLR     1,X
1ADA  6F 03                     CLR     3,X
1ADC  86 80                     LDA A   #10000000B
1ADE  A7 00                     STA A   0,X             INTO DDR
1AE0  43                        COM A
1AE1  A7 02                     STA A   2,X             INITIALIZE CASSETTE
1AE3  86 04                     LDA A   #4
1AE5  A7 03                     STA A   3,X
1AE7  39                        RTS

                                LON     L

                        **      TTST - TERMINAL TESTER
                        *
                        *       ENTRY:  NONE
                        *       EXIT:   NEVER

1AF6  86 01             TTST    LDA A   #1
1AF8  B7 10 00                  STA A   TERM
1AFB  C6 04                     LDA B   #4
1AFD  F7 10 01                  STA B   TERM.C
1B00  BD 16 18          TTSO    JSR     OUTIS
1B03  0D 0A 54                  FCB     CR,LF,'THIS IS A TERMINAL TEST',0
1B1D  20 E1                     BRA     TTSO
```

```
HEATH KEYBOARD MONITOR
TERMINAL TEST

    1B1F                         END




STATEMENTS =1632

FREE BYTES =16823

NO ERRORS DETECTED
```

APPENDIX D

Excerpts from "Kilobaud"

The following magazine articles have been reproduced with permission from Kilobaud. They provide entertaining and educational material that enables you to more fully appreciate and enjoy your ETA-3400 microcomputer accessory.

The programs will not necessarily run as is on your computer accessory, but with some modifications you can run the programs.

Ron Anderson
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Tiny Basic

Issue #1 of *Kilobaud* contained an article by Tom Pittman describing his Tiny BASIC. As a very optimistic owner of a new KIM-1, and with a SWTP CT-1024 TV terminal on order, I sent my order off to Tom's Itty Bitty Computer Company, and soon my Tiny BASIC listing arrived. Lacking the terminal, I spent a Saturday loading Tiny by hand with the hex keyboard and verifying it. When the last kit of the TV terminal arrived, I loaded Tiny. A close reading of the instructions indicated that I had to insert some I/O jump addresses. This done, Tiny ran with nothing more than operator problems.

It was not hard to begin programming some of the simpler games from *Basic Computer Games* published by Digital Equipment Corp.

As limited as it is, using only 2½K of memory (I had added an Econoram 4K expansion to my KIM), a great deal can be done with it that is not obvious on first glance.

At the bargain price of $5 I didn't expect a full course in BASIC programming. But there are some features that are not obvious and could be expanded upon for those of us who are rank beginners.

First, here are a couple of ways to save memory:

1. PRINT may be abbreviated PR in all cases. For example:

```
50 PR"HI THERE!"
```

2. Tiny needs no spaces in the program statements. A listing is hard to read without them, but it is better than running out of memory.

3. Tiny has no absolute value function. This can be implemented easily as follows:

```
100 IF A<0 A=-A
```

4. Tiny has no ON N GOTO statement (see Example 1).

```
150 ON N GOTO (100,110,120,130)
```

Example 1.

The following allows the same results:

```
60 GOTO 100+10*N
```

This is particularly useful in implementing a game like Bombers (see *Basic Computer Games*). Here the player is given a multiple choice, and the number he enters (N) determines a branch in the program.

My TV typewriter is the kind that "pages"; when the screen fills, it "flips" a page and starts to fill it from the top. If output such as instructions extends to more than one full page, it is lost before it can be read. This would also be a problem with a scrolling display, particularly if the TVT is running at 1200 baud. The program can contain a "pause for read" which can be implemented easily at the desired point.

```
100 T=0
105 T=T+1
110 IF T<150 GOTO 105
```

The T less-than number may be adjusted for a suitable time delay. These steps may be a subroutine, and T may be randomized by Example 2.

```
110 IF T<(RND(150)+10) GOTO 105
115 RETURN
```

Example 2.

The delay loop is used to add interest to a game, where the computer outputs "LET ME THINK A MOMENT . . ." and that is what seems to be happening.

I've made my Hunt the Hurkle game a little more interesting for a first-time player by including a random 1 out of 15 chance of seeming confusion on the part of the computer. The result is that instead of the normal THE HURKLE IS HIDING message, the printout is as shown in Example 3.

```
THE HURDLE IS HIKING        (pause random time)
NO, THAT'S NOT RIGHT        (pause random time)
THE HIDEL IS HURKING.       (pause random time)
NOW WAIT A MINUTE!          (pause random time)
THE HURKLE IS HIDING.
```

Example 3.

Here the program resumes its regular course.

Last but not least, Tiny BASIC lacks any kind of string manipulation. It is possible to get around this by using Y and N for Yes and No responses as shown in Example 4.

```
50 PR"WANT TO PLAY AGAIN";
60 Y=1
70 N=0
80 INPUT R
85 REMARK R FOR RESPONSE
90 IF R=1 GOTO 10
100 PR"THANKS FOR PLAYING. HOPE YOU ENJOYED IT"
999 END
```

Example 4.

A little ingenuity allows many tricks in Tiny BASIC. Use a little imagination, and it can be great fun.

I started out in this hobby with full intentions never to waste time playing games with my computer. Obviously I've changed my mind. The reason is that programming games seems to be a very good way to learn all the tricks and non-tricks of programming in BASIC. I still intend to do a lot of machine language programming, but I can't imagine a way to learn BASIC faster than by using it to program a game. Thanks, Tom Pittman, for Tiny BASIC. It really works. ■

Along with pointing out the differences between Tiny BASIC and standard BASIC, Tom offers here some comments and opinions on BASIC and structured programming. Interestingly, his manuscript is one of the few we've received which was prepared using a text editor (a Model 37 TTY driven by a COSMAC 1802 microprocessor). It would seem that more of us (including myself) should be at this stage by now. – John.

Tiny Basic

... a mini-language for your micro

Tom Pittman
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San Jose CA 95153

If you have an Altair or IMSAI computer or any 8080-based system, you have your choice of several versions of BASIC. There are rumors of BASIC for 6800 and 6502 within the next few months. But these require memory – probably more than you have with your low budget machine.

The alternative is *Tiny BASIC*. The language is a stripped down version of regular BASIC, with integer variables only – no strings, no arrays, and a limited set of statement types. It was first proposed by Bob Albrecht, the "dragon" of Peoples Computer Company (PCC) in Menlo Park, as a language for teaching programming to children. The PCC newspaper ran a series of articles (largely written by Dennis Allison) entitled "Build Your Own BASIC," suggesting how Tiny BASIC might be implemented in a microprocessor. The important portions of these articles have been reprinted in Dr. Dobb's *Journal of Computer Calisthenics and Orthodontia*, published by PCC and available in most computer stores.

BASIC

Before we get into Tiny BASIC, let us look at high level languages in general and BASIC in particular.

When you program in machine language, each command, or statement, represents one operation from the machine's point of view. When we think of a single concept like, "A is the sum of B and C," a machine language program to perform this operation may take several operations, such as:

```
LDA  B
LDA  C
STO  A
```

A high level language, on the other hand, lets you put a single human idea into a single program statement, for instance:

```
LET A = B + C
```

BASIC is one of a class of "algebraic" languages in that it permits the representation of algebraic formulae as part of the language. Other languages in this class are FORTRAN and ALGOL. COBOL does not generally fall in this class (except for the "super" versions).

Of critical importance to all algebraic languages is the concept of an expression. An expression is the programming language notation for what we might think of as "the right-hand side of a formula." Alternatively, we can think of an expression as "a way of expressing the value of some number which the computer is to compute."

An expression may consist of a single number, a single variable name (all variables are referred to by name in high level languages), a single function call (discussed in detail later), or some combination of these, separated by operators and possibly grouped by parentheses. For this discussion, when we refer to an operator, we mean one of the four functions found on a cheap pocket calculator: addition symbolized by " + "; subtraction by " - "; multiplication by " * " (we do not use "X" because that would be confused with the name of the variable "X"); and division by " / ". (The usual symbol for division does not appear on most typewriter and computer keyboards.) Thus,

$$\frac{A-B}{C-D}$$

becomes, in computerese,

```
(A - B) / (C - D)
```

Here the parentheses are used to indicate priority of operations. Normally multiplication and division are performed first, then addition and subtraction. Without the parentheses the expression,

$$\frac{A-B}{C-D}$$

would be understood by the high level language as,

$$a - \frac{B}{C} \quad d$$

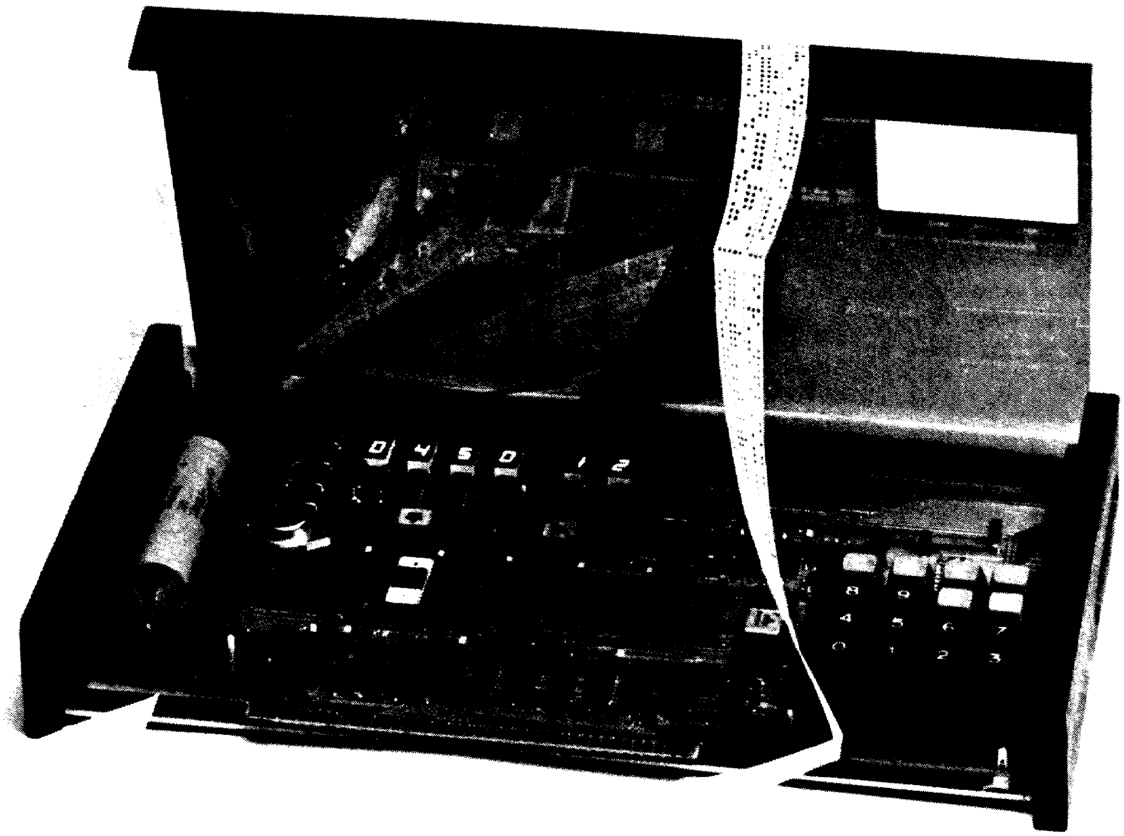

Photo courtesy of Electronic Product Associates, Inc., 1157 Vega Street, San Diego CA 92110.

which is not the same at all.

In BASIC, when an expression is encountered, it is evaluated. That is, the values of the variables are fetched, the numbers are converted (if necessary), the functions are called, and the operations are performed. The evaluation of an expression always results in a number which is defined to be the value of that expression.

The first example which we discussed showed a simple BASIC statement,

```
LET A=B+C
```

This is called an assignment statement, because it assigns the value of the expression "B + C" to the variable A. All algebraic high level languages have some form of assignment statement. They are characterized by the fact that when the computer processes an assignment statement, a single named variable is given a new value. The new value may not necessarily be different from the old; for example:

```
LET A=A
```

This is also a valid assignment statement, even though nothing changes. Assignment statements are also used to put initial values into variables, for instance:

```
LET P=3
```

Control Structures

One of the important characteristics distinguishing different high level languages is the control structure afforded to the programmer. The control structure is determined by the various permitted control statements, which alter the flow of program execution. Normally program execution advances from statement to statement in sequence, although there are however, circumstances in which this sequence is altered. The most common control structure allows one set of operations to be performed if a certain condition is true, and another, if it is false. In "structured programming" this is referred to as the "IF . . . THEN . . . ELSE" construct; its general form is "IF condition is true, THEN do something, ELSE do some other thing." The full generality of this control structure is not directly available in BASIC, but, as we shall see, this is only a minor inconvenience.

Standard BASIC uses the IF . . . THEN construct, and makes it work something like a conditional GOTO:

```
IF A>3 THEN 120
```

If the value of the variable A is greater than three, then (GOTO) line 120, otherwise continue with the next statement in sequence. Actually, the condition to be tested consists of a comparison between two expressions, using any of the comparison operators which are given in Fig. 1. In each case, if the comparison of the two expressions evaluates as true, the implied GOTO is taken; otherwise the next statement in sequence is executed. In Tiny BASIC the syntax is slightly different. Instead of a statement number, a whole statement follows the THEN part of the IF . . . THEN. The comparison above, in Tiny BASIC, would be:

```
IF A>3 THEN GOTO 120
```

But we could also validly write:

```
IF A<=3 THEN LET A=A+10
```

or some such. Note that this is *not* valid in standard BASIC.

The GOTO construct has been the subject of controversy in the last few years. A strong case has been made for "GOTO-less programming" which uses only certain other control structures to achieve structured programs which are more readable and less

=	Equality (the comparison is true if the two expressions are equal)
>	Greater than
<	Less than
< =	Less or Equal (not Greater)
> =	Greater or Equal
< >	Not Equal

Fig. 1. Comparison Operators.

prone to errors. I believe that both good and incomprehensible programs are possible regardless of the control structures used or not used, but I seem to be in a minority at this time. Suffice to say that BASIC is not conducive to structured programming in the technical sense of the term.

Standard BASIC has one control structure which has been omitted from Tiny BASIC. This is the FOR . . . NEXT loop. Normally, if a program requires some sequence to be performed thirteen times, the following program steps might be used:

```
10 FOR I=1 TO 13
20 ...
30 NEXT I
```

Statement 20 would be executed 13 times, with the variable I containing successively the values, 1, 2, 3 . . . 12, 13. In Tiny BASIC the same operation is a little more verbose:

```
10 LET I=1
20 ...
30 LET I=I+1
40 IF I<=13 THEN GOTO 20
```

but, as you can see, nothing is lost in program capability.

Data Structures

Standard BASIC also has some data structures which have not been carried over into Tiny BASIC. The only data structure in Tiny BASIC is the integer number, which is further limited to 16 binary bits for a value in the range of -32768 to +32767. Compare this precision with the six digit precision in standard BASIC, which also gives you fractional numbers (sometimes called "floating point"). Regular BASIC allows arrays, or variables with multiple values distinguished by "subscripts," and strings, which are variables with text information for values instead of numbers. We will see presently how these deficiencies in Tiny BASIC can be overcome.

Input/Output

Thus far we have said nothing about input and output, how to see the answers the computer has calculated, or how to put in starting values. These needs are accommodated in BASIC by the PRINT and INPUT statements. Numbers are printed (in decimal, for us humans to read) at the user terminal by the PRINT statement:

```
PRINT A, B + C
```

This prints two numbers; the first is the value of the variable A, and the second is the value of the expression B+C. In general, the PRINT statement evaluates and prints expressions. It is perfectly valid to write

```
PRINT 1, 123, 0-0
```

although we know in advance what will be displayed on the terminal. To make our output more readable, BASIC permits the program to print out text labels on the data.

```
PRINT "THE SUM OF 1 + 2 IS", 3 + 2
```

will display the line:

```
THE SUM OF 1 + 2 IS 5
```

To feed new numbers from the terminal to the program the INPUT statement is used.

```
INPUT A, B, C
```

will request three numbers from the input keyboard. The more popular versions of Tiny BASIC have an extra capability here beyond standard BASIC, in that the operator can type in numbers *and* whole expressions. Thus, if in response to the INPUT request above, the operator types

```
1+2, 3*(4+5), B-A
```

the variable A will receive the value 3, B will receive the value 27, and C will receive the value 24 = 27-3. Therefore, a program in Tiny BASIC, which permits no text strings, can display and accept as input limited text information:

```
10 LET Y=1
20 LET N=0
30 PRINT "PLEASE ANSWER Y OR N";
40 INPUT A
50 IF A=Y THEN GOTO 100
60 IF A=N THEN GOTO 120
70 GOTO 30
```

This little program asks for an answer, which should be either the letter "Y" or the letter "N" (or their equivalents, the numbers 1 or 0, respectively). If the operator types anything else, the request is repeated. Obviously, this technique will not work for something like a person's name where any letters of the alphabet in any sequence must be expected, but it is certainly an improvement over no alphabetic input at all.

A generalized text output capability in Tiny BASIC depends on another characteristic peculiar to Tiny BASIC and not shared by standard. That is the fact that the line number in a GOTO or GOSUB statement is not limited to numbers only, but may itself be any valid expression which evaluates to a line number. The program which is shown in Fig. 2 prints A, B, or C, depending on whether the variable N has the value 1, 2, or 3. Note that, if N is out of range, nothing is printed.

The USR Function

What about the fact that there are no arrays? Let us turn to the USR function for a way to store and retrieve blocks of data. The remarks which follow apply only to my version of Tiny BASIC and are unique in that respect.

The USR function is invoked with one, two, or three arguments (expressions separated by commas within the parentheses). The first (or only) argument is evaluated to the binary address of a machine language subroutine somewhere in the computer memory. The USR function does a machine language subroutine call (JSR instruction) to that address. The user is obliged to be sure that there is in fact a subroutine at that address. If there is not, Tiny BASIC (and thus your computer) will execute whatever is there. The second and third arguments, if present, will be loaded into the CPU registers before jumping to this subroutine. On exit, any answer the subroutine produces may be left in the CPU accumulator, and it becomes the value of the function. Two machine language routines are already provided with the BASIC Interpreter; if S is the address of the beginning of the interpreter,

```
USR(S + 20, M)
```

has as its value the byte stored in memory at the address in the variable M (that is, the contents of the second argument is evaluated to a memory address). Also,

```
USR(S + 24, M, B)
```

stores the low order 8 bits of the value of B into the memory location addressed by M. The return value of this function is meaningless.

Consider the standard BASIC program in Fig. 3(a) to input ten numbers and print the largest as compared to the Tiny BASIC program in Fig. 3(b).

I have used this example for two reasons: First, it shows how the USR function may be used to simulate the operation of arrays. Second, it is typical of many of the applications commonly ad-

```
10 IF N>0 THEN IF N<4 THEN GOSUB 20+(N * 10)
20 RETURN
30 PRINT "A"
35 RETURN
40 PRINT "B"
45 RETURN
50 PRINT "C"
55 RETURN
```

Fig. 2. Program to Print A, B, or C, depending on the value of N.

to argue for arrays; however, neither real nor simulated arrays are required for this program! Here is the same program, with no arrays:

```
10 LET I=1
20 LET L=0
30 INPUT V
40 IF L<V THEN LET L=V
50 LET I=I+1
60 IF I<=10 THEN GOTO 30
90 PRINT L
```

Summary

Tiny BASIC is not a super language. But, it also does not require a super computer to run. I've given here only a cursory examination of the power of Tiny BASIC. A full description of Tiny BASIC may be found in the Itty Bitty Computers *Tiny BASIC User's Manual.* This comes with a hex paper tape of the program and is available for $5 from: Itty Bitty Computers, PO Box 23189, San Jose CA 95153.

There are different versions for each of the following systems, so be sure to specify which system you are running:

M6800 with MIKBUG, EXBUG, or home brew (Executes in 0100-08FF); AMI Proto board (Executes in E000-E7FF); SPHERE (Executes in 0200-09FF); 6502 with KIM, TIM or homebrew (Executes in 0200-0AFF); JOLT (Executes in 1000-18FF); APPLE (Executes in 0300-0BFF); KIM-2 4K RAM (executes in 2000-28FF).

Although few people have paper tape systems, we are unable to provide the program on audio cassette. But if you request it, we will supply a hexadecimal listing of the program instead of tape which you can key in and then can save on cassette for future use.

If you have a small 8080 system, there are several widely differing versions of Tiny BASIC in the public domain. Most of them have been published in Dr. Dobb's Journal, which is $10 per year from: People's Computer Company, PO Box 310, Menlo Park CA 94025. This journal has also published a number of games which run in Tiny BASIC.

One final comment. Tiny BASIC was originally conceived as "free software" by the people at PCC. The 6800 and 6502 versions described in this article are not free; they are proprietary and copyrighted. Software is my only source of income, and, if I cannot make it from programs like Tiny BASIC, I won't write them. Please respect the labor of those of us who are trying to make quality software available to you: pay for the programs you use. ■

```
10 FOR I=1 TO 10
20 INPUT V(1)
30 NEXT I
40 LET L=V(1)
50 FOR I=2 TO 10
60 IF L>=V(I) THEN 80
70 LET L=V(I)
80 NEXT I
90 PRINT L
```

```
10 LET I=1
20 INPUT V
25 LET V=USR(S=24,I,V)
30 LET I=I+1
35 IF I<=10 THEN GOTO 20
40 LET L=USR (S+20, I)
50 LET I=2
60 IF L<USR(S+20,I) THEN LET L=USR(S+20,I)
80 LET I=I+1
90 PRINT L
```

Fig. 3. Programs to input ten numbers and print the largest. (a) Standard BASIC; (b) Tiny BASIC.

Tiny BASIC Shortcuts

Tom Pittman's Tiny BASICs (6502, 1802, etc.) are somewhat limited in capabilities. This is the first of several articles discussing methods to expand those capabilities.

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Writing small but useful programs in Tiny BASIC (to paraphrase Tom Pittman) is a practical reality. Getting the most out of your programs is easier if you work with the interpreter's limitations. The utility program in Fig. 1 shows how to work with some of these limitations. This program is titled "Loans," but it could be any comparison of WHAT-IF alternatives. Here's what we'll be working with (and without):

- Decimal numbers not allowed.
- Number range limited from -32768 to +32767.
- 72 characters maximum on Input lines.
- Implied statements and abbreviations to save bytes of memory.

(Note: Tom Pittman now has an experimenter's manual available that explains many of these features and how to work with them. They are not as simple as my approach. The manual is available from Itty Bitty Computers, PO Box 23189, San Jose CA 95153.)

These are not significant handicaps if you're estimating the effect of several alternatives. Round numbers are usually acceptable if you only want to get on base in some specific ball park (clichés are fun once in a while).

Byte-saving Tips

Saving bytes of memory is a practical approach if your computer has limited memory (I have 1250 bytes of free space now). Let's talk about the memory-saving part first.

Fig. 1 is an example of a program with no statement shortcuts; Fig. 2 uses all the implied and abbreviated statements possible in this Tiny BASIC interpreter. Memory in Fig. 1 is 492 bytes, an average of 17 bytes per line, while Fig. 2 uses 410 bytes for an average of 14 bytes per line. REM comments were added later and used 470 bytes.

Using implied statements causes the program to run

```
:
:LIST
10  REM  TINY BASIC FOR KIM-1
11  REM  6502 V.1K BY T. PITTMAN.
12  REM
13  REM  PROGRAMMED BY:
14  REM  C.R. (CHUCK) CARPENTER W5USJ
15  REM  2228 MONTCLAIR PL.
16  REM  CARROLLTON TX 75006
17  REM
18  REM  THESE PROGRAMS ILLUSTRATE BYTE SAVING
19  REM  TECHNIQUES IN LIMITED MEMORY SYSTEMS.
20  REM  THE FIRST PROGRAM USED 492 BYTES. THE
21  REM  OTHER USED 410 BYTES. AN INCREASE
22  REM  (OR SAVING) OF 82 BYTES. IMPLIED
23  REM  STATEMENTS AND ABBREVIATIONS ARE
24  REM  THE REASON.
25  PR
26  PR
100  PRINT"LOANS : HOW MANY -"
110  INPUT N
115  PRINT
120  LET A=0
130  PRINT"INPUT: PRINCIPAL IN HUNDREDS (P)"
140  PRINT"        RATE IN PERCENT (R)"
150  PRINT"        TIME IN YEARS (T)"
160  PRINT"        PAYMENTS IN MONTHS (X)"
170  INPUT P,R,T,X
190  LET I=P*T*R
200  LET O=100*P+I
210  LET M=O/X
220  LET A=A+1
230  PRINT
240  PRINT"LOAN NUMBER -";A;""
250  PRINT"INTEREST IS $";I
260  PRINT
270  PRINT"MONEY OWED IS $";O
280  PRINT
290  PRINT"PAYMENTS ARE $";M
300  PRINT
310  LET N=N-1
320  IF N>0 THEN GOTO 170
360  PRINT
370  PRINT"DONE"
380  PRINT
390  END
:
:
:
:
:I=0
:1 I=I+2
:2 GOSUB 1
:RUN

!226 AT 1
:END

:PRINT"THERE ARE ";I;" BYTES LEFT"
THERE ARE 288 BYTES LEFT
:
```

Fig. 1. First program version using no shortcuts to write the program or save bytes. This program uses 492 bytes, exclusive of the REM statements. REM statements use 470 bytes. The short routine above illustrates how Tiny BASIC finds the number of bytes of free space remaining. The user's manual tells how to do it.

slower, but the increase in program lines is worth the loss of speed (if speed is your concern then Tiny BASIC may not be for you, anyway). Memory saving wasn't really necessary for this short program; but in a 100-line program over 200 bytes could be saved (12 to 15 lines' worth). Such significant savings allow you to write longer programs. The programs are still small, but even a few more lines make them more useful. And that's what we're trying to do. Bytes could be saved in a few more places, such as the spaces in the print input, lines 130 through 160, but in the interest of clarity, I left them alone.

Decimal Values

Calculations involving decimal numbers can be handled several ways. Anytime a percentage or a calculation resulting in a fraction occurs, a decimal number results. Dollars and cents are decimal numbers, too. Tiny BASIC truncates decimal numbers down to the next lower whole number. If the number is less than one, the result is zero. (For this reason, accountants would probably not want to use Tiny BASIC.)

Lines 130 through 180 are the input lines for this program. I used principal in hundreds and rate in percent to avoid decimal percentage entry and to prevent dividing percent by 100 (to get back to a decimal percentage). The math comes out right when it's printed out in line 250. I then multiplied the total loan value by 100 in line 200 to make the right amount print in lines 270 and 290.

Principal input in hundreds also helps avoid the number-limitation problem. Keeping the numbers to be operated on small limits precision but keeps the multiplication results in range. Adding a statement in a print line to multiply (or divide, etc.) by some factor will put the answer back in the right magnitude. This is sort of like using engineering notation with a slide rule. The difference is the lack of decimal numbers.

An input-line limitation of 72 characters restricts the amount of data you can input. Two character spaces are used by the prompting question mark and following space. This reduces actual data input to 70 characters, including the required commas between the data entries. With the loan amount in hundreds, I was able to input values for six loans instead of five. To overcome the limited data-input situation, write programs that will perform calculations, hold the results and return for more data. I've done this on some data-processing routines with good results.

There's another way to accommodate more data than the line will hold. Simply input as many loan numbers (or WHAT-IFs) as needed in line 100. When the program has used the data entered, it will ask for more until the number of N entries is reached in line 320. Question marks will show up each time

```
:LIST

100  PR"LOANS : HOW MANY -"
110  INPUT N
115  PR
120  A=0
130  PR"INPUT: PRINCIPAL IN HUNDREDS (P)"
140  PR"       RATE IN PERCENT (R)"
150  PR"       TIME IN YEARS (T)"
160  PR"       PAYMENTS IN MONTHS (X)"
165  PR
170  INPUT P,R,T,X
190  I=P*T*R
200  O=100*P+I
210  M=O/X
220  A=A+1
230  PR
240  PR"LOAN NUMBER - ";A;""
250  PR"INTEREST IS $";I
260  PR
270  PR"MONEY OWED IS $";O
280  PR
290  PR"PAYMENTS ARE $";M
300  PR
310  N=N-1
320  IF N>0 GOTO 170
360  PR
370  PR"DONE"
380  PR
390  END
```

Fig. 2. Second program version using implied statements and abbreviations to save bytes. This version uses 410 bytes.

```
LOANS : HOW MANY -
?6

INPUT: PRINCIPAL IN HUNDREDS (P)
       RATE IN PERCENT (R)
       TIME IN YEARS (T)
       PAYMENTS IN MONTHS (X)

?40,10,3,36,40,12,4,48,40,18,5,60,50,10,3,36,50,1
2,4,48,50,18,5,60

LOAN NUMBER - 1
INTEREST IS $1200

MONEY OWED IS $5200

PAYMENTS ARE $144

LOAN NUMBER - 2
INTEREST IS $1920

MONEY OWED IS $5920

PAYMENTS ARE $123

LOAN NUMBER - 3
INTEREST IS $3600

MONEY OWED IS $7600

PAYMENTS ARE $126

LOAN NUMBER - 4
INTEREST IS $1500

MONEY OWED IS $6500

PAYMENTS ARE $180

LOAN NUMBER - 5
INTEREST IS $2400

MONEY OWED IS $7400

PAYMENTS ARE $154

LOAN NUMBER - 6
INTEREST IS $4500

MONEY OWED IS $9500

PAYMENTS ARE $158

DONE

:
```

Fig. 3. Sample run. Simple interest calculations of two different loan values at three rates.

From Fig. 3			*From Fig. 5*		
Simple Int			**Compound Int**		
Interest%	**Years**	**Amount**	**Equiv-Int%**	**Years**	**Amount**
1. 10	3	$5200.00	11	3	$5320.00
2. 12	4	5920.00	15	4	6400.00
3. 18	5	7600.00	26	5	9200.00

Mult	**Actual Loan Value**	**Difference**
1. 1.331	$5324.00	+$ 4.00
2. 1.574	$6296.00	− 104.00
3. 2.288	$9152.00	+ 48.00

Fig. 4. For a loan of $4000.

line 170 runs out of data and line 320 is still greater than zero.

This program only calculates simple interest loans. Compound-interest calculations require decimal numbers and raising numbers to some power. The multiplier for compounding over n periods is $(1 + I)^n$, where I is the interest expressed as a decimal and n is the number of years (or periods).

You can use this multiplier to calculate the approximate equivalent while percentage over the term of the loan. Your calculated answer will result in a much more realistic loan evaluation. I made some of these calculations, and Fig. 4 has some examples.

In the program itself, there are no unusual or unique programming techniques. There are two counting loops—one starting at line 110 and the other at line 120. Whatever value is input for N is decremented in line 310 until the data sets, input in line 170, are used up. The counter that starts in line 120 numbers the printed output each time a pass through the program is completed.

I tried to use N to do both, but could not without using more program lines. Otherwise, this is simply a fundamental program with input between lines 100 and 170, calculations between lines 190 and 220 and output between lines 240 and 290.

Summary

It is easy to save bytes of memory if you remember to use implied statements and statement abbreviations. The user's manual for Tiny BASIC shows what is, and is not, allowed. Both the decimal number and number range limitation can be handled by using software math techniques (multipliers, dividers, engineering notation, etc.). Line input characters limited to 70 (72 with prompting question mark and space) can also be handled by programming techniques.

Remember, if you input more than a total of 72 characters in a single line, the program will stop. Nothing more will happen until you reset your system. If you have to reset and want to save the program already in memory, then reenter the interpreter at the soft entry point. The Tiny BASIC user's manual explains how to do this, too. A program does not have to be big to be useful.■

```
LOANS : HOW MANY -
?3

INPUT: PRINCIPAL IN HUNDREDS (P)
       RATE IN PERCENT (R)
       TIME IN YEARS (T)
       PAYMENTS IN MONTHS (X)

?40,11,3,36,40,15,4,48,40,26,5,60

LOAN NUMBER - 1
INTEREST IS $1320

MONEY OWED IS $5320

PAYMENTS ARE $147

LOAN NUMBER - 2
INTEREST IS $2400

MONEY OWED IS $6400

PAYMENTS ARE $133

LOAN NUMBER - 3
INTEREST IS $5200

MONEY OWED IS $9200

PAYMENTS ARE $153

DONE
```

Fig. 5. Loan value two, rerun to show the effect of compound interest on the total loan value. Compare the results with the simple interest calculation.

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Not So Tiny

Perhaps after running this series we won't be calling it Tiny *anymore!*

KIM-1 and KIM-2 in redwood enclosure, ACT-1 TVT, Telpar Printer, Computerist power supply, Radio Shack recorders.

```
:LIST

10 REM   ORIGINAL VERSION
11 REM
100 FOR Y=1 TO 10
110 LET C=0
120 FOR X=1  TO 50
130 LET F=INT(2*RND(1))
140 IF F=1 THEN 180
150 PRINT "T";
160 GOTO 200
170 REM   C COUNTS NO OF HEADS
180 LET C=C+1
190 PRINT "H";
200 NEXT X
210 PRINT
220 PRINT "HEADS    ";C;"    OUT OF 50 FLIPS"
230 NEXT Y
240 END
```

Listing 1.

Programs written in Tiny BASIC and other small interpreters can be useful and fun. First, some changes in programming techniques and philosophy are needed, though, because there are fewer statements and commands in small interpreters.

One basic and very useful programming tool is the loop. Several articles have been written about the power and use of loops properly written and executed in a program. Usually in larger BASICs, these loops are written with FOR-NEXT statements. In Tiny BASIC, the equivalent statements are LET, IF . . . THEN GOTO.

To illustrate the conversion of FOR-NEXT statements to LET, IF . . . THEN GOTO statements, I have used the program in Listing 1. This is a coin-flipping routine with one counting loop inside another. The outside loop resides between lines 100 and 230; the inside loop is between lines 120 and 230. Lines 10 and 11 are my comment and are not part of the original program. It is not possible to run this program on my system because the Tiny BASIC interpreter would not recognize line 100 and would stop.

Listing 2 is my version rewritten in Tiny BASIC. I have added a couple of features, such as the INPUT N line, which lets you select N sets of 50 flips. Also, I like to see DONE (or something) at the end of a program. This way I know the program didn't quit in the middle (if the algorithm was right, anyway). Otherwise, Tiny BASIC used two more program lines than the larger BASIC version.

In my program, the two main loops comparable to the sample program are started with a LET statement. The outside loop is between lines 110 and 250 and controls the number of passes of 50 flips set in line 100. The inside loop is between lines 130 and 210 and controls the number of flips set in line 210. As I stated there are two additional lines—the counters for the two loops. The loop counter in line 200 increments by one on each pass through the program until it reaches the values in line 210. Incrementing the I loop (in line 240) by one occurs until the value in line 250 is reached. In this case, I is compared to N, the value input in line 100. The value of N lets the user select how many sets of 50 flips are to be run by the program before it ends.

Coin flipping, counting and printing are handled in lines 140 to 190. Line 140 randomizes the number 2 (1 is added so there are no zeros). If the random number is 1, it becomes a "head" and passes to the head counter in line 180. The head counter increments by one and prints an H, then increments the X loop by one. If X is less than the limiting value (50), the program returns to the flip routine at line 140 and starts through again.

If F does not equal 1 in line 150, the value becomes a "tail," a T is printed, X is incremented (by jumping to line 200) and compared to the limiting value. This time; if 50 flips have occurred, the program falls through to the print statement in line 230. Heads (C) counted in line 180 are printed out and the program tests the relationships in lines 240 and 250. When I > N, the program prints DONE and ends.

Tiny BASIC, even though small in size, has power enough to produce significant programs. Applications are limited only by your imagination and user space in your computer's memory. In addition to some tricks using implied statements and commands to save memory, I have written programs to plot a graph, do simple graphics, do some limited data processing and simulate assembly processes in a small manufacturing company.

I plan to try several potential capabilities that include use of the USR function to save and load from a cassette tape. I would like to share my ideas with anyone interested, and I believe *Kilobaud* would be happy to publish programs for the development of a Tiny BASIC software library. ■

```
:LIST
10 REM   TINY BASIC FOR KIM-1
11 REM   6502 V.IK BY T. PITTMAN.
12 REM
13 REM   PROGRAMED BY:
14 REM   C. R. (CHUCK) CARPENTER W5USJ
15 REM   2228 MONTCLAIR PL.
16 REM   CARROLLTON, TX. 75006
17 REM
18 REM   FLIPS A COIN 'N' TIMES 50 AS SELECTED
19 REM   IN LINE 100, THEN PRINTS THE NUMBER OF
20 REM   HEADS IN EACH 50 FLIPS.
21 PR
22 PR
100 INPUT N
110 LET I=1
120 LET C=0
130 LET X=1
140 LET F=(RND(2)+1)
150 IF F=1 GOTO 180
160 PRINT "T";
170 GOTO 200
180 LET C=C+1
190 PRINT "H";
200 LET X=X+1
210 IF X<=50 GOTO 140
220 PRINT
230 PRINT "HEADS    ";C;"    OUT OF 50 FLIPS"
240 LET I=I+1
250 IF I<=N GOTO 120
260 PRINT
270 PRINT "DONE"
280 END

:RUN
? 5
HTTHTTTHHTHHTTTTHHHHHHTHHHTHTHHTTTHHTTHHTTTHHTHTTH
HEADS  26  OUT  OF  50  FLIPS
HHTHHHTHHHHHTTHTTHHTTHHTHHTTTTHHTHHHTHTHTHTTTTTHHH
HEADS  28  OUT  OF  50  FLIPS
TTHHTTTHHHHTTTHHTHHHHHTHTTHTHHTHHTHHHTHHTHTTTTTHHH
HEADS  28  OUT  OF  50  FLIPS
THTHHHHTTTTHTTTTTHTTTTHHHTHTHTHHHHHHTTTTHTHHHTHTHH
HEADS  25  OUT  OF  50  FLIPS
TTHTTHHTTTTTTTTHTTHTHTTTTHTTTHTTHHHTTHTHHTHTHTHTHT
HEADS  18  OUT  OF  50  FLIPS

DONE
```

Listing 2.

Tiny BASIC: Still Going Strong!

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After assembling a home computer system, one of the first things hobbyists want to do is demonstrate to their friends and neighbors what their new machines can do. Unfortunately, those things we love to do, like machine-language subroutines or vectored interrupts, don't come across well to "outworlders." Furthermore, most of the games or educational programs available require BASIC with string capability. This implies eight to ten kilobytes of read-write memory, usually more than beginning systems have.

Fortunately, a language, Tiny BASIC, exists that fits comfortably in the 4K generally available in a minimal system. Versions are available for most popular CPU's from Itty Bitty Computers of San Jose CA. Although Tiny BASIC does not have strings, FOR-NEXT loops or several other features of "standard" BASIC, it is still a useful language.

As an aid to those needing software to implement on a "Tiny" system, I present three game programs. Extensive personal research (I cornered my wife) demonstrated the appeal of these games to non-computer-oriented (i.e., normal) people. Each will run in a Tiny BASIC-equipped computer with 4K of memory. Although I used the SWTP M-68, programs should be interchangeable with any Tiny BASIC.

Remember, these programs are written in *Tiny* BASIC. Although with minor modifications, as in the RND function, they will run in standard BASIC, they will not be efficient. String handling and FOR-NEXT loops could simplify and speed up these programs, but then they wouldn't be Tiny BASIC.

Enough introduction. On to the programs.

Battle of Numbers

Battle of Numbers, fre-

```
10 REM BATNUM [TINY BASIC]
20 REM VER 1.2 — 13 AUG 77
30 REM MARC I. LEAVEY, M.D.
40 REM *HOME UP, ERASE, PRINT HEAD*
50 PR "","BATTLE OF NUMBERS"
60 PR
70 PR "HOW MANY OBJECTS IN"
80 PR "THE PILE";
90 INPUT P
100 IF P<=0 GOTO 70
110 PR "WHAT IS THE MINIMUM YOU"
120 PR "CAN TAKE";
130 INPUT A
140 IF A>0 GOTO 180
150 PR "YOU HAVE TO TAKE AT"
160 PR "LEAST 1 EACH TIME!"
170 GOTO 110
180 PR "WHAT IS THE MAXIMUM"
190 PR "YOU CAN TAKE";
200 INPUT B
210 IF B>=A GOTO 250
220 PR "THE MINIMUM CAN'T BE"
230 PR "LARGER THAN THE MAXIMUM!"
240 GOTO 110
250 W=1
260 L=0
270 PR "DO YOU WIN OR LOSE BY TAKING"
280 PR "THE LAST OBJECT (W OR L)";
290 INPUT Z
300 IF Z=1 GOTO 320
310 L=A
320 T=A+B
330 Y=1
340 N=0
350 PR "DO YOU WANT TO GO FIRST";
360 INPUT Z
370 IF Z=1 GOTO 600
380 IF P>B GOTO 410
390 IF P<=A GOTO 540
400 IF L=0 GOTO 540
410 R=P-T*(P/T)
420 IF R>=A GOTO 450
430 IF R=0 GOTO 450
440 R=A
450 IF R=L GOTO 500
460 C=R-L
470 IF C>0 GOTO 510
480 C=C+B
490 GOTO 510
500 C=A+RND(B-A+1)
510 PR "I TAKE ";C
520 P=P-C
530 GOTO 600
540 PR ""
550 IF L=0 GOTO 580
560 PR "I TAKE" ;P;"AND LOSE! [LUCKY!]"
570 GO TO 770
580 PR "I TAKE";P;"AND WIN!!"
590 GO TO 770
600 PR ""
610 PR "THERE ARE";P;"OBJECTS."
620 PR "HOW MANY DO YOU TAKE";
630 INPUT H
640 IF H<A GOTO 660
650 IF H<=B GOTO 700
660 IF H<>P GOTO 680
670 IF P<A GOTO 720
680 PR "YOU MAY TAKE FROM";A;"TO";B
690 GO TO 620
700 P=P-H
710 IF P>0 GOTO 380
720 IF L=0 GOTO 750
730 PR ">>YOU LOSE! <<"
740 GOTO 770
750 PR "** YOU WIN! **"
760 GOTO 770
770 PR ""
780 PR "ANOTHER MATCH";
790 INPUT Z
800 IF Z=1 GOTO 10
999 END
```

BATNUM program listing.

quently abbreviated BATNUM, is one of the oldest number games. In it, a pile of objects is established and items are removed until the game ends.

In the computer version, the size of the starting pile, minimum and maximum number per turn and win or lose on the last token are all determined by the player. The computer will go first or give you the option. It is a challenging game, and, with the proper strategy, you can win it.

As with all listings in this article, BATNUM is fairly self-explanatory, but a few points bear mentioning. Tiny BASIC allows PR for PRINT; all other commands are spelled out. The statement PR "" contains control characters used for homing the cursor and clearing the screen or line. Although Tiny has no string inputs, single-letter variables may be input at INPUT statements. Thus the sequency

```
100 Y=1
200 N=0
300 PR "ANOTHER GAME";
400 INPUT Z
```

could be answered by Y or N, and the variable Z would equal 1 for yes or 0 for no. Kind of a pseudo-string.

Bagels

The second listing shows the Bagels program, which also has been around in various forms for some time. The theory of this game is that the computer selects a random number with three *different* digits. It then requests a guess from you. After first checking for other than three digits or double digits, the computer responds three ways (shown in Example 1).

Thus, if the computer's number was 439 and you guessed 497, it would respond: PICO FERMI, showing two correct digits — one in the right place and one in the wrong. PICOs come out

```
I HAVE A NUMBER
GUESS? 111
NO DOUBLE NUMBERS!
GUESS? 234
B A G E L S !
GUESS? 123
B A G E L S !
GUESS? 5678
THREE DIGITS, PLEASE!
GUESS? 567
PICO
GUESS? 890
PICO FERMI
GUESS? 590
FERMI
GUESS? 690
FERMI FERMI
YOU MUST BE NEW AT THIS GAME!
THE FIRST NUMBER IS 6
GUESS? 691
FERMI FERMI
GUESS? 698

CORRECT! IN 10 GUESSES!
TRY ANOTHER? Y
I HAVE A NUMBER
GUESS? 123
B A G E L S !
GUESS? 456
PICO PICO
GUESS? 789
PICO
GUESS? 457
PICO PICO
GUESS? 458
PICO PICO PICO
GUESS? 845

CORRECT! IN 6 GUESSES!
TRY ANOTHER? N
```

Bagels run.

```
HOW MANY OBJECTS IN
THE PILE? 21
WHAT IS THE MINIMUM YOU
CAN TAKE? 3
WHAT IS THE MAXIMUM
YOU CAN TAKE? 1
THE MINIMUM CAN'T BE
LARGER THAN THE MAXIMUM!
WHAT IS THE MINIMUM YOU
CAN TAKE? 1
WHAT IS THE MAXIMUM
YOU CAN TAKE? 3
DO YOU WIN OR LOSE BY TAKING
THE LAST OBJECT (W OR L)? L
DO YOU WANT TO GO FIRST? N
I TAKE 2

THERE ARE 19 OBJECTS.
HOW MANY DO YOU TAKE? 3
I TAKE 2

THERE ARE 14 OBJECTS.
HOW MANY DO YOU TAKE? 2
I TAKE 2

THERE ARE 10 OBJECTS.
HOW MANY DO YOU TAKE? 2
I TAKE 2

THERE ARE 6 OBJECTS.
HOW MANY DO YOU TAKE? 2
I TAKE 2

THERE ARE 2 OBJECTS.
HOW MANY DO YOU TAKE? 1

I TAKE 1 AND LOSE! [LUCKY!]

ANOTHER MATCH? N
```

BATNUM run.

```
BAGELS = No digit correct
PICO = Correct digit in wrong place
FERMI = Correct digit in correct place
```

Example 1.

Bagels program listing.

```
10 REM BAGELS <TINY BASIC >
20 REM VER 2.0 - 31 AUG 77
30 REM MARC I. LEAVEY, M.D.
50 Y=1
60 N=0
70 PR "";
100 X=100+RND(900)
120 W=X
130 X=W/100
140 Y=(W-X*100)/10
150 Z=(W-X*100-Y*10)
200 IF X=Y GOTO 100
210 IFY=ZGOTO 100
220 IFX=ZGOTO 100
290 PR"I HAVE A NUMBER"
300 G=0
310 G=G+1
312 IF G=9 PR "YOU MUST BE NEW AT THIS GAME!"
313 IF G=9 PR "THE FIRST NUMBER IS ";X
314 IF G=14 PR "I CAN'T BELIEVE IT!"
315 IF G=14 PR "THE FIRST TWO NUMBERS ARE";X;Y
320 PR "GUESS";
330 INPUT D
340 IF D=W GOTO 900
344 IF G=18 PR "I G I V E U P!"
346 IF G=18 PR "THE NUMBER WAS ";W
348 IF G=18 GOTO 920
350 IF D< 100 GOTO 950
360 IF D >999 GOTO 950
370 A=D/100
380 B=(D-100*A)/10
```

```
390 C=(D-100*A-10*B)
400 IF A=B GOTO 850
410 IF A=C GOTO 850
420 IF B=C GOTO 850
430 F=0
440 P=0
450 IF A=X THEN F=F+1
460 IF A=Y THEN P=P+1
470 IF A=Z THEN P=P+1
480 IF B=X THEN P=P+1
490 IF B=Y THEN F=F+1
500 IF B=Z THEN P=P+1
510 IF C=X THEN P=P+1
520 IF C=Y THEN P=P+1
530 IF C=Z THEN F=F+1
540 IF P+F=0 PR "B A G E L S !";
550 IF P=0 GOTO 600
560 P=P-1
570 PR "PICO ";
580 GOTO 550
600 IF F=0 GOTO 640
610 F=F-1
620 PR "FERMI ";
630 GOTO 600
640 PR
650 GOTO 310
850 PR "NO DOUBLE NUMBERS!"
860 GOTO 310
900 PR
910 PR "CORRECT! IN";G;"GUESSES!"
920 PR "TRY ANOTHER";
930 INPUT Z
940 IF Z=Y GOTO 10
945 GOTO 999
950 PR "THREE DIGITS, PLEASE!"
960 GOTO 310
999 END
```

before FERMIs, so their order is of no help in determining the correct sequence.

This program demonstrates a few useful techniques. The sequence from lines 100 to 220 breaks the three-digit number W down to three integers: X, Y and Z. They are then checked for duplicate digits; if one is found, another number is selected. Similar statements at lines 370 to 390 break the guess D down to integers A, B and C. Comparisons between A, B and C, and X, Y and Z increment the PICO and FERMI flags (P and F, respectively). These flags are used in a pseudo FOR-NEXT loop to print the PICO and FERMI. If neither is set (P+F=0), BAGELS gets printed. A guess counter (G) is also tallied in to offer the player some form of feedback.

Lunar Lander

Another popular game is the simulated landing of a spacecraft on the moon. Versions have been published in all major books and magazines, including *Kilobaud*. The object is quite simple: Land your lunar excursion module (LEM) without crashing. In this program, constants for fuel, velocity, height and gravity are randomized at each play. This adds a degree of difficulty because the same strategy does not always work.

The loop at lines 92 to 96 counts to 50, giving the player a chance to read the introduction. Subroutine 600 produces a line feed and line erase for each 40 feet or so below 500 feet. This makes the LEM, which is drawn by lines 700 to 720, descend the screen as the game progresses.

```
10 REM LUNAR LANDER [TINY BASIC]
20 REM VER 3.0 - 30 AUG 77
30 REM MARC I. LEAVEY, M.D.
40 PR "","LUNAR LANDER"
50 PR
55 PR
60 PR "TRY TO LAND THE LEM ON THE"
65 PR
70 PR "SURFACE OF THE MOON BY ENTERING"
75 PR
80 PR "FUEL BURN RATES WHEN REQUESTED."
85 PR
90 PR "G O O D  L U C K !"
92 I=50
94 I=I-1
96 IF I >0 GOTO 94
100 F=100+RND(75)
110 V=RND(50)-100
120 D=400+RND(200)
130 G=1+RND(8)
200 GOSUB 600
210 GOSUB 700
220 IF F >0 GOTO 240
230 B=0
235 GOTO 250
240 GOSUB 750
250 IF B >F THEN B=F
255F=F-B
260 C=B-G
270 D=D+V+C/2
280 V=V+C
400 IF D >0 GOTO 200
410 IF D <-1 GOTO 500
420 GOTO 530
500 GOSUB 660
510 GOTO 800
530 GOSUB 900
540 GOTO 800
600 PR"";
610 S=12-D/40
615 IF S <=0 GOTO 650
620 PR ""
630 S=S-1
640 IF S >0 GOTO 620
650 RETURN
660 PR ""
665 PR "CRASH","CRASH","CRASH"
670 PR "******","******","******"
675 PR
680 PR "IMPACT VELOCITY:";V
685 PR "LEM BURIED";-D;"FEET"
690 PR
695 GOTO 1010
700 PR "0","FUEL:";F
710 PR"[#]","SPEED: ";V
720 PR" - ","HEIGHT: ";D;
730 RETURN
750 PR " BURN: ";
760 INPUT B
770 RETURN
800 PR
810 PR "ANOTHER GAME";
820 Y=1
830 INPUT A
840 IF A=Y GOTO 100
850 END
900 PR ""
910 PR
920 PR "LEM ON SURFACE OF THE MOON"
930 IF V <-5 GOTO 1000
935 PR
940 PR "C O N G R A T U L A T I O N S !"
945 PR
950 PR "","PERFECT LANDING!"
955 PR
960 PR"TOUCHDOWN VELOCITY: ";V
970 PR"FUEL REMAINING:  ";F
980 RETURN
1000 PR "EXCESSIVE SPEED ON IMPACT!"
1005 PR
1010 IF F=0 GOTO 1050
1020 PR F;" UNITS OF FUEL REMAINING"
1030 PR "PRODUCED EXPLOSION COVERING"
1040 PR 100*RND(F+3);"SQ MILES OF LUNAR SURFACE"
1050 PR
1060 PR "L E M  D E S T R O Y E D !"
1070 PR"****** YOU BLEW IT! ******"
1080 RETURN
```

Lunar Lander program listing.

In the sample run, this routine has been bypassed since it makes little sense on hard copy. It does add some flavor to the CRT version, though.

I hope the reader will be able to introduce his or her acquaintances to the world of personal computers by implementing these simple programs. Comments or questions are welcome; readers interested in Tiny BASIC should write (I have no connection with IBC): Itty Bitty Computers, P.O. BOX 23189, San Jose CA 95153. (A self-addressed stamped envelope should accompany requests for replies.) ■

```
TRY TO LAND THE LEM ON THE
SURFACE OF THE MOON BY ENTERING
FUEL BURN RATES WHEN REQUESTED.
G O O D   L U C K !


 0    FUEL:     111
[#]   SPEED:    -84
/-\   HEIGHT:   431   BURN:  ?  5

 0    FUEL:     106
[#]   SPEED:    -80
/-\   HEIGHT:   349   BURN:  ?  3

 0    FUEL:     103
[#]   SPEED:    -78
/-\   HEIGHT:   270   BURN:  ?  0

 0    FUEL:     103
[#]   SPEED:    -79
/-\   HEIGHT:   192   BURN:  ?  0

 0    FUEL:     103
[#]   SPEED:    -80
/-\   HEIGHT:   113   BURN:  ?  6

 0    FUEL:      97
[#]   SPEED:    -75
/-\   HEIGHT:    35   BURN:  ?  12

CRASH   CRASH   CRASH
*****   *****   *****

IMPACT VELOCITY: -64
LEM BURIED 35 FEET

85 UNITS OF FUEL REMAINING
PRODUCED EXPLOSION COVERING
300 SQ MILES OF LUNAR SURFACE

L E M   D E S T R O Y E D !
****** YOU BLEW IT! ******

ANOTHER GAME? N
```

Lunar Lander run.

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Match Pennies:
A Game That Learns

Here is a program that demonstrates a computer's ability to show adaptive (artificial) intelligence and pattern recognition. The program is in the form of a simple penny-matching game and is planned as follows.

The computer guesses whether you are going to pick heads or tails. If it guesses correctly, it will subtract a point from your score. If it is wrong, your score is increased by a point.

To perform this task, the computer must decide whether to pick heads or tails. In the program, I have established criteria for making this decision. The computer has to keep a record of the human's previous plays. It will then look up in this record previous plays that match the situation with which it is now presented. Using earlier results, it now has a basis to make a decision on whether to play heads or tails.

Here's an outline of this basic concept:

1. Situation memory (16 cells)
2. Situation comparer
3. Input data (heads or tails)
4. Decision maker
5. Decision output (heads or tails)
6. Win/lose detector
7. Scorekeeper (from human's view)

The implementation of the outline has a different appearance. The program is written in Pittman Tiny BASIC. To set up the situation memory, I selected 16 variables. These act as 16 memory cells, each to contain a 0 = heads or a 1 = tails. The 16 cells are addressed by a memory address register that represents the last four human plays (head, tail, head, tail, etc.). This address (situation) register is contained in four variables. As a new play is generated, the play that occurred four plays ago is shifted out and each play is shifted one position, with the present play being shifted in as the least significant part of the address (situation) register. Thus, the address (situation) register is at all times a representation of the last four human plays.

The computer uses this address register to compute a cell number (address). This is done by giving each of the four plays contained in the address register a value (power of 2). The oldest play, if it was a tail (= 1), is represented by 8; next, if it was a tail, by 4, and so on until the latest play equals 1. These are then added to compile a number (0-15). This corresponds to a cell number. The program stores the human's latest play (input data – heads = 0; tails = 1) in the cell whose cell number is computed from the address register. This tells the computer that the human played H, T, H, T, for example, and then played heads again.

The next part of the program shifts the latest play into the address register. It then compares the latest play to the variable V (computer's guess from the end of the last play) to determine if the guess is a match or not. Depending on the results of the comparison, the human's score is incremented or decremented, and the human is shown the results. Then the computer (using the latest shift address register value) looks up the cell number and gets the human's play the last time this situation occurred. This is then used for computer's next guess (variable V).

Fig. 1 is a flowchart of the entire program and shows the four main parts of the program's main loop:

1. Store (present data with last situation).
2. Shift (to get latest situation).
3. Check Win/Lose.
4. Fetch guess (based on latest situation).

At first, the program will tend to make the computer appear dumb. This is because the memory cells and address register are initialized with data that is not derived from data

```
10 LET H = 0
15 LET T = 1
20 PRINT "TYPE HEADS OR TAILS (H OR T)"
25 INPUT X
```

Example 1.

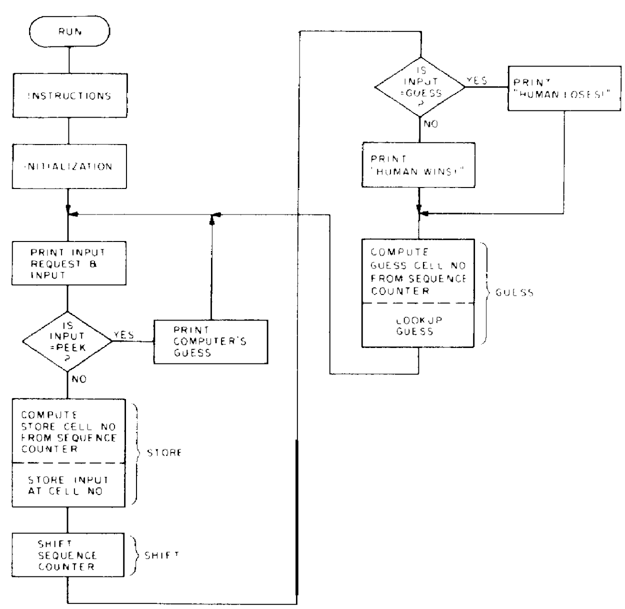

Fig. 1. Flowchart.

the human is presently playing. As soon as the memory contains data acquired from play-ing, the computer adapts and seems to get progressively more intelligent.

The chart in Table 1 shows how the program gradually adapts to different patterns of play. The program uses a little-known aspect of Pittman Tiny BASIC: that a variable may be set to a given value and an input requested. The letter of the preset variable may then be typed, and the input will be equal to the preset value, as in Example 1. If a player types H, the value of X will be 0; if he types T, the value of X will be 1.

So, try your luck playing the computer at matching pennies. Remember, it may sucker you at first. You may think that the computer cheats, so I have included a PEEK command in the program. If you type 2 instead of H or T, the computer will show you its next guess. It is not fair to "peek" every time as you may cause the program to have a nervous breakdown.■

Game No.	Computer's Play	Human's Play	Win/Lose	Wrote Cell No.	Read Cell No.	Game Total	Read from Comment Game No.	
0	T		W			0	*	Reset
1	T	H	W	H-0	H-1	1	8	
2	H	H	L	H-1	H-3	0	*	
3	H	H	L	H-3	H-7	-1	*	H, H Pattern
4	H	H	L	H-7	H-15	-2	*	
5	H	H	L	H-15	H-15	-3	5	
6	H	T	W	T-15	H-14	-2	*	
7	H	T	W	T-14	H-12	-1	*	
8	H	H	L	H-12	H-9	-2	*	
9	H	H	L	H-9	H-3	-3	3	
10	H	T	W	T-3	H-6	-2	*	H, H, T, T Pattern
11	H	T	W	T-6	H-12	-1	8	
12	H	H	L	H-12	H-9	-2	9	
13	H	H	L	H-9	T-3	-3	10	
14	T	T	L	T-3	T-6	-4	11	
15	T	T	L	T-6	H-12	-5	12	
16	H	H	L	H-12	H-9	-6	13	
17	H	T	W	T-9	H-2	-5	*	
18	H	H	L	H-2	H-5	-6	*	H, T Pattern
19	H	T	W	T-5	H-10	-5	*	
20	H	H	L	H-10	T-5	-6	19	
21	T	T	L	T-5	H-10	-7	20	
22	H	T	W	T-10	H-4	-6	*	
23	H	T	W	T-4	H-8	-5	*	T, T Pattern
24	H	T	W	T-8	H-0	-4	1	
25	H	T	W	T-0	T-0	-3	25	
26	T	T	L	T-0	T-0	-4	26	
27	T	H	W	H-0	H-1	-3	2	
28	H	H	L	H-1	T-3	-4	14	
29	T	H	W	H-3	H-7	-3	4	H, H Pattern
30	H	H	L	H-7	T-15	-4	6	
31	T	H	W	H-15	H-15	-3	31	
32	H	H	L	H-15	H-15	-4	32	
33	H	H	L	H-15	H-15	-5	33	
34	H	T	W	T-15	T-14	-4	7	
35	T	H	W	H-14	H-13	-3	*	
36	H	H	L	H-13	H-11	-4	*	
37	H	H	L	H-11	H-7	-5	30	H, H, H, T Pattern
38	H	T	W	T-7	H-14	-4	35	
39	H	H	L	H-14	H-13	-5	36	
40	H	H	L	H-13	H-11	-6	37	
41	H	H	L	H-11	T-7	-7	38	
42	T	T	L	T-7	H-14	-8	39	
43	H	T	W	T-14	H-12	-7	16	
44	H	T	W	T-12	T-8	-6	24	
45	T	H	W	H-8	H-1	-5	28	
46	H	T	W	T-1	H-2	-4	18	
47	H	T	W	T-2	T-4	-3	23	H, T, T, T Pattern
48	T	T	L	T-4	H-8	-4	45	
49	H	H	L	H-8	T-1	-5	46	
50	T	T	L	T-1	T-2	-6	47	
51	T	T	L	T-2	T-4	-7	48	
52	T	T	L	T-4	H-8	-8	49	
53	H	H	L	H-8	T-1	-9	50	

*Reset State (initialization)

Table 1. Penny-match game.

```
50 PR"MATCH PENNIES WITH THE COMPUTER!"
60 PR"IF THE COMPUTER GUESSES THE SAME AS YOU PICK "
70 PR"THEN THE COMPUTER WINS AND THE HUMAN LOSES!"
86 PR"TYPE YOUR FAVORITE NUMBER(0-100)"
87 INPUT X
100 GOSUB 600
105 PR"HEADS OR TAILS(H OR T)"
110 INPUT X
120 IF X=2 GOSUB 210
130 IF X>1 GOTO 105
140 GOSUB 300
150 GOSUB 400
160 GOSUB 215
170 IF X=V PR"HUMAN LOSES!"
175 IF X=V W=W-1
180 IF X<>V W=W+1
185 IF X<>V PR"HUMAN WINS!"
190 PR"YOUR SCORE IS ";W
195 GOSUB 500
200 GOTO 105
210 PR"YOU PEEKED!! -- NOT FAIR!"
215 PR"THE COMPUTER GUESSED ";
220 IF V=0 PR"HEADS"
225 IF V=1 PR"TAILS"
230 RETURN
300 Y=(8*A)+(4*B)+(2*C)+D
305 IF Y=0 F=X
310 IF Y=1 G=X
315 IF Y=2 E=X
320 IF Y=3 I=X
325 IF Y=4 J=X
330 IF Y=5 K=X
335 IF Y=6 L=X
340 IF Y=7 M=X
345 IF Y=8 N=X
350 IF Y=9 O=X
355 IF Y=10 P=X
360 IF Y=11 Q=X
365 IF Y=12 R=X
370 IF Y=13 S=X
375 IF Y=14 Z=X
380 IF Y=15 U=X
390 RETURN
400 D=C
405 C=B
410 B=A
415 A=X
420 RETURN
500 Y =(8*A)+(4*B)+(2*C)+D
505 IF Y=0 V=F
510 IF Y=1 V=G
515 IF Y=2 V=E
520 IF Y=3 V=I
525 IF Y=4 V=J
530 IF Y=5 V=K
535 IF Y=6 V=L
540 IF Y=7 V=M
545 IF Y=8 V=N
550 IF Y=9 V=O
555 IF Y=10 V=P
560 IF Y=11 V=Q
565 IF Y=12 V=R
570 IF Y=13 V=S
575 IF Y=14 V=Z
580 IF Y=15 V=U
590 RETURN
600 A=0
605 B=0
610 C=0
615 D=0
617 E=0
620 F=0
625 G=0
630 H=0
635 I=0
640 J=0
645 K=0
650 L=0
655 M=0
660 N=0
665 O=0
670 P=0
675 Q=0
680 R=0
685 S=0
687 T=1
690 U=0
692 V=0
695 W=0
696 Z=0
697 RETURN
```

Program listing.

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Euless Tx 76039

Why Not Trig Functions For Your 4K BASIC?

A while back, a neighbor's kid was looking through y copy of *101 Basic Computer Games* and asked if he could play Gunner. "No," I replied, "my computer can't do this line with SIN(X) in it." So he settled for Lunar Lander. While he was occupied, I wondered if it was possible to simulate this and other math functions, included in 8K BASIC but missing in my 4K version. They weren't called often, but used up lots of programming space whether needed or not. So, why not just have subroutines to add only when necessary?

I recalled from calculus classes that any function can be approximated by a series equation, a method using successive iterations—ideal for a computer. After a lot of research and some trial and error, I had subroutines to calculate SIN(X), COS(X), TAN(X), EXP(X) and LOG(X). Since they're all based on the same principle, let's use SIN(X) to demonstrate.

In 4K BASIC, you can approximate the sine of X by following the function in Example 1—provided that X is in radians, and $X^n/n!$ is less than some predetermined value, such as 1E-7.

I chose this value to compare with the 8K version. Actually, you could speed things up by stopping at 1E-4. This is more than enough accuracy for most games. For those of you unfamiliar with the term n! (called factorial), it is defined as the multiplication of all integers (whole numbers) from one to n. 3! equals 6, 5! equals 120 and 7! equals 5040.

You can see that $X^n/n!$ very quickly becomes smaller and smaller. This is called converging, because the more terms you add, the closer you get to the actual answer.

Here's the procedure for finding SIN(X):

1. Convert X in degrees to R in radians.
2. Set X equal to R.
3. Set S equal to R.
4. Set counter N equal to 1.
5. Add 2 to N.
6. Convert term R to (−R)*(S * S)/[−N * (N −1)].
7. Add R to X.
8. If the absolute value of R is

```
100 REM artillery game by G.L. Oliver
110 REM demonstrates 4K SIN(X) subroutine
200 Let T = 50000 - INT (RND (0) *45000)
205 REM T is distance to target
210 Let A = 0
215 REM A is shot count
220 Input X
230 If X<90 then go to 260
240 Print "Bad Angle"
250 Go to 220
260 If X<1 then go to 240
270 Let X = X * 2
280 Gosub 1000
290 Let A = A + 1
300 Let H = T - INT (50000*X)
310 If H<100 then go to 350
320 Print "Over By"; H; "Yards"
330 Go to 370
350 If H<-100 then go to 400
360 Print "Under By"; H; "Yards"
370 If A<5 then go to 220
380 Print "You Got Hit!"
390 Go to 500
400 Print "Got Him In"; A; "Shots"
410 Print H; "Yards"
500 Print "Try Again? (1 = Yes; 0 = No)";
510 Input A
520 If A = 1 then go to 200
530 Stop
```

Program B.

$$SIN(X) = X - \frac{X^3}{3!} + \frac{X^5}{5!} - \frac{X^7}{7!} + \ldots + \frac{X^n}{n!}$$

Example 1.

less than 1×10^{-7}, you are done and should return with X equal to SIN (X).

9. Otherwise, go back to step 5.

Fig. 1 is the flowchart for this procedure, and Program A shows the completed subroutine. As to application, I freely changed and simplified the Gunner program to demonstrate my subroutine (see Program 2).

Now that we have SIN(X), how about COS(X)? All you need to do is add 90 degrees to the angle, and then use the same subroutine you use for SIN(X). Believe me. So, that gives us SIN(X) and COS(X).

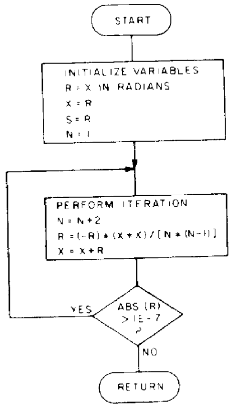

Fig. 1. Flowchart.

TAN(X) is just SIN(X) divided by COS(X). It may take a bit longer to calculate since you have to call the same subroutine twice and juggle a few numbers; but look at the space you save! That was the reason for using 4K to begin with.

```
1000 Let R = X *.01754293
1010 Let X = R
1020 Let S = R
1030 Let N = 1
1040 Let N = N + 2
1050 Let R = -R * S * S/[N * (N - 1)]
1060 Let S = X + R
1070 If ABS (R) <1E-7 then return
1080 Go to 1040
```

Program A.

You save a lot of space—as I stated earlier—but what are you giving up? Time, of course. It takes about a second for angles less than 90 degrees, and maybe two seconds when you are up to 360 degrees. So what! You now have 4K extra of programmable memory.■

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