## Summary of Conventions Used in This Manual

<table>
<thead>
<tr>
<th>Notation (Example)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO</td>
<td><strong>Black keybox.</strong> Primary keyboard function.</td>
</tr>
<tr>
<td>10^x</td>
<td><strong>Gold keybox.</strong> Shifted keyboard function. Press and release the shift key (▁) first. These can be on the Normal or Alpha keyboard.</td>
</tr>
<tr>
<td>DATE</td>
<td><strong>Blue keybox.</strong> Nonkeyboard function. For Alpha execution: use □ followed by the Alpha name spelled out on the Alpha keyboard. For User-key execution: assign the function to the User keyboard.</td>
</tr>
<tr>
<td>ABC</td>
<td><strong>Blue letters.</strong> Alpha characters.</td>
</tr>
<tr>
<td>123</td>
<td><strong>Gold digits or characters.</strong> Shifted Alpha characters.</td>
</tr>
<tr>
<td>T</td>
<td><strong>Black letters in keyboxes.</strong> These are special functions, <em>not</em> Alpha characters, and are active only in special circumstances. If it is a shifted function, it is preceded by □</td>
</tr>
<tr>
<td>parameter</td>
<td><strong>The type of parameter</strong> required for a function.</td>
</tr>
</tbody>
</table>

For a full description, refer to “How This Manual Represents Keystrokes,” page 16.
Introducing Volume 2

This is the second volume of the two-volume *HP-41CX Owner's Manual*. Volume 1, *Basic Operation*, is an extensive introduction to most aspects of the HP-41CX. This second volume, *Operation in Detail*, is an advanced, detailed examination of all aspects of the HP-41CX. Together, these two volumes form one manual, so the page numbers in this volume continue sequentially from where those in volume 1 left off. The numbers of the sections and the parts also continue in sequence from volume 1.

“How To Use This Manual” on page 9 (volume 1) explains the scheme of this handbook and recommends places to start reading. Look there for a brief overview of the two volumes. This volume (volume 2) emphasizes *completeness* of information and *reference* information. All the appendices are in this volume, as is an index to all the functions (inside the back cover) and a comprehensive summary of all the functions in the Function Tables (the blue-edged pages in front of the Subject Index). If you are already familiar with the HP-41, remember to check appendix I, “A Comparison With the HP-41C/CV.”
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- Section 3: Storing and Recalling Numbers
- Section 4: How to Execute HP-41 Functions
- Section 5: The Standard HP-41 Functions
- Section 6: The Time Functions
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The Keyboard and Display

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The Toggle Keys

Just below the display are four toggle keys labeled [ON], [USER], [PRGM], and [ALPHA]. They control how the computer interprets the other keys. The toggle keys are so named because of their dual action: when you press one, it gives a particular interpretation to the keyboard which generally continues until you press the same toggle key again, returning the keyboard to its previous state.

The [ON] Key. This toggle key turns the computer on and off. After about 10 minutes of inactivity the computer automatically turns itself off to prolong battery life.* While the computer is off, Continuous Memory maintains the contents of main and extended memory and the status of certain flags. To reset the computer (that is, to clear main and extended memory and set all flags to default status):

1. Turn the computer off.
2. Hold down [←].
3. Press [ON].
4. Release [←].

The display will show MEMORY LOST.

The [USER] Key. This toggle key activates and deactivates the User keyboard, which is your redefined version of the Normal keyboard. The USER annunciator appears (and flag 27 is set) when the User keyboard is active.

The [PRGM] Key. This toggle key shifts the computer between Execution mode and Program mode. When you turn on the computer, it is in Execution mode—you can execute functions and programs. In Program mode you can write or edit programs; functions are stored as program steps to be executed later when you run the program in Execution mode. The PRGM annunciator indicates that the computer is in Program mode or that a program is running in Execution mode.

The [ALPHA] Key. This toggle key activates and deactivates the Alpha keyboard, which includes the blue letters on the lower face of the keys. The ALPHA annunciator appears (and flag 48 is set) when the Alpha keyboard is active. Pressing [ON] or [PRGM] deactivates the Alpha keyboard.

The Keyboards

This manual shows each function name in a color that indicates how to execute that function. The following overview of the keyboards covers this use of color and the basic purpose of each keyboard.

* Unless you execute [ON], which sets flag 44 (Continuous On). Flag 44 is cleared each time you turn on the computer.
The Normal Keyboard

The Normal keyboard comprises the functions printed in white on the upper face of the keys and the functions printed in gold above the keys. This is the default keyboard—it is active after Continuous Memory is cleared.

When you press the \textbf{SHIFT} annunciator appears, indicating that a shifted function will be executed. The annunciator disappears when you press a second key (to execute the shifted function) or press \textbf{SHIFT} a second time (to cancel the shift command).

This manual represents an unshifted function by its name in black inside a black box, and a shifted function by its name in gold inside a gold box. For example, \texttt{LN} is the unshifted function on the top right key, and \texttt{e^x} is the shifted function. This rule applies to other keyboards too; for example, \texttt{AVIEW} is a shifted function on the Alpha keyboard.

When a key has a special meaning associated with the letter on its lower face, that key is represented by the letter in black inside a black box. For example, the keystroke sequence that produces \texttt{Z} would be \texttt{RCL \cdot Z}, with \texttt{Z} representing the \texttt{1} key.

The User Keyboard

The User keyboard is your customized version of the Normal keyboard. You can assign a function or global label to any key except the toggle keys or the \textbf{SHIFT} key. You can then execute that function, or start program execution at that global label, by pressing the redefined key on the User keyboard.

Because shifted key positions can be redefined as well, one key can execute four different functions, depending on whether the User keyboard is active and whether the \textbf{SHIFT} key is pressed first. The operation of the User keyboard is described on page 166.

Many functions are not on the Normal keyboard but can be assigned to the User keyboard. These are called nonkeyboard functions. This manual represents a nonkeyboard function by its name in blue inside a blue box.

The Alpha Keyboard

The Alpha keyboard comprises letters, functions, symbols, and digits considered as characters rather than numbers. The blue letters and symbols on the lower face of the keys are the unshifted characters on the Alpha keyboard. Digits 0 through 9 and the arithmetic symbols are shifted characters on the keys where they appear on the upper face. Shown on the next page is the entire Alpha keyboard, which includes functions and additional symbols in shifted positions.
The Alpha Keyboard
There are two distinct uses for the Alpha keyboard.

- To spell out a function or global label as a parameter for \texttt{ASN}, \texttt{CLP}, \texttt{COPY}, \texttt{GTO}, \texttt{LBL}, or \texttt{XEQ}. In such cases the characters become part of the instruction.

- To key characters into the Alpha register. Here they are saved until you write over them or clear the register. The Alpha register is used to display your own messages, to specify file names and global labels for certain functions, and to manipulate bytes of data.

This manual shows unshifted characters on the Alpha keyboard in blue, shifted characters in gold. Note that a digit printed in gold represents an Alpha character while a digit printed in black represents a number on the Normal keyboard.

**Special Keyboards**

In addition to the keyboards activated by the \texttt{USER} and \texttt{ALPHA} toggle keys, there are special keyboards activated by functions. Some major examples are:

- The Text Editor keyboard, activated by \texttt{ED}. Based on the Alpha keyboard, this keyboard includes commands to manipulate a text file in extended memory. The \texttt{ED} function is described in section 14.

- The Alarm Catalog keyboard, activated by \texttt{ALMCAT} and \texttt{CATALOG}. These functions enable you to examine and alter alarms in memory. Alarms are described in section 16.

- The Stopwatch keyboard, activated by \texttt{SW} and \texttt{SWPT}. Stopwatch operations are described in section 17.

**Keying In Numbers and Characters**

Keying numbers into the X-register and keying characters into the Alpha register are similar processes. In both cases:

- When you enter the first digit or character, the display shows that digit or character followed by the input cue (\texttt{\_}).

- The input cue indicates that the computer will append the next entry from the keyboard to the string of digits or characters in the display.

- When the input cue is displayed, you can correct your entry by pressing \texttt{\textasciicircum} to delete the rightmost digit or character.* The input cue then moves left to replace it.

- If the input cue is not displayed, entry has been terminated and the next entry from the keyboard will start a new number or Alpha string.*

---

* If you key 10 digits or a two-digit exponent into the X-register, the input cue will disappear because no additional digits are allowed. However, entry has not been terminated: your next entry will not start a new number, and pressing \texttt{\textasciicircum} will delete the rightmost digit.
Keying In Numbers

Up to 10 digits can be keyed into the X-register—additional digits will be ignored. The only keys used for digit entry are digit keys [0] through [9], [+/-], [CHS] (change sign), [EEX] (enter exponent), and [«]. Pressing any key other than a digit entry key, [+/-], or [USER] terminates digit entry—subsequent digits will be considered a new number.

Pressing [CLx] replaces the number in the X-register with zero; if you key in another number now, it will replace this zero. If there is only one digit in the display or if digit entry has been terminated, [+/-] has the same effect as [CLx].

Entering an Exponent. To enter a number in the form $a \times 10^b$, first key in the digits and decimal point for $a$ and then press [CHS] if the number is negative. To enter more than eight digits for $a$, you must key in a decimal point somewhere to the left of the ninth digit.

Second, press [EEX]. Any digits to the right of the eighth digit will disappear but will remain internally. Enter one or two digits for the exponent $b$ and press [CHS] if $b$ is negative. If you press [EEX] without first entering a value for $a$, the computer sets $a$ equal to 1.

Entering $\pi$. Pressing $\pi$ has the same effect as keying in 3.141592654 and terminating digit entry.

Keying In Characters

In Execution Mode. If the Alpha keyboard is active and you are not specifying a parameter, the characters go into the Alpha register. For keyboard input to the Alpha register under program control, execute [AON] before the program pauses or halts for input, and then [AOFF] when execution resumes.

The Alpha register can hold up to 24 characters. As you key in the 24th character, a tone sounds to warn you that the Alpha register is full. If you key in a character when the Alpha register is full, the leftmost character is pushed out of the Alpha register and is lost.

Character entry is terminated by [ASTO], [BST], [SST], [AVIEW], [R/S], or by deactivating the Alpha keyboard. Character entry is restored by [~] (append) or by [ARCL].

Pressing [CLA] deletes all characters from the Alpha register. If character entry has been terminated, [+/-] has the same effect as [CLA].

In Program Mode. Up to 15 characters can be stored in a program line, which will be displayed with a leading ¶. The characters that follow are entered into the Alpha register when the program is run. To add a string of characters to the Alpha register without replacing the previous contents, begin the string with [~]. For example, you can load more than 15 characters into the Alpha register by using two program lines, beginning the second line with [~]. (The character ~ appears only when the program line is displayed; the “append function” is executed when the program is run.)
Note: Alpha strings appear within quotation marks when listed by a printer or video monitor. Only program lines that begin and end with quotation marks are Alpha strings; if a listed program line is not within quotation marks, it is a function. Don’t mistake an unfamiliar function name for an Alpha string—be sure to press \[ \text{[XEQ]} \] before keying in the function name.

Status Annunciators

The status annunciators appear along the bottom of the display. In addition to the USER, PRGM, ALPHA, and SHIFT annunciators mentioned above, the following annunciators may appear.

- **BAT** indicates that the batteries are low. With alkaline batteries, about 5 to 15 days of operating time remain after BAT first appears. With the HP 82120A Rechargeable Battery/Reserve Power Pack, about 2 to 50 minutes of operating time remain. If you use the HP 82104A Card Reader or the HP 82153A Optical Wand, the operating time remaining will be reduced. For more information about batteries, refer to appendix G.

- **GRAD** or **RAD** indicates that the computer is in Grads or Rads mode for trigonometric and rectangular/polar functions. If neither **GRAD** nor **RAD** appears, the computer is in Degrees mode.

- **0 1 2 3 4** indicates that the corresponding flag (00, 01, 02, 03, or 04) is set.

Some status annunciators have special meanings when \[ \text{[ED]} \] is operating. They return to their previous states when you exit \[ \text{[ED]} \].

Numeric Display Format

The computer represents every number internally in the form \( a \times 10^b \) where \( a \) is number with nine decimal places, \( 1 \leq |a| < 10 \), and \( b \) is a two-digit integer, \( 0 \leq |b| < 100 \). You can control how numbers are displayed without altering their internal representation. (If you do want to alter the number internally to match the display, refer to \[ \text{[RND]} \] on page 186.) The format and punctuation you specify are maintained by Continuous Memory.

Formatting Numbers

There are three options for formatting numbers, which are selected by the functions \[ \text{[Fix]} \], \[ \text{[Sci]} \], and \[ \text{[Eng]} \].

**[Fix]** \( n \). This format displays numbers with up to \( n \) decimal places \( (0 \leq n \leq 9) \). If the integer portion of a number requires more than \((10 - n)\) digits, fewer than \( n \) decimal places will be displayed. For example, the default format is \[ \text{[Fix]} 4 \], which displays numbers to four decimal places; but if a number has eight digits before the radix mark, only two decimal places will be displayed.

The last displayed digit is rounded up if the first hidden digit is 5 or greater. If the fractional portion of a number requires fewer than \( n \) digits, trailing zeros are added. If a number is too large or too small for the display, the format automatically and temporarily switches to \[ \text{[Sci]} n \].
SCI $n$. This format displays numbers with one digit before and $n$ digits after the radix mark ($0 \leq n \leq 9$), multiplied by a power of 10. For $n \leq 7$, the number is rounded to $n$ decimal places. A maximum of 7 decimal places can be displayed, so SCI 8 or SCI 9 cause rounding to occur outside the display. (These formats can be useful when numbers are printed.)

ENG $n$. This format displays a number with the same digits as SCI $n$, but with an exponent that is always a multiple of three. The radix mark is moved to the right to compensate for any change in the exponent.

### Punctuation

Flags 28 and 29 control how periods and commas are used in number displays. In the U.S.A. a period is used as the radix mark (usually called the decimal point) to separate the integer and fractional parts of a number, and a comma is used as the separator mark between groups of digits in a large number. In some other countries, the comma is the radix mark and the period is the separator mark.

Flag 28 determines the roles of periods and commas. The default state for flag 28 is set, which produces the display normal for the U.S.A. Clearing flag 28 switches the roles of periods and commas to correspond with usage in some other countries.

Flag 29 determines whether a separator mark is displayed, regardless of which symbol represents the separator mark. The default state for flag 29 is set, which displays the separator mark. Clearing flag 29 suppresses all separator marks and, in the special case of FIX 0 format, suppresses display of the radix mark.

### Standard Displays and Messages

The computer displays either the standard display or a message. The contents of the X-register are the standard display unless:

- The Alpha keyboard is active (and you’re not keying in a parameter), in which case the contents of the Alpha register are the standard display.
- The computer is in Program mode, in which case the current program line is the standard display.
- A program is running, in which case the program execution indicator (#-) is the standard display.

Any other display is a message. Examples include the displays for the text editor (section 14), the clock (section 15), the stopwatch (section 17), and a program’s messages for the user (section 21). Examples covered in this section include the displays for parameter specification, function preview, the catalogs, and error messages. Flag 50 is set when the display contains a message.
Display Scrolling

To show more characters than the display can hold at one time, the computer “scrolls” the characters across the display until the last character enters the display. While the characters are moving you can press any key to bypass this process and immediately see the final display. The function whose key you pressed isn’t executed.

Specifying Parameters

Certain functions require parameters to become complete commands. When the display shows the function name followed by one or more input cues ( _ ), you must enter a parameter.

- For a numeric parameter such as a register address, flag number, local numeric label, program line number, and so on, observe how many input cues are shown and key in the desired digits. (You might need to add leading zeros, like 042 to specify program line 42.)
- For an Alpha parameter such as a function name or global label, press [ALPHA] to activate the Alpha keyboard, then spell out the name or label, and then press [ALPHA] again to complete parameter specification.

Indirect Parameter Specification

The parameters for most functions can be specified indirectly: rather than entering the parameter itself in response to the input cue, you enter the address of a register (the “indirect register”) that contains the parameter. This feature is particularly useful when the value of the parameter depends on previous calculations in a program or when a routine is executed repeatedly to access sequential registers. In addition, the addresses for main memory registers \( R_{100} \) through \( R_{318} \) must be specified indirectly.

To specify a parameter indirectly:

1. Execute the function.
2. In response to the input cue, press \([\text{.]})\). The display will show IND _ _ after the function name.
3. Specify the indirect register.

The following examples demonstrate how indirect parameter specification works for three types of parameters. In each example \( R_{10} \) is the indirect register containing a parameter of 5; in the first example 5 is simply a number, in the second example 05 is an address, and in the third example 05 is a label.
Example. Suppose that R₁₀ contains 5. If you execute \texttt{TONE IND} 10, the number in R₁₀ becomes the parameter for \texttt{TONE}. Therefore, \texttt{TONE IND} 10 is equivalent to \texttt{TONE} 5 when R₁₀ contains 5.

\[
\text{R₁₀} \rightarrow \begin{array}{c}
\text{TONE IND} 10 \\
+ \\
\text{TONE} 5.
\end{array}
\]

Example. Suppose that R₁₀ contains 5. If you execute \texttt{STO IND} 10, the address in R₁₀ becomes the parameter for \texttt{STO}. Therefore, \texttt{STO IND} 10 is equivalent to \texttt{STO} 05 when R₁₀ contains 5.

\[
\text{R₁₀} \rightarrow \begin{array}{c}
\text{STO IND} 10 \\
+ \\
\text{STO} 05.
\end{array}
\]

Indirect specification of an address—called \textit{indirect addressing}—is the most common use for indirect parameter specification, and the most common use for indirect addressing is to access a series of registers by a looping routine in a program. For example, a loop containing \texttt{RCL IND} 10, \texttt{1/x}, \texttt{STO IND} 10 will replace the number in R₀₅ with its reciprocal when R₁₀ contains 5 (as illustrated above). The loop can then increment the address in R₁₀ from 5 to 6 and start over, this time replacing the number in R₀₆ with its reciprocal and incrementing the address in R₁₀ from 6 to 7, and so on. (Loops are described in section 20, “Branching”.)

Example. Suppose that R₁₀ contains 5. If you execute \texttt{XEQ IND} 10, the label in R₁₀ becomes the parameter for \texttt{XEQ}. Therefore, \texttt{XEQ IND} 10 is equivalent to \texttt{XEQ} 05 when R₁₀ contains 5.

\[
\text{R₁₀} \rightarrow \begin{array}{c}
\text{XEQ IND} 10 \\
+ \\
\text{XEQ} 05.
\end{array}
\]

You can also indirectly specify any global label listed in catalog 1 or any programmable function or global label listed in catalog 2, provided that the label doesn’t exceed six characters.
Parameters can be indirectly specified for the following functions:

- **Functions with register-address parameters.**
  - `STO`, `RCL`.
  - `STO +`, `STO −`, `STO ×`, `STO ÷`.
  - `ASTO`, `ARCL`.
  - `ISG`, `DSE`.
  - `X<>`, `VIEW`, `ΣREG`.
- `XEQ`, `GTO`.
- `FIX`, `SCI`, `ENG`.
- `TONE`.

**Special Keys**

The following diagram shows the keys that have special meanings when you’re specifying a parameter for functions in catalog 3.
Special Keys for Specifying Parameters
Stack Register Addresses. To specify a stack register or the LAST X register, press \( \text{[} \) followed by \( \text{X, Y, Z, T, or L} \).

Program Line Numbers. To specify line numbers over 999, press \( \text{[} \text{EEX} \text{]} \). The display will show \( 1_\_\_\_ \). Then key in the remaining three digits.

Single-Key Parameter Specification. For convenience, you can specify a one-digit parameter of 0 through 9, or a two- or three-digit parameter of 1 through 10, by pressing the appropriate key in the two top rows. For example, when one, two, or three input cues are displayed, pressing \( \text{[} \Sigma + \text{]} \) enters a parameter of 1, 01, or 001. If only one input cue is displayed, pressing \( \text{[} \tan \text{]} \) enters a parameter of 0; if two or three input cues are displayed, pressing \( \text{[} \tan \text{]} \) enters a parameter of 10 or 010.

Redefining the User Keyboard

There are two functions that assign functions and global labels to the User keyboard, \( \text{[} \text{ASN} \text{]} \) (assign) and \( \text{[} \text{PASN} \text{]} \) (programmable assign). Use \( \text{[} \text{ASN} \text{]} \) to make assignments manually; it’s easier to use but isn’t programmable. Use \( \text{[} \text{PASN} \text{]} \) to make assignments under program control.

To make an assignment manually:
1. Execute \( \text{[} \text{ASN} \text{]} \).
2. Press \( \text{[} \text{ALPHA} \text{]} \), key in the function name or global label, and press \( \text{[} \text{ALPHA} \text{]} \) again.
3. Press the key (or \( \text{[} \) and the key) to be redefined.

To make an assignment under program control:
1. Enter the function name or global label into the Alpha register.
2. Enter the key code of the key to be redefined (according to the diagram on the facing page) into the X-register.
3. Execute \( \text{[} \text{PASN} \text{]} \).

The following diagram shows the keycodes for the User keyboard. Note that:
- All keycodes have two digits.
- Keycodes for shifted locations are negative.
- You can’t redefine the toggle keys or the shift key.
- You can redefine the \( \text{[} \text{R/S} \text{]} \) key. Your redefinition supersedes the “run” function in Execution mode and the \( \text{[} \text{STOP} \text{]} \) function in Program mode, but you can still press \( \text{[} \text{R/S} \text{]} \) to stop a running program.
The User Keyboard
When you assign a function listed in catalog 2 or 3, or a global label listed in catalog 2, the assignment is stored in User keyboard memory. (User keyboard memory is a part of main memory and is described in section 12.) However, when you assign a global label listed in catalog 1, that assignment is stored as a part of the label itself. If the label is deleted from program memory, the assignment is cancelled. If the program containing the assigned label is stored in extended memory, and if the User keyboard is active (flag 27 is set) when the program is recalled from extended memory, the assignment stored in the label will be reactivated.

**The User Keyboard Catalog**

Executing **CATALOG** 6 displays all functions and global labels assigned to the User keyboard. The order of display is by keycode, with smaller numbers before larger numbers (left to right and top to bottom on the keyboard) and positive before negative (unshifted before shifted). You can stop the listing by pressing **R/S**, and then:

- Press **SST** to see the next assignment.
- Press **BST** to see the previous assignment.
- Press **C** to clear the displayed assignment.
- Press **R/S** to restart the listing.

If there are no assignments or if the only assignment is cleared using **C**, the computer displays **CAT EMPTY**.

**Restoring Normal Functions**

You can cancel the assignment to a redefined key by any one of the following methods:

- Executing **ASN** twice, pressing **ALPHA** twice, and then pressing the appropriate key.
- Clearing the Alpha register, entering the appropriate keycode into the X-register, and executing **PASN**.
- Pressing **C** when catalog 6 is halted and displays the assignment.

To cancel all assignments currently in effect, execute **CLKEYS**. Note that assignments that are stored in global labels in extended memory will be reactivated if the User keyboard is active (flag 27 is set) when the program is recalled.
The Two Top Rows

There is a special type of program label, the local Alpha label, that is designed for use with the two top rows of the User keyboard. The name of each label corresponds to an Alpha character on the top two rows: A through E on the top row, F through J on the second row, and a through e on the shifted top row. Section 20, “Branching,” discusses how to program with these labels; the discussion here covers only the conditions required to execute a local Alpha label on the User keyboard. These conditions are:

- The User keyboard is active.
- The current program contains the local Alpha label.
- You haven’t redefined the key that corresponds to the local Alpha label.

These conditions combine with the general rules for the User keyboard to produce the following priorities. When you press a key on the top two rows of the User keyboard:

1. If you have assigned a function or global label to the key, that function is executed or program execution begins at that global label.
2. If you haven’t redefined the key and the corresponding local Alpha label exists within the current program, execution begins at that local Alpha label.
3. If neither of the first two conditions is true, the Normal keyboard function—the one printed on (or above) the key—is executed.

Execution of a Normal keyboard function may take significantly more time when the User keyboard is active because the computer checks the higher priorities first. To avoid this delay when executing a Normal keyboard function, you can deactivate the User keyboard before pressing the key or else assign the Normal keyboard function to that key.

Function Preview and Null

You can display the current meaning of a key, without necessarily executing the resulting function, by holding down the key. This preview is particularly helpful on the User keyboard when you’re not sure which keys are redefined.

- If the function requires a parameter (one or more input cues appear), release the key. If you want to cancel the function, press [←].
- If the function doesn’t require a parameter, you can either release the key to execute the function or else hold the key down until NULL is displayed to cancel the function.
In addition, there are four situations when a program line is previewed. (Assume that you release the key before NULL is displayed.)

- If the User keyboard is active and you press a key to which you’ve assigned a global label, that label is displayed and program execution begins at that label.
- If the User keyboard is active and you press a key that corresponds to a local Alpha label in the current program, XEQ label is displayed and program execution begins at that label.
- If you press \( \text{[R/S]} \), the current program line is displayed and program execution begins at the current program line.
- If you press \( \text{[SST]} \), the current program line is displayed and only the current program line is executed.

The Catalogs

There are six catalogs that enable you to review memory contents. The \( \text{[CATALOG]} \) function is not programmable, but there are programmable functions equivalent to catalogs 4 and 5. The rules of operation common to all catalogs are described first, followed by an overview of each catalog.

Basic Catalog Operation

Execute \( \text{[CATALOG]} n \) to start the listing of catalog \( n \).

While the listing is running:
- Pressing any key except \( \text{[R/S]} \) and \( \text{[ON]} \) speeds up the listing.
- Pressing \( \text{[R/S]} \) stops the listing.

While the listing is stopped:
- Pressing \( \text{[SST]} \) displays the next item in the catalog.
- Pressing \( \text{[BST]} \) displays the previous item in the catalog.
- Pressing \( \text{[R/S]} \) restarts the listing.
- Pressing \( \text{[→]} \) exits the catalog.

Catalogs 4, 5, and 6 consume as much power as a running program even when the listing is stopped. Therefore, the computer exits these catalogs after about two minutes of inactivity.

A printer in Trace mode will print a catalog listing.
Types of Catalogs

Catalog 1: User Programs. A list of all global labels and END instructions. With each END instruction appears the number of bytes in that program; with the permanent END (the final entry) appears the number of registers available for new programs.

You can use catalog 1 to make any program the current program: press R/S to stop the listing at that program’s global label or END instruction, and then press (to exit the catalog. (Page 284.)

Catalog 2: External Functions. A list of all functions and programs currently available to the computer from peripheral devices and plug-in modules, plus all extended memory and time functions. A T precedes global labels for programs to distinguish them from functions.

Functions and programs are grouped by source. Initially the catalog lists only the main entries (headers) in each group. To list all entries, press R/S to stop the listing, wait for the display to blink, and then press ENTER+. To return to a listing of headers only, press R/S to stop the listing and then press ENTER+. (Page 394.)

Catalog 3: Standard Functions. An alphabetical listing of the standard functions of the HP-41. This listing shows the Alpha name for each function, which may differ from the name that appears on the keyboard. You need to know the Alpha name to assign a function to the User keyboard and to interpret program lines.

Catalog 4: Extended Memory Directory. A list of all files in extended memory. The name, type, and number of registers for each file is shown. After listing all existing files, the computer displays the number of registers available for a new file. A program can execute this catalog as [EMDIR].

You can use catalog 4 to make any file the current file: press R/S to stop the listing at the desired file, and then press ( to exit the catalog. (Page 206.)

Catalog 5: Alarm Catalog. A list of all alarms in alarm memory. The time, date, and message for each alarm is shown. You can delete alarms, reset repeating alarms, and look at specific parts of the alarm using the Alarm Catalog keyboard. A program can execute this catalog as [ALMCAT]. (Page 255.)

Catalog 6: User Keyboard Catalog. A list of all functions and global labels assigned to the User keyboard. The name of the function or global label and the key code indicating key location is shown for each assignment, starting at keycode 11 (Σ+) and ending at −84 (VIEW).

You can use catalog 6 to cancel any assignment: press R/S to stop the listing at the desired assignment, and then press ( C). (Page 168.)
Error Messages

An operation that is illegal is never executed. If the attempted operation is a program instruction, the computer stops program execution and displays an error message.*

- To clear the error message from the display, press [×].
- To execute a different function, simply press the appropriate key—you don’t need to clear the error message first.
- To discover which instruction caused the error, press [PRGM] to switch to Program mode. The display then shows the program line containing the illegal operation (or an XROM number if a missing plug-in module caused a NONEXISTENT error).

A list of error and status messages appears in appendix A. Many devices that plug into the computer have their own messages which may appear in the computer display. Refer to the literature for those devices to learn about such messages.

* Flags 24 and 25 can prevent certain anticipated errors from stopping program execution. These flags are described on page 290.
Introduction

Numeric functions use four registers called the automatic memory stack. Numbers automatically move “up and down” in the stack when you enter numbers and perform calculations. The logic used is Reverse Polish Notation (RPN), which minimizes keystrokes and produces all intermediate results. If you are unfamiliar with RPN, refer to page 20.

- The first topic in this section, “RPN Calculations,” evaluates a typical numeric expression and describes the principles underlying use of the stack. Included is a method for constant arithmetic based on filling the stack with a constant.

- The second topic, “The LAST X Register,” covers a special register closely related to the stack registers. The LAST X register is used for error correction and for a second method of constant arithmetic.

- The third topic describes other stack operations that give you more flexibility in using the stack, again emphasizing the repeated use of a constant.
**RPN Calculations**

The diagrams below show the contents of the automatic memory stack and the LAST X register following each step of an RPN calculation. Let x, y, z, t, and \( l \) represent numbers in the stack initially. The calculation evaluates the expression

\[
\frac{32}{5^2 - 9}.
\]

This example will be the basis for explaining how the stack works and how to use it efficiently.

**Stack Lift and Stack Drop**

The automatic movements of stack contents are called stack lift (moving upward in the diagram) and stack drop (moving downward).

**Stack Lift.** This usually occurs when a number is moved into the X-register. The numbers in the Y- and Z-registers are lifted into the Z- and T-registers; the number in the T-register is lost. In the example, stack lift occurs when 32 is keyed in, when \( \text{ENTER} \) copies 32 into the Y-register, and when 9 is keyed in.

**Stack Drop.** This usually occurs when a function combines the numbers in the X- and Y-registers. The number in the Z- and T-registers are dropped into the Y- and Z-register; the number in the LAST X register is lost. In the example, stack drop occurs when \(-\) and \(\div\) are executed.

**Using \( \text{ENTER} \)**

Pressing \( \text{ENTER} \) separates two numbers keyed in one after the other (32 and 5 in the example). This copies the number in the X-register (32) into the Y-register. The copy left in the X-register is replaced by the next number keyed in (5) because \( \text{ENTER} \) disables stack lift.
Enabling/Disabling Stack Lift

Nearly all functions enable stack lift: the stack will lift if you place a number in the X-register after executing the stack-lift enabling function. However, four functions disable stack lift and others are neutral.

Stack-Lift Disabling Functions. The four functions that disable stack lift are \[^{\text{ENTER}^+}\], \[^{\text{CLx}}\], \[^{\text{Σ+}}\], and \[^{\text{Σ-}}\]. If you execute one of these functions and then place a number in the X-register, that number will replace the previous contents and the Y-, Z- and T-registers will not be affected. Stack diagrams show when stack lift is disabled by shading the X-register, indicating that its contents will be replaced.

Neutral Functions. The following functions neither enable nor disable stack lift, but maintain the previous status:

- The toggle keys (\[^{\text{ON}}\], \[^{\text{USER}}\], \[^{\text{PRGM}}\], \[^{\text{ALPHA}}\]).
- The backarrow key (\[^{\text{«}}\]) during digit or character entry.
- The shift key (\[^{\text{I}}\])
- Catalogs 1, 2, 3, and 6.

Order of Entry

Two major considerations affect the order in which you should enter operands. You can save many keystrokes by observing the following rules, although sometimes you must choose between them.

Nested Terms. For expressions with terms nested in parentheses, calculate the innermost term first and then use that result in the simplified expression. If two nested terms must be calculated before you can combine them, the automatic memory stack saves the result of the first term while you evaluate the second term. The example in “Polynomial Expressions” below demonstrates this rule.

Noncommutative Functions. Functions like subtraction and division are called noncommutative because the order of the operands is essential: \(5 - 3 \neq 3 - 5\), and \(5 \div 3 \neq 3 \div 5\). For expressions involving noncommutative functions, enter or calculate the number that must be in the Y-register before entering or calculating the number that must be in the X-register. The previous example demonstrates this rule twice.

- The numerator (32) is entered before the denominator \((5^2 - 9)\) is calculated.
- The term \(5^2\) is calculated before 9 is subtracted from it.
Filling the Stack

Note in the last three steps of the previous example how x propagates from the T-register into the Y- and Z-registers. This consequence of stack drop can keep the Y-register filled with a constant, as demonstrated in the next two examples. This technique is particularly appropriate when the constant must be in the Y-register for noncommutative operations like [−] and [÷]. (In contrast, LASTx supplies the constant in the X-register.)

Cumulative Growth. Suppose that you want to calculate the growth of a quantity that starts at a value of 16 and increases by 50% each period. First fill the stack with the growth factor (1.5) and key the starting value (16) into the X-register. Then press [×] to calculate the value after the first period and press [×] again for each subsequent period.

![Diagram of stack operations]

Keys: 1.5 ENTER+ 16 [×] [×] [×] [×]

Polynomial Expressions. Filling the stack aids the evaluation of a polynomial, which requires several copies of the variable. For efficiency, use Horner’s Method to rewrite the polynomial in a nested fashion that eliminates exponents greater than 1. Suppose that you want to evaluate

\[ x^4 - 2x^3 + 5x \]

for \( x = 3 \). First, rewrite the polynomial to eliminate the exponents.

\[
x^4 - 2x^3 + 5x = (x^3 - 2x^2 + 5)x
\]

\[
= ((x^2 - 2x)x + 5)x
\]

\[
= (((x - 2)x)x + 5)x
\]
Then fill the stack with the variable by pressing 3, ENTER+, ENTER+, ENTER+, ENTER, and execute the steps below. Note that the calculation begins at the innermost nested term.

Once you are familiar with Horner's Method you can key in the steps for a polynomial without actually rewriting it. For example, the steps to evaluate the polynomial

\[ ax^5 + bx^4 + cx^3 + dx^2 + ex + f \]

after filling the stack with the variable are:

- Note that coefficients (except the first and last) are followed by \( \text{[]} \) and \( \text{x} \). (There is no previous result to add to first coefficient, and the last coefficient isn’t multiplied by any power of the variable.)
- If the first coefficient is 1, start with the second coefficient. (The variable is already in the X-register.)
- For negative coefficients you may enter a positive value and substitute \( - \) for \( + \) following that coefficient.
- When there is no term for a power of \( x \), just press \( \text{x} \). (In effect, this enters a coefficient of 0 for that power.)

**Noncumulative Results.** You can also use constant arithmetic to perform a series of unrelated (noncumulative) operations with a constant. After each calculation, press \( + \) to clear the X-register before you key in the next operand. This disables stack lift, preventing the previous result from displacing the constant in the Y-register.
The LAST X Register

The LAST X register holds the x-operand from the last numeric function (except \texttt{CHS}). To recall this number to the X-register, press \texttt{LASTx}. This enables you to recover from errors and to retrieve an operand for further calculations.

Correcting Errors

One-Number Function Errors. If you execute the wrong one-number function, you can recover from your error as follows:

1. Press \texttt{←}. This replaces the incorrect result with zero and disables stack lift.
2. Press \texttt{LASTx}. This recalls your operand, which replaces the zero in the X-register.
3. Continue your calculation with the correct function.

Two-Number Function Errors. If you make a mistake with a function like \texttt{+} or \texttt{−}, you can use \texttt{LASTx} and the inverse function (\texttt{−} or \texttt{×}) to recover. Suppose that you made a mistake in adding two numbers. Press \texttt{LASTx} and then \texttt{−} as shown below. The nature of your mistake determines how you should continue; the alternatives are listed after the diagram.

\begin{itemize}
  \item If you wanted to multiply instead of add, execute \texttt{LASTx} again to return the stack to its original state, and then multiply.
  \item If 16 was the wrong number to add, press \texttt{←} to clear 16, key in the correct number, execute \texttt{LASTx} to recover 4, and then add.
  \item If 4 was the wrong number to add, key in the correct number and then add.
\end{itemize}

Errors with some other types of two-number functions are even easier to correct. For example, you can cancel the effect of \texttt{P+R} by executing \texttt{R→P}, and you can correct errors with \texttt{\%} and \texttt{\%CH} as you would for a one-number function. To correct errors with other functions, determine how the function affects the stack, and then reverse that process.
Constant Arithmetic

The following example shows how to retrieve a constant for further calculations. Suppose that you want to divide both 63 and 87 by a factor of 1.5. This constant factor is entered second (after 63) to be in the X-register for the first calculation, and is subsequently maintained in the LAST X register.

This technique is particularly appropriate when the constant must be in the X-register for noncommutative operations like [−] and [+] (In contrast, constant arithmetic using stack drop supplies the constant in the Y-register.)

Other Stack Operations

You can consider the four stack registers as two pairs of registers. The X- and Y-registers are the center of almost all activity, while the Z- and T-registers are like storage registers connected by stack lift and stack drop to the more active X- and Y-registers. If you make an extra copy of a number while it’s in the X-register or retrieve a copy from the LAST X register, you can temporarily store that copy in the higher stack registers and retrieve it later.

To take full advantage of the Z- and T-registers, plan ahead when you’re programming a series of calculations. Figure out where the operands must be for each step, work backwards from the final calculation, and use the operations in the remainder of this section to link the result of one calculation with the input for the next. This efficient use of the stack saves program memory and reduces the need for storage registers.
Exchanging Stack Contents

**Exchanging the X- and Y-registers.** Executing \( x \leftrightarrow y \) (X exchange Y) exchanges the contents of the X- and Y-registers. This function has several uses:

- To examine the contents of the Y-register. Press \( x \leftrightarrow y \), examine the display, and then press \( x \leftrightarrow y \) again to restore the numbers to their original order. This is useful when a function returns results to both the X- and Y-registers, as do the statistics functions and polar/rectangular coordinate conversions.
- To switch numbers that are in the wrong order for noncommutative operations such as subtraction and division.
- To rearrange the contents of the stack in combination with \( \text{R}+ \) or \( \text{R}+ \); refer to “Rolling the Stack” below.

**Exchanging X and Other Stack Registers.** To exchange the contents of the X-register with a stack register or the LAST X register, execute \( x \leftrightarrow \) and then press \( \text{R}+ \) followed by \( y, z, t, \) or \( l \). Refer to “Stack Register Arithmetic” below for an example of this function’s use.

**Rolling the Stack**

The \( \text{R}+ \) (roll down) and \( \text{R}+ \) (roll up) functions shift all stack contents without duplicating or losing any data.

Note that the LAST X register is unchanged. To review all numbers in the stack, press either \( \text{R}+ \) or \( \text{R}+ \) four times. Each number is displayed when it is rolled into the X-register, and the stack returns to its original state after four shifts.
Use \([R^+\]) and \([R^+]\) in combination with \([x \equiv y]\) to exchange stack registers other than the X-register. You can rearrange the stack in any order with these functions; here are two simple examples.

\[
\begin{array}{c|c|c|c}
\text{T} & t & t & y \\
\text{Z} & z & z & t \\
\text{Y} & y & x & z \\
\text{X} & x & y & x \\
\end{array}
\quad
\begin{array}{c|c|c|c}
\text{T} & t & z & z \\
\text{Z} & z & y & y \\
\text{Y} & y & x & t \\
\text{X} & x & t & x \\
\end{array}
\]

\[
\begin{array}{c|c}
\text{LAST X} & l \\
\end{array}
\quad
\begin{array}{c|c}
\text{LAST X} & l \\
\end{array}
\]

Keys: \([x \equiv y]\) \quad \text{Keys:} \quad \begin{array}{c}
[R^+] \\
[x \equiv y]
\end{array}

\textbf{Store and Recall}

You can duplicate any number in the stack by executing \([\text{STO}]\) or \([\text{RCL}]\) and then specifying a stack register. Both functions result in the X-register and the specified register containing the same number.

\textbf{Store.} To copy the number in the X-register into a stack register or the LAST X register, press \([\text{STO}]\) followed by \([Y], [Z], [T]\) or \([L]\). The number in the specified register is lost.

\textbf{Recall.} To copy the number in a stack register or the LAST X register into the X-register, press \([\text{RCL}]\) followed by \([Y], [Z], [T],\) or \([L]\). The number in the T-register is lost as the stack lifts (unless stack lift is disabled).

\textbf{Register Arithmetic}

You can combine the number in the X-register with any stack register by pressing \([\text{STO} + \cdot \cdot \cdot], [\text{STO} - \cdot \cdot \cdot], [\text{STO} \times \cdot \cdot \cdot],\) or \([\text{STO} \div \cdot \cdot \cdot]\) followed by \([X], [Y], [Z], [T]\), or \([L]\). Remember that the order of the operands is essential for subtraction and division; the operand in the specified register corresponds to the operand in the Y-register for stack arithmetic. Register arithmetic in the stack differs in several ways from normal arithmetic in the stack:

- The result is placed in the specified register.
- The X-register is unchanged (unless you specify it as the parameter).
- The LAST X register is unchanged (unless you specify it as the parameter).
- The stack doesn’t drop.
The following routine cubes the number in the X-register and places the original value in the LAST X register without disturbing the other stack registers.

### Clearing the Stack

To place zeros in the X-, Y-, Z-, and T-registers, execute `CLST` (*clear stack*). The LAST X register is unchanged.
Introduction

This section describes the numeric functions in the computer. All one- and two-number functions operate in the stack; their actions are shown by stack diagrams. Although data for the statistical functions are entered from the stack, they are accumulated in statistics registers in main memory. The results of operations on these accumulations are then returned to the stack. Certain other functions that involve calculations but do not necessarily return results to the stack (such as register arithmetic and [ISG]) are not included here.
There are three error conditions that can result from numeric functions.

1. If you try to calculate with an operand that is illegal for that function (such as division when \( x = 0 \)), a **DATA ERROR** results.

2. If you try to calculate with an operand that is not a number, an **ALPHA DATA** error results. Note that a string of Alpha digits from the Alpha register is not a number.

3. If you attempt a calculation that would produce a number with magnitude greater than \( 9.999999999 \times 10^9 \), an **OUT OF RANGE** error results. (Statistical accumulations \( \sum^+ \) and \( \sum^- \) are exceptions.)

The computer does not execute a function that causes an error condition. Unless flag 25 is set, a **DATA ERROR** or **ALPHA DATA** error will stop program execution (if a program is running) and display the error message; an **OUT OF RANGE** error will stop execution and display the error message unless either flag 24 or 25 is set.

**One-Number Functions**

One-number functions replace the operand in the X-register with the result, save the operand in the LAST X register, and leave the Y-, Z-, and T-registers unchanged. \( f(x) \) represents the result in the stack diagram on the left. The only exception is \( [\text{CHS}] \) (change sign), shown on the right, which doesn’t save the operand.

### General Functions

**Reciprocal.** Executing \( \frac{1}{x} \) returns the reciprocal of \( x \).

**Square and Square Root.** Executing \( x^2 \) returns the square of \( x \). Executing \( \sqrt{x} \) returns the positive square root of \( x \).

**Factorial.** For a positive integer \( n \), executing \( \text{FACT} \) returns \( n! = n(n - 1)(n - 2) \ldots 1 \).
Number-Alteration Functions

Absolute Value and Sign. Executing ABS returns $|x|$, the absolute value of $x$. Executing SIGN returns:

- 1 if $x \geq 0$,
- $-1$ if $x < 0$, or
- 0 if the X-register contains Alpha data.

Integer Part and Fractional Part. These functions reduce a number to its integer part or its fractional part. For example, if the X-register contains 777.888, executing INT returns 777 or executing FRC returns 0.888.

Round. Recall that the display-format functions affect only how a number is displayed, not its internal representation. To round the internal representation of the number in the X-register:

1. Set the display format to the number of decimal places that you want the rounded number to contain.
2. Execute RND.

For example, to round a number to the nearest integer, execute FIX 0 and then RND.

Trigonometric Operations

Angular Modes. The angular mode determines how the computer interprets numbers as angles. Your choice of angular mode is maintained by Continuous Memory. These functions alter only the angular mode; they do not alter any numbers currently in the computer.

- Execute RAD to select Radians mode. The RAD annunciator appears, indicating that numbers will be interpreted as angles expressed in radians. (There are $2\pi$ radians in a circle.)
- Execute GRAD to select Grads mode. The GRAD annunciator appears, indicating that numbers will be interpreted as angles expressed in grads. (There are 400 grads in a circle.)
- Execute DEG to select decimal Degrees mode. This is the default angular mode; when neither the RAD nor the GRAD annunciator appear, numbers will be interpreted as angles expressed in degrees. Digits following the decimal point in the argument are interpreted as a decimal fraction of one degree, not as minutes and seconds.

Trigonometric Functions.

- [SIN] (sine) and [SIN$^{-1}$] (arc sine).
- [COS] (cosine) and [COS$^{-1}$] (arc cosine).
- [TAN] (tangent) and [TAN$^{-1}$] (arc tangent).
Conversions

**Degrees/Radians Conversions.** Execute **D−R** (degrees to radians) to convert a number expressing an angle in decimal degrees into the number that expresses the same angle in radians. For the inverse conversion, execute **R−D** (radians to degrees).

**Hours-Minutes-Seconds/Decimal Hours Conversions.** Hours and degrees can be expressed in HMS (hours-minutes-seconds) format rather than the normal decimal format. The first two digits following the decimal point are interpreted as minutes, the next two digits as seconds, and any subsequent digits as a decimal fraction of seconds. For example,

\[
HH.MMSSssss = HH \text{ hours} + MM \text{ minutes} + SS.ssss \text{ seconds (HMS format)}
\]

\[
= HH + MM/60 + SS.ss/3600 \text{ (decimal format)}
\]

To convert a number in decimal format into HMS format, execute **HMS** (to hours-minutes-seconds). For the inverse conversion, execute **HR** (to decimal hours).

**Decimal/Octal Conversions.** To convert a decimal integer into its octal (base 8) equivalent, execute **OCT** (to octal). To convert an octal integer into its decimal (base 10) equivalent, execute **DEC** (to decimal).

Logarithmic and Exponential Functions

**Common Logarithmic and Exponential Functions.** Press **LOG** to calculate the common logarithm (logarithm to base 10) of the number in the X-register. Press **10^x** to calculate 10 raised to the power of the number in the X-register.

**Natural Logarithmic and Exponential Functions.** Press **LN** to calculate the natural logarithm (logarithm to base e) of the number in the X-register. Press **e^x** to calculate e raised to the power of the number in the X-register.

Hyperbolic functions, inverse hyperbolic functions, and certain financial calculations evaluate the expressions \( \ln (1 + x) \) and \( e^x - 1 \) for arguments near zero and with results also near zero. To allow greater accuracy in such calculations, **LN1+X** and **E×X−1** evaluate these expressions directly.

- **LN1+X** computes \( \ln (1 + x) \).
- **E×X−1** computes \( e^x - 1 \).

Two-Number Functions

All two-number functions use operands in the X- and Y-registers; most return a single number to the X-register and cause the stack to drop. (Percentages and polar/rectangular coordinate conversions are exceptions.)
Basic Arithmetic

Stack diagrams for [*], [-], [×], and [+] appear in the previous section. Remember the order of entry for subtraction and division: for x in the X-register and y in the Y-register,

- Subtraction returns y — x (not x — y).
- Division returns y/x (not x/y).

Time Arithmetic

To add or subtract numbers that are in HMS (hours-minutes-seconds) format, use [HMS+] (hours-minutes-seconds add) or [HMS−] (hours-minutes-seconds subtract). The order of entry and stack drop are identical to those for normal addition and subtraction.

Percentages

The two percentage functions use the number in the Y-register as a base and alter the number in the X-register, expressing it in terms of the base. Note that the base number in the Y-register is unaltered and that the stack doesn’t drop.

\[
\begin{array}{c|c}
T & t \\
Z & z \\
Y & y \\
X & x \\
\hline
& xy/100
\end{array}
\]

\[
\begin{array}{c|c}
T & t \\
Z & z \\
Y & y \\
X & x \\
\hline
100(x−y)/y
\end{array}
\]

Percent. To calculate a percentage, place the base number in the Y-register and the percent rate in the X-register, and then execute [%].

Percent Change. To calculate the increase or decrease from one number to another, place the first (base) number in the Y-register and the second number in the X-register, and then execute [%CH]. The increase or decrease is returned as a positive or negative percentage of the first (base) number.
Percent of Total. To calculate the percentage that one number is of another number:

1. Place the total (base) number in the Y-register and the number to be converted to a percentage in the X-register.
2. Execute \([1/x]\).
3. Execute \([\%]\).
4. Execute \([1/x]\).

Polar/Rectangular Conversions

A point in a plane can be described by either polar or rectangular coordinates. Polar coordinates are \(r\) (magnitude) and \(\theta\) (angle); rectangular coordinates are \(x\) (horizontal) and \(y\) (vertical). (An illustration of these coordinates is on page 54.) Two functions, \([P+R]\) and \([R+P]\), convert between polar and rectangular coordinates.

- To convert polar coordinates to rectangular coordinates, execute \([P+R]\) (polar to rectangular).
- To convert rectangular coordinates to polar coordinates, execute \([R+P]\) (rectangular to polar). The resulting \(\theta\) will have the same sign as the \(y\)-coordinate input.

As input or output, \(\theta\) is interpreted according to the current angular mode. In the stack diagrams below, note the order of the coordinates in the stack and that the stack doesn’t drop. Press \([x\ y]\) to see the result returned to the Y-register.

Other Two-Number Functions

Raising a Number to a Power. To raise a number to a power, place the base number in the Y-register and the power in the X-register, and then execute \([y^x]\). Stack drop is the same as for arithmetic functions. Legal values for \(x\) depend on the value of \(y\):

- If \(y\) is positive, \(x\) can be any number.
- If \(y\) is negative, \(x\) must be an integer.
If $y$ is zero, $x$ must be positive.

Any other combination causes a **DATA ERROR**.

**Finding Roots.** To calculate the $n$th root of a number:
1. Place the number in the Y-register.
2. Place $n$ in the X-register.
3. Execute $\left[\frac{1}{x}\right]$.
4. Execute $\sqrt[n]{x}$.

**Modulo.** For positive integers $x$ in the X-register and $y$ in the Y-register, executing $[\text{MOD}]$ calculates the remainder when $y$ is divided by $x$ (“$y \mod x$”). For example, you can test whether $y$ is evenly divisible by $x$ by executing $[\text{MOD}]$ and testing whether the result is zero. Stack drop is the same as for arithmetic functions.

You can also use $[\text{MOD}]$ with numbers that are not positive integers. The general equation for $y \mod x$ is $y - x <y/x>$, where $<y/x>$ represents the largest integer not larger than $y/x$. Performing $y \mod x$ when $x = 0$ returns an answer of $y$.

**Statistics**

There are two stages in performing statistical calculations. First you enter data from the stack; the computer accumulates intermediate statistics from this data. Then you execute statistical calculations; the computer uses the intermediate statistics to calculate the overall results, which are returned to the stack. Basic statistical operations are described on pages 55 through 58.

**Statistics Registers**

The statistics registers are a block of six data registers in main memory that hold the intermediate statistics accumulated from your data. When the computer memory is reset, the statistics registers are $R_{11}$ through $R_{16}$.

- You can assign other storage registers to be the statistics registers by executing $[\text{ΣREG}]$ and specifying the address of the first register in the block you select. This assignment is maintained by Continuous Memory.

- To check the current assignment, execute $[\text{ΣREG?}]$. The address of the first register in the block is returned to the X-register.*

- To place zeros in all six statistics registers, execute $[\text{CLΣ}]$.

* $[\text{ΣREG?}]$ doesn’t check whether the assigned registers actually exist (that is, whether sufficient memory is allocated to data storage), but only what the assigned address is.
The statistics registers accumulate the following intermediate statistics from your data in the X- and Y-registers.

### The Statistics Registers

<table>
<thead>
<tr>
<th>Register</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_{11}</td>
<td>$\Sigma x$ Summation of x-values.</td>
</tr>
<tr>
<td>R_{12}</td>
<td>$\Sigma x^2$ Summation of squares of x-values.</td>
</tr>
<tr>
<td>R_{13}</td>
<td>$\Sigma y$ Summation of y-values.</td>
</tr>
<tr>
<td>R_{14}</td>
<td>$\Sigma y^2$ Summation of squares of y-values.</td>
</tr>
<tr>
<td>R_{15}</td>
<td>$\Sigma xy$ Summation of products of x- and y-values.</td>
</tr>
<tr>
<td>R_{16}</td>
<td>$n$ Number of data points accumulated. (Displayed.)</td>
</tr>
</tbody>
</table>

### Entering Data

**Accumulating Data Points.** When you press $\Sigma+$:

- The results of calculations using the numbers in the X- and Y-registers are added to the first five statistics registers. If this causes the contents of a register to exceed $\pm 9.999999999 \times 10^{99}$, there is no overflow error; the overflowed register contains $\pm 9.999999999 \times 10^{99}$.

- The number of data points $n$ in the sixth register is incremented and its current value is returned to the X-register.

- The number previously in the X-register is saved in the LAST X register.

- Stack lift is disabled, so the next data entered will replace $n$ in the X-register.

You can accumulate either one-value or two-value data points, as discussed in part I. If you are accumulating only x-values, clear the Y-register first ($0 \text{ ENTER+}$). Because $\Sigma+$ and $\Sigma-$ disable stack lift, the Y-register will remain clear while you accumulate x-values.

**Error Correction.** To correct erroneous data that have been accumulated:

1. Re-enter the erroneous data. If you just accumulated the erroneous data, simply press $\text{LASTx}$ to retrieve them. (The erroneous y-value is still in the Y-register and the erroneous x-value was saved in the LAST X register.)

2. Press $\Sigma-$. This function acts similarly to $\Sigma+$ except that the results are subtracted from (rather than added to) the first five statistics registers, and the sixth register is decremented (rather than incremented).

3. Enter the correct data.

4. Press $\Sigma+$. 
Limitation on Data Values. The computer might be unable to perform some statistical calculations if your data values differ by a relatively small amount. To avoid this, you should normalize your data by entering the values as the difference from one value (such as the mean). This difference must then be added back to any calculations of the mean. For instance, if your x-values were 665999, 666000, and 666001, you should enter the data as —1, 0, and 1; then add 666000 back to the relevant results.

Mean

Executing [MEAN] returns the arithmetic average \( \bar{x} \) of the accumulated x-values to the X-register and the arithmetic average \( \bar{y} \) of the accumulated y-values to the Y-register, according to the following formulas:

\[
\bar{x} = \frac{\Sigma x}{n}, \quad \bar{y} = \frac{\Sigma y}{n}.
\]

Press [x \( \times \) y] to display the resulting y-value. The number previously in the X-register is saved in the LAST X register; the number previously in the Y-register is lost.

Standard Deviation

Executing [SDEV] returns the sample standard deviation \( s_x \) of the accumulated x-values to the X-register and the sample standard deviation \( s_y \) of the accumulated y-values to the Y-register, according to the following formulas:

\[
s_x = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x)^2}{n(n - 1)}}, \quad s_y = \sqrt{\frac{n\Sigma(y^2) - (\Sigma y)^2}{n(n - 1)}}.
\]

Press [x \( \times \) y] to display the resulting y-value. The number previously in the X-register is saved in the LAST X register; the number previously in the Y-register is lost.
Part III: 
Memory in Detail
Section 12

Main Memory

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Organization

Main memory contains 319 registers divided into two major groups.*

- One group contains the data storage registers. The number of main memory registers allocated to data storage changes only when you execute a function to specify the allocation.

- The other group contains programs, alarms, key redefinitions, and uncommitted registers. The uncommitted registers are automatically committed to programs, alarms, and key redefinitions as needed. However, the size of this group as a whole changes only when you change the number of registers allocated to data storage.

* Main memory actually contains 320 registers, but program memory always contains at least one register for the permanent .END.
Main Memory Configurations
The preceding diagram illustrates five configurations of main memory—each column represents all of main memory at one time. The leftmost column shows the default configuration, 100 registers allocated to data storage and 219 registers for all other purposes. The columns to the right show main memory at four later times. The computer handles most of these details automatically, but understanding main memory will help you use it more effectively.

The first column represents the default configuration after Continuous Memory is cleared. There are 100 registers for data storage with the largest-numbered register at the top. The first register below the data register block holds the permanent .END., which marks the bottom of program memory. The uncommitted registers below the permanent .END. are available for programs, alarms, and key redefinitions.

The second column shows main memory after you’ve entered programs and assigned functions to keys. Program memory consumes uncommitted registers as the permanent .END. is pushed down by new program lines. User-keyboard memory consumes one uncommitted register for every two assignments.

The third column shows alarm memory after you have set alarms. The fourth column shows the result after you allocate more registers to data storage, write more programs, set more alarms, and redefine more keys. When all registers are committed, any operation that would consume main memory registers causes an error. If you are setting an alarm, the computer displays NO ROOM. Other operations cause the computer to display PACKING and then TRY AGAIN.

If packing doesn’t produce a sufficient number of uncommitted registers, you’ll have to reduce the size of the data storage block or delete other memory contents. You can review the contents of program, alarm, or User-keyboard memory by executing CATALOG 1, 5, or 6 respectively; also remember that data and programs can be stored in data or program files in extended memory.

The fifth column shows the reappearance of uncommitted registers after you allocate fewer registers to data storage and delete other memory contents.

**Program Memory**

When Continuous Memory is cleared, program memory contains only the permanent .END.. If you press GTO and key in a program, each instruction is added just before the permanent .END. which moves down to make room. As a result:

- The first instruction of the program you keyed in first is at the top of program memory.
- The last instruction of the program you keyed in most recently precedes the permanent .END. at the bottom of program memory.

Catalog 1 shows the number of uncommitted registers along with the permanent .END. (.END. nnn). There can be up to six bytes (nearly a full register) available in addition to nnn registers.
Program Lines

Each function, number, or Alpha string in a program is considered to be a separate program line. The number of program lines depends on how many functions, numbers, and Alpha strings are in the program; the number of registers and bytes occupied by these program lines depends on the particular functions and the lengths of the numbers and Alpha strings:

- Functions require from one to four bytes, depending on the particular function (and on the parameter if one is needed). The number of bytes required for each function is listed in the Function Tables at the back of this manual.
- Functions with global labels as parameters require one byte per character in addition to their normal length.
- Numbers require one byte per digit, plus another byte for each [±], [CHS], or [EEX] keyed in with the number.
- Alpha strings require one byte per character, plus one additional byte for the entire string.

Null Bytes

Usually the first byte of an instruction immediately follows the last byte of the previous instruction, but sometimes there are null bytes between instructions. Null bytes result from:

Deleting an Instruction. When you delete an instruction, the bytes it occupied are replaced by null bytes.

Inserting an Instruction within a Program. If there are not already null bytes available where you want to insert a new instruction, seven null bytes are inserted and all subsequent instructions bumped down seven bytes in memory. The new instruction replaces inserted null bytes and, if the new instruction requires fewer than seven bytes, the rest of the inserted null bytes remain.

Program Lines That Are Numbers. The computer places a null byte before a string of bytes representing a number. This is done in case the previous program line is also a number. The null byte acts as a spacer between the two program lines so they won’t be misinterpreted as a single number.
Packing

When your program is complete, the only useful null bytes are those separating sequential program lines that are both numbers. To eliminate unneeded null bytes, execute \texttt{PACK}. When memory is packed, bytes within all programs move up in program memory to replace unneeded null bytes. (User-keyboard memory is also packed as described below.) Main memory is packed when:

- You execute \texttt{PACK}.
- You execute \texttt{GTO}.
- You clear programs by executing \texttt{CLP} or \texttt{PCLPS}.
- There are not enough uncommitted registers available to complete an operation that requires them. Such operations are: increasing the data register allocation, entering a program line, or assigning a function to a key.

Alarm Memory

When you set the first alarm, two uncommitted registers are consumed to define the limits of alarm memory. (These registers are in addition to the registers consumed by the alarm itself.) They will be released only when all alarms are cleared. The number of registers consumed by each alarm depends on the type of alarm.

- Each alarm uses one register for the time and date of its next activation.
- An alarm with a reset interval requires one additional register.
- An alarm that uses the Alpha register requires one register for every 7 characters. \(\dagger\) is an ordinary character for counting purposes.) For example, a message of 18 characters requires two registers for the first 14 characters and one register for the last 4 characters, for a total of three registers.

User Keyboard Memory

When you assign a function to a key, that information is stored in User keyboard memory. An assignment for either a function or global label in a plug-in module is also stored in User keyboard memory. However, when you assign a global label listed in catalog 1 to a key, that information is not stored in User-keyboard memory, but rather with that global label in program memory.

A register can hold two assignments. The first assignment requires one register; the second assignment fits with the first assignment in that register. Similarly, each odd-numbered assignment adds another register to the User keyboard memory, and each even-numbered assignment fills out the register.

An assignment is cancelled when you assign a different function to the same key, or if you explicitly cancel the assignment by one of the methods on page 168. If both assignments in a register have been cancelled and main memory is packed, that register becomes an uncommitted register.
Data Register Memory

Allocation

Changing the Allocation. There are two functions that allocate main memory registers to data storage, one for manual execution and one for program execution. Decreasing the number of registers loses the data in the largest-numbered registers.

- You can manually change the allocation to data storage by executing `SIZE` and then specifying the number of registers to be allocated.
- A program can change the allocation to data storage by placing the number of registers to be allocated in the X-register and then executing `PSIZE`.

Checking the Allocation. To check the current allocation of registers to data storage, execute `SIZE?`. The total number of data storage registers is returned to the X-register.

Example. The following program routine will change the allocation only if the current allocation is too small.

```
01 SIZE?  Returns the current allocation to the X-register.
02 50    The number of data registers required by the program. The current allocation (from line 01) is now in the Y-register.
03 X>Y?   Is the required number of data registers greater than the current allocation?
04 PSIZE  If so, change the allocation to the required number.
```

Registers Above R_{99}

If you allocate more than 100 registers to data storage, registers whose addresses exceed 99 can be accessed only by indirect addressing. To emphasize this distinction, this manual shows three-digit addresses in parentheses: R_{(120)}, for example. Unless you want to use indirect addressing in a loop or to perform special main memory operations like register arithmetic, it’s often easier to use a data file in extended memory.

Data Register Operations

Store and Recall

There are three sources/destinations for the data in data registers: the stack registers, the Alpha register, and data files in extended memory. The functions that move data between the stack registers or the Alpha register and the data registers in main memory are described in this section. All functions that access data files in extended memory are discussed in section 13, “Extended Memory.”
Specifying a Register as a Parameter. Most data register functions access just one register, whose address must be specified as a parameter. You can specify a register in several ways.

- For $R_{00}$ through $R_{99}$, key in the two-digit address.
- For convenience, $R_{01}$ through $R_{10}$ can be specified with a single key in the top two rows.
- For the stack or LAST X registers, press followed by $X$, $Y$, $Z$, $T$, or $L$.
- For any register to be addressed indirectly, press and then specify the address of the indirect register by one of the means above.

Store. To copy data from the X-register into a data register, press and then specify the destination register. The X-register is unchanged; the data previously in the data register are lost.

Recall. To copy data from a data register into the X-register, press and then specify the source register. The contents of the source register are unchanged. If stack lift was disabled, the recalled data replace the contents of the X-register; otherwise the stack is lifted.

Alpha Store. To copy the six leftmost characters from the Alpha register into a data register, press and then specify the destination register. The contents of the Alpha register are unchanged and the data previously in the destination register are lost.

- A punctuation mark counts as one of the six characters.
- A string of digits in the Alpha register is not a number. If you store Alpha digits in a register, the contents appear to be a number, but you can't perform numeric operations on those contents.
- If you do want to perform numeric operations on Alpha digits in the Alpha register, you must use to interpret the digits as a number and place the number in the X-register (page 311).
- Copying data from the Alpha register to the X-register by using is not like — that is, the stack does not lift and so the previous contents of the X-register are lost.

To copy more than six characters into a data register you must alter the contents of the Alpha register before repeating (or you will copy the same characters again).

- To remove the six characters you already copied, execute (Alpha shift). The six leftmost characters are shifted out of the Alpha register.
- To rotate the six characters you already copied to the right-hand end of the Alpha register, place 6 in the X-register and execute (Alpha rotate).

Alpha Recall. To copy data from a data register into the Alpha register, execute and then specify the source register. The contents of the source register are unchanged, the data are appended to the contents of the Alpha register, and character entry is activated. If you want the copied data to start a new message, execute before recalling that data.
Register Arithmetic

Register arithmetic enables you to combine a number in the X-register and a number in a data register without recalling the stored number to the stack.

- Executing $\text{STO } + \ n n$ adds the number in the X-register to the number in $R_{nn}$, and then stores the sum in $R_{nn}$.
- Executing $\text{STO } - \ n n$ subtracts the number in the X-register from the number in $R_{nn}$, and then stores the difference in $R_{nn}$.
- Executing $\text{STO } \times \ n n$ multiplies the number in the X-register by the number in $R_{nn}$, and then stores the product in $R_{nn}$.
- Executing $\text{STO } \div \ n n$ divides the number in the X-register into the number in $R_{nn}$, and then stores the quotient in $R_{nn}$.

As with $\text{STO}$, the original number in $R_{nn}$ is lost and the number in the X-register is unchanged. This allows you to reuse a constant in the X-register without executing $\text{LASTx}$.

Exchange

Note that $\text{STO}$ and $\text{RCL}$ duplicate one number and lose another. To move numbers without duplicating or losing any data, execute $\text{X<>}$ and specify the register whose contents you want to exchange with the X-register.

Block Operations

You can move or swap blocks of data registers by using $\text{REGMOVE}$ or $\text{REGSWAP}$. Both use a control number $sss.dddnnn$ in the X-register to define the source and destination blocks, where:

- $R_{sss}$ is the first (smallest-addressed) register in the source block;
- $R_{ddd}$ is the first (smallest-addressed) register in the destination block;
- $nnn$ is the number of registers in both blocks. If you don’t specify $nnn$, the computer assumes $nnn = 001$.

The blocks can’t overlap—make sure that $|sss - ddd| \geq nnn$.

Moving Register Contents. To copy the source block into the destination block, place the control number in the X-register and execute $\text{REGMOVE}$. As with $\text{STO}$, the contents of the source block are unchanged and the previous contents of the destination block are lost.

Swapping Register Contents. To exchange the contents of two blocks of registers, place the control number in the X-register and execute $\text{REGSWAP}$. Which block is called the source and which is called the destination is immaterial.
Clearing Registers

Clearing a Single Register. To clear a single register, store zero in that register.

Clearing a Block of Registers. It’s wise to begin a program by clearing the data registers used by that program. To clear a block of registers, execute \texttt{CLRX} \textit{(clear registers by X)} with a control number in the X-register. The control number has the form \texttt{bbb.eeeii} where:

- \texttt{R_{bbb}} (begin) is the first (smallest-addressed) register to be cleared;
- \texttt{R_{eee}} (end) is the last (largest-addressed) register to be cleared;
- \texttt{ii} is the \textit{increment} if you want only every \textit{i}th register cleared. If you don’t specify \textit{ii}, the computer assumes \textit{ii} = 01.

As an example of using the optional increment, suppose you have a 4 \times 4 matrix stored sequentially in memory, row by row. You can clear any row of the matrix by specifying just the first and last addresses in the row—you don’t need to specify an increment. But to clear a column (whose entries aren’t sequential in memory), first specify the addresses for the first and last entries in that column, and then set \textit{ii} = 04 to clear only the registers for that column.

\texttt{R_{bbb}} is cleared even if \textit{bbb} > \textit{eee} or \textit{bbb} + \textit{ii} > \textit{eee}. The sign of the control number and any excess fractional digits are ignored.

Clearing All Registers. To clear all data registers, execute \texttt{CLRG}.
Section 13

Extended Memory

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Introduction

Extended memory is an extension of main memory, but it also has special advantages of its own. All information in extended memory is organized into files; there are three types of files for three types of information:

- A program in main memory can be stored in a program file. You must return the program to main memory to execute it or edit it.
- Register contents can be stored in a data file, which is a collection of registers. A single data-file operation can access all data registers in main memory, a block of data registers, or the X-register. Directly accessing the X-register makes extended memory an alternative to main memory as well as an extension of it.
- Alpha data can be stored in a text file (also called an ASCII file), which is a collection of Alpha strings. The size and structure of text files, along with direct keyboard access to them through a text editor, give text files an Alpha capability far surpassing main memory.

Because each file requires two registers for the computer’s use, the number of extended memory registers available for your use depends on the number of files. A single file can contain up to 124 registers for your use; two files can contain up to 122 registers for your use; in general, \( n \) files offer \( 126 - 2n \) registers for your use.

You can increase the number of extended memory registers by adding one or two HP 82181A Extended Memory Modules. (These modules are described in appendix E.) Each module adds 238 registers. The maximum number of extended memory registers is therefore \( 124 + 238 + 238 = 600 \), almost twice as many registers as in main memory.

Files in Extended Memory

Header Information

Each file starts with a header, two registers that describe the file. Although you never access headers directly, you should be aware of the memory space and the information involved. A header contains:

The File Name. You give each file a name when you create the file. The name can include any characters except commas and a maximum of seven characters.* You enter the file name into the Alpha register when you create the file and when you specify the file.

The File Type. A file may be a program file, a data file, or a text file. A program file is a copy of a program in main memory; a data file is a collection of data registers; and a text file is a collection of character strings.

---

* A file name can’t consist of seven bytes of decimal value 255.
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The File Size. This is the number of extended-memory registers the file requires. For program files the header also contains the program size in bytes.

The Pointer. Data and text files use a number called a pointer to indicate which element in the file to access. Program files do not use pointers.

Specifying a File

You can access only one file at a time. The computer keeps track of which file you accessed last; this file is called the current file. Only some extended memory functions can specify which file to access.

- Some functions require a file name in the Alpha register. Program-file functions and destructive functions are examples.
- Some functions can specify a file name in the Alpha register. If the Alpha register is empty, these functions act on the current file.
- Some functions never specify a file name in the Alpha register. These functions act only on the current file.

Extended Memory Directory

Both EMDIR (extended memory directory) and EMDIRX (extended memory directory by X) are programmable functions that access the files in extended memory. The function EMDIR, which lists all files, is designed for interaction with the user; the function EMDIRX, which returns information about one specified file, is designed for automatic operations in a program.

Using EMDIR. For convenience you can manually execute EMDIR as catalog 4. If you want to assign it to a key or enter it as a program line, you must use the function’s Alpha name EMDIR. When you execute EMDIR:

- The files are listed in the order that you created them.
- Each file’s name, type (P = program, D = data, A = ASCII or text), and number of registers are shown. For example, the display for a data file ABC that occupies 20 registers is:

  ABC D020

- You can speed up the listing by holding down any key except R/S or ON.
- You can stop the listing by pressing R/S, and restart the listing by pressing R/S again.
- When the listing is stopped you can go to the next file by pressing SST or return to the previous file by pressing BST. Pressing SST while the last file is displayed or BST while the first file is displayed has no effect.
You can either allow the computer to complete the listing and exit \(\text{EMDIR}\) automatically, or else you can terminate \(\text{EMDIR}\) yourself. If you allow the listing to run past the last file, the computer automatically exits \(\text{EMDIR}\) and returns the number of registers available for the next file you create. The two registers required for a new header are included in this calculation, so you can use the total number of registers indicated for your own data. This number is returned to the X-register, lifting the stack unless stack lift is disabled.

When the computer automatically exits \(\text{EMDIR}\) it doesn’t change which file is the current file. Alternatively, you can make any file the current file by stopping the listing with that file displayed and then pressing \(\downarrow\). This terminates \(\text{EMDIR}\); the number of available registers is not returned to the X-register.

If there are no files in extended memory the computer displays \text{DIR EMPTY} and returns the number of available registers to the X-register, lifting the stack unless stack lift is disabled.

\textbf{Using} \(\text{EMDIRX}\). To determine the name and type of the \(n\)th file in extended memory, place \(n\) in the X-register and execute \(\text{EMDIRX}\). For example, \(n = 1\) for the file you created first (which is also the file displayed first by \(\text{EMDIR}\)).

\textbf{If the \(n\)th file exists:}

- The name of the \(n\)th file is returned to the Alpha register.
- The file type is returned to the X-register as a two-letter code:
  
  \begin{itemize}
    \item \text{PR} = \text{program file}.
    \item \text{DA} = \text{data file}.
    \item \text{AS} = \text{ASCII (text) file}.
  \end{itemize}
- \(n\) is placed in the LAST X register.
- The \(n\)th file becomes the current file.

\textbf{If the \(n\)th file doesn’t exist:}

- The Alpha register is cleared.
- Zero is returned to the X-register.
- \(n\) is placed in the LAST X register.
- The computer doesn’t change which file is the current file.

Note that \(\text{EMDIRX}\) does not lift the stack. The input \(n\) is the absolute value of the integer part of the number in the X-register.

* A positive integer is returned if the computer doesn’t recognize the file type.
Using **EMROOM**. To check how many registers are available for the next file you create, execute **EMROOM** (extended memory room). The result takes into account two registers for one new header; if you plan to create more than one new file, subtract two registers for each additional file. The result is returned to the X-register, lifting the stack unless stack lift is disabled. (This is the same information that **EMDIR** provides if it exits automatically.)

**Checking File Size**

To check the number of registers in a file (excluding the header), place the file name in the Alpha register and execute **FSIZE** (file size). The result is returned to the X-register, lifting the stack unless stack lift is disabled. You can check the size of the current file by clearing the Alpha register and executing **FSIZE**.

**Purging a File**

To remove a file from extended memory—both its header and its contents—place the file name in the Alpha register and execute **PURFL** (purge file). All later files in extended memory move up to fill the space previously held by the purged file.

There is no current file after you execute **PURFL**, so the next extended memory function executed must specify a file name to define a new current file.

**Program File Operations**

Program files are the simplest type of extended memory file. A program file comprises a two-register header plus an exact copy of a program from main memory.

**Saving a Program**

You can create a file that is a copy of a program in main memory by first specifying the program to be copied and the new file’s name in the Alpha register and then executing **SAVEP** (save program). There are three ways to specify the program and name the new file:

- Indicate the program to be copied by any global label in that program, followed by a comma, followed by the name you want to give the new file.  
  
  | Alpha Register | label, file name |

- If you want to use the global label for the name of the new file, you can place only the global label in the Alpha register.  
  
  | Alpha Register | label |

- If the program to be copied is the current program in main memory, you can place just a comma and the name of the new file in the Alpha register.  
  
  | Alpha Register | , file name |
If a global label is in the Alpha register, \texttt{SAVEP} copies the program closest to the bottom of program memory (that is, listed last in catalog 1) containing that global label.

The file name can include any characters except commas and a maximum of seven characters. The eighth and all subsequent characters, or a comma and all subsequent characters, will be ignored.

\textbf{Note:} If the new file name (whichever of the three ways it is defined) is identical to the name of an existing program file, the existing program file is overwritten.

\section*{Getting a Program}

There are two functions, \texttt{GETP} (get program) and \texttt{GETSUB} (get subroutine), that copy a program from extended memory to main memory. The functions both place the copied program at the bottom of program memory, but they differ in other respects.

- \texttt{GETP} deletes the program that was at the bottom of program memory and (in some cases) makes the first line of the recalled program the current program line.
- \texttt{GETSUB} retains the program that was at the bottom of program memory and never alters the current program line.

\section*{Keyboard Execution.}

- If you want to replace the program at the bottom of program memory, place the name of the program file in the Alpha register and execute \texttt{GETP}. The first line of the recalled program becomes the current program line; press \texttt{R/S} to run the program.

- If you want to run the recalled program by pressing \texttt{R/S} but you want to save the program at the bottom of program memory, press \texttt{GTO} \textbullet{} \textbullet{} before you execute \texttt{GETP}. (The null program created by \texttt{GTO} \textbullet{} \textbullet{} will be replaced.)

- If you want to save the last program, and especially if you’re recalling several programs at once, place the name of the program file in the Alpha register and execute \texttt{GETSUB}. This doesn’t change which program line is the current program line.
Program Execution. \([\text{GETP}]\) operates in two different ways, depending on whether the program containing \([\text{GETP}]\) is at the bottom of program memory; \([\text{GETSUB}]\) operates identically in either case. This means that there are three options for a program to recall another program from extended memory:

- If a program executes \([\text{GETSUB}]\), the recalled program is placed at the bottom of program memory and execution continues with the instruction following \([\text{GETSUB}]\).
- If a program not at the bottom of program memory executes \([\text{GETP}]\), the recalled program replaces the program at the bottom of program memory and execution continues with the instruction following \([\text{GETP}]\).
- If a program at the bottom of program memory executes \([\text{GETP}]\), that program is replaced by the recalled program and execution continues with the first line of the recalled program.

Examples. The three options above give you great flexibility to recall a program from another program, and in many situations there is more than one option that will work. These examples illustrate situations in which you would select a particular option. Suppose that MAIN is a program in main memory (but not at the bottom) and that AA, BB, and CC are programs in extended memory that MAIN calls as subroutines.

The first four examples illustrate the first two options, using \([\text{GETSUB}]\) and \([\text{GETP}]\) in the program MAIN. To ensure that MAIN isn’t at the bottom of program memory you could press \([\text{GTO}]\) before executing MAIN (to create a null program), or MAIN could first use \([\text{GETSUB}]\) to recall a dummy program containing only a global label and an \([\text{END}]\) instruction. (Recalling a dummy program could also enable MAIN to conclude with \([\text{PCLPS}]\), clearing the dummy program and all subroutines recalled by MAIN.)

- If MAIN calls AA, BB, and CC as subroutines and there is enough room in main memory for all three programs: use \([\text{GETSUB}]\) three times at the start to recall AA, BB, and CC, and use \([\text{XEQ}]\) as needed to call each subroutine.
- If there isn’t enough room for AA, BB, and CC at once (and MAIN always calls them in that order): use \([\text{GETSUB}]\) and \([\text{XEQ}]\) to call AA, and use \([\text{GETP}]\) and \([\text{XEQ}]\) to call BB and CC.
- If there isn’t enough room for AA, BB, and CC at once (and you don’t know in advance in which order MAIN will call them): use \([\text{GETSUB}]\), \([\text{XEQ}]\), and \([\text{PCLPS}]\) for each subroutine call; or place a null program or dummy program at the bottom of program memory and then use \([\text{GETP}]\) and \([\text{XEQ}]\) for each subroutine call.
- If AA contains a second global label DD and you want the subroutine call to begin at DD: use \([\text{GETSUB}]\) to recall AA and then use \([\text{XEQ}]\) DD to start the subroutine at DD.

The next two examples illustrate the first and third options, using \([\text{GETSUB}]\) and \([\text{GETP}]\) in the subroutine AA. Assume that MAIN has recalled AA to the bottom of program memory.

- If AA branches to BB, use \([\text{GETP}]\) in AA to recall BB. This automatically clears AA and transfers execution to BB.
- If AA calls BB as a subroutine, use \([\text{GETSUB}]\) and \([\text{XEQ}]\) in AA to call BB. This leaves AA intact in program memory so that execution can return to AA after BB finishes.
Automatic Key Redefinition

Recall from section 10 that a global label assigned to the User keyboard contains that assignment information. (This is true only for programs listed in catalog 1.) When [SAVEP] copies a program into extended memory, any current assignments are saved along with the assigned global labels. If the User keyboard is active (that is, if flag 27 is set) when [GETSUB] or [GETP] recall a program from extended memory, any assignments stored with that program will be reactivated.

Checking Program Size

You can check how many bytes are in a program stored in a program file by using [RCLPT] or [RCLPTA]. (These functions are primarily used with data and text files; this application with program files is distinct from their primary purpose.) Both functions return the number of bytes to the X-register, lifting the stack unless stack lift is disabled.

- If the program file is not the current file, place its name in the Alpha register and execute [RCLPTA].
- If the program file is the current file, execute [RCLPT] or else clear the Alpha register and execute [RCLPTA].

Creating Data and Text Files

You must explicitly allocate space in extended memory for each data or text file. Before creating a file you can check how many registers are available by executing [EMDIR] (also available as [CATALOG] 4) or [EMROOM]. The number returned to the X-register is the maximum number of registers you can allocate to a new file.

Creating Data Files

Use [CRFLD] (create file/data) to create a data file as follows.

1. Place the name of the new file in the Alpha register. The name can include any characters except commas and a maximum of seven characters.
2. Place the number of registers you want to allocate to the file in the X-register. (Do not include registers for the header.)
3. Execute [CRFLD].

This new file is now the current file, and its pointer is set to the first register.
Creating Text Files

Text files are created similarly to data files, but first you must translate the memory requirements of your file into registers. A rough estimate is usually sufficient because you can adjust the size later; the exact formula given here can be useful when a program creates the file.

Shown below is a text file of three records: ABC, ABCDEFGHI, and ABCDEFG. At the start of each record is an extra byte (like \texttt{XTOA} creates) that indicates the length of that record. A record can contain up to 254 characters.

![Header Registers](chart)

The \texttt{Header Registers} contain the file name, file type, file size, and current pointer value.

![Text-String Registers](chart)

The \texttt{Text-String Registers} contain the size of the file.

The \textbf{“\texttt{*}”} at the end of the file is a byte that indicates the end of the current contents of the file. (The decimal value for this byte is 255; this is why each record must have a length less than 255.) This byte and the bytes indicating record lengths are invisible to you; the file looks like the diagram on page 215 when you use it. The only time you must consider these extra bytes is when you create a text file.

If you know exactly how many records and characters will be in the file, you can calculate exactly how many registers are required.

1. Add the number of records to the number of characters in all records.
2. Add 1 to the result.
3. Divide the result by 7. If there is any remainder, round up to a whole number.

Now use \texttt{CRFLAS} (create file/ASCII) to create the file.

4. Place the name of the new file in the Alpha register. The name can include any characters except commas and a maximum of seven characters.
5. Place the number of registers to be allocated in the X-register.
6. Execute \texttt{CRFLAS}.

The new file is now the current file, and its pointer is set to the first character in the first record.
Resizing Files

You can change the number of registers allocated to a data or text file by executing \texttt{RESZFL} (resize file) as follows:

1. Make sure that the file to be resized is the current file.
2. Place in the X-register the number of registers to be allocated.
3. Execute \texttt{RESZFL}.

The integer part of the number in the X-register becomes the new size of the current file. The pointer is unchanged.

Increasing File Size. Before enlarging a file you can check how many registers are available by executing \texttt{EMDIR} or \texttt{EMROOM}. You can usually add two registers more than the result, because \texttt{EMDIR} and \texttt{EMROOM} reserve two registers for a new header that isn’t required in this case. However, if the number returned is zero, there might be two, one, or no registers left.

Reducing File Size. If you reduce the size of a file by $n$ registers, the last $n$ registers in the file are lost. With a positive number in the X-register, \texttt{RESZFL} executes only if no registers currently in use will be lost. A register is considered in use if it:

- Contains a non-zero number (for data files).
- Contains characters or the end-of-file byte (for text files).

If the number in the X-register is positive and registers in use would be lost, \texttt{RESZFL} causes a \texttt{FL SIZE ERR}. For data files you can bypass this protection by a negative number in the X-register. In this case, the last $n$ registers are lost regardless of their contents.

Clearing Files

You can clear the contents of a data or text file without purging the header as well by executing \texttt{CLFL} (clear file) as follows:

1. Place the name of the file in the Alpha register.
2. Execute \texttt{CLFL}.

The cleared file becomes the current file. If it’s a data file, all registers contain zero and the pointer is set to the first register. If it’s an text file, no records exist and the pointer is set to the first character in the first record to be added.

Pointers in Data and Text Files

Data and text files are collections of registers and Alpha strings, respectively, with pointers that enable you to access individual elements in those collections. The structures of data and text files are described first, followed by pointer operations.
Structure of Data Files

A data file comprises two header registers and one or more data registers. The header contains the current pointer value, which indicates the register that will be accessed next.

The diagram below shows a data file of five registers. Note that the pointer values start with 000 for the first register and are greater by one for each subsequent register.

- **Header Registers.** Contain file name, file type, file size, and current pointer value.
- **Data Registers.** The number of data registers is the file size.

Structure of Text Files

A text file comprises two header registers and one or more registers that contain your records. Each record is a string of up to 254 characters. This means that records can be different lengths, and that the pointer for a text file (contained in the header) has two components:

- **Record Pointer.** The integer part of a text-file pointer is the record pointer. Its value indicates the current record.
- **Character Pointer.** The fractional part of a text-file pointer is the character pointer. Its value indicates the current character within the current record. Functions that act on an entire record ignore this part part of the pointer.

A text-file pointer is represented as rrr.ccc, where rrr is the record pointer and ccc is the character pointer. In the diagram below, which shows a text file containing three records, the pointer values for the three A’s are 000.000, 001.000, and 002.000. The pointer values for H and I are 001.007 and 001.008. (This diagram illustrates how to interpret text-file pointers. The diagram on page 212 shows the same file as it would actually be stored in registers.)
Pointer Operations

Pointers allow you to access individual elements within data and text files. The current value of a pointer indicates the current register or the current record and character; the pointer must be set before you execute the function that accesses that register, record, or character.

Often you will explicitly set a pointer when you first access a file, preparing for the subsequent functions that will access the indicated data. Most functions that use pointers also automatically advance the pointer. This makes it possible to access sequential elements simply by repeating the function.

There are times when the value of a pointer doesn’t correspond to any stored information. For example, if a function accesses the last register in a data file and then advances the pointer, the new pointer value doesn’t correspond to a register in the file. If you repeated that function, an END OF FL error would result.

Setting a Pointer. To set a pointer, execute \texttt{SEEKPTA} (seek pointer by Alpha) or \texttt{SEEKPT} (seek pointer).

If the desired file is not the current file, use \texttt{SEEKPTA}.
1. Place the name of a data or text file in the Alpha register.
2. Place the desired pointer value in the X-register.
3. Execute \texttt{SEEKPTA}.

The file named in the Alpha register becomes the current file, with its internal pointer set to the number in the X-register. For a data file, the integer part of this number sets the register pointer. For a text file, the integer part sets the record pointer and the first three digits of the fractional part set the character pointer.

If the desired file is already the current file, you can either:

- Place the pointer value in the X-register and then execute \texttt{SEEKPT}; or
- Clear the Alpha register, place the pointer value in the X-register, and then execute \texttt{SEEKPTA}. 

Checking a Pointer Value. You can check the current value of a pointer by using \texttt{RCLPTA} (recall pointer by Alpha) or \texttt{RCLPT} (recall pointer). If the desired file is not the current file, use \texttt{RCLPTA} as follows:

1. Place the name of the file in the Alpha register.
2. Execute \texttt{RCLPTA}.

The file named in the Alpha register becomes the current file. Its current pointer value is returned to the X-register, lifting the stack unless stack lift is disabled. For a data file, the number represents the register pointer. For a text file, the number has the form \texttt{rrr.ccc}, where \texttt{rrr} is the record pointer and \texttt{ccc} is the character pointer.

You can check the current pointer value for the current file by executing \texttt{RCLPT} or by clearing the Alpha register and executing \texttt{RCLPTA}. The pointer value is returned to the X-register as described above. \texttt{RCLPTA} and \texttt{RCLPT} also have a secondary use with program files, described on page 211.

\section*{Data File Operations}

Data files are useful as an extension of main memory and as an alternative to main memory. For operations such as register arithmetic and indirect addressing, your data must be in main memory; but there are also extended memory operations that can't be duplicated in main memory. The functions that access data registers in main memory are described first, followed by the functions that access the X-register.
Accessing All Data Registers

You can copy all data registers in main memory into a data file by using [SAVER] (save registers), and you can copy all or some of a data file into main memory by using [GETR] (get registers). In either direction, data moves between registers with corresponding addresses and pointer values: between $R_{00}$ in main memory and register 000 in the data file, between $R_{01}$ and register 001, and so on. The current value of the pointer doesn’t affect these functions, but both functions advance the pointer just past the last file register accessed.

Copying Data From All Main Memory Data Registers. To copy each data register in main memory into the corresponding register in a data file, place the name of the data file in the Alpha register and then execute [SAVER]. If the desired file is already the current file, you can simply clear the Alpha register and execute [SAVER].

If there are fewer destination registers (in the data file) than source registers (in main memory), no registers are copied and an END OF FL error occurs. This is because [SAVER] expects to save the data in all main memory registers.
Copying Data Into All Main Memory Data Registers. To copy the registers in a data file into the corresponding data registers in main memory, place the name of the data file in the Alpha register and then execute \texttt{GETR}. If the desired file is the current file, you can simply clear the Alpha register and then execute \texttt{GETR}.

Starting with file register 000 and main memory register R₀₀₀, \texttt{GETR} moves data between corresponding registers until there are no further registers of one type or the other. (This is unlike \texttt{SAVER}, which causes an error if not all main memory data registers are accessed.)

**Accessing a Block of Data Registers**

You can move data between a block of data registers in main memory and a block of the same size in a data file by using \texttt{SAVERX} (save registers by X) and \texttt{GETRX} (get registers by X). The data file must be the current file. The two blocks of registers are defined as follows:

- The block of registers in main memory is defined by a control number in the X-register. The control number has the form \( bbb.eee \), where \( R_{bbb} \) is the register that begins the block and \( R_{eee} \) is the register that ends the block.

- The block of registers in the data file is defined by the current pointer value and by the control number in the X-register. The block begins with the current register and includes the \( eee - bbb \) registers that follow.

The data move between \( R_{bbb} \) in main memory and the current register in the file, between \( R_{bbb} + 1 \) and the next register in the data file, and so on. Both \texttt{SAVERX} and \texttt{GETRX} advance the data file's pointer just past the last register accessed. If there are fewer file registers (from the current register to the end of the file) than specified for the block in main memory, no registers are copied and an \texttt{END OF FL} error occurs.

**Copying Data From a Block of Main Memory Data Registers.** Use \texttt{SAVERX} to copy the contents of a block of registers in main memory into a block of registers in a data file:

1. Be sure that the destination file is the current file and that its pointer is set to the first register to receive data.

2. Place the control number \( bbb.eee \) in the X-register.

3. Execute \texttt{SAVERX}.  


Copying Data Into a Block of Main Memory Data Registers. Use \texttt{GETRX} to copy the contents of a block of registers in a data file into a block of data registers in main memory:

1. Be sure that the source file is the current file and that its pointer is set to the first register to send data.
2. Place the control number \texttt{bbb.eee} in the X-register.
3. Execute \texttt{GETRX}.
Accessing the X-Register

You can move data between the X-register and a data file by using \texttt{SAVEX} \texttt{(save X)} and \texttt{GETX} \texttt{(get X)}. The data file must be the current file and the register to be accessed must be the current register. Both functions advance the data file’s pointer just past the register accessed.

Storing the Contents of the X-register. Use \texttt{SAVEX} to copy the contents of the X-register into a data-file register:

1. Be sure that the destination file is the current file and that the destination register is the current register.
2. Execute \texttt{SAVEX}.

The X-register is unchanged and the previous contents of the destination register are lost. (This is similar to \texttt{STO}.)

Recalling Data to the X-register. Use \texttt{GETX} to copy the contents of a data-file register to the X-register:

1. Be sure that the source file is the current file and that the source register is the current register.
2. Execute \texttt{GETX}.
The source register is unchanged; the stack lifts and the contents of the T-register are lost, unless stack lift is disabled. (This is similar to \(\text{RCL}\).)

**Example.** Suppose that a program needs to store the stack contents before using the stack to set an alarm, and then later needs to return those contents to the stack. This is done in three stages, listed below as separate routines.

The first routine creates a data file named STACK; it is executed at the beginning of the program, before the stack contains the values to be stored.

```
01 TSTACK
  Places the file name in the Alpha register.
02 4
  Places the number of registers in the X-register.
03 CRFLD
  Creates a data file named STACK containing four registers.
```

The second routine copies the numbers in the stack into the file; it is executed just before placing the alarm parameters in the stack.

```
01 TSTACK
  Places the file name in the Alpha register.
02 STO L
  Saves the contents of the X-register in the LAST X register.
03 CLX
  Places zero in the X-register (without lifting the stack).
04 SEEKPTA
  Makes STACK the current file and makes register 000 the current register.
05 X<> L
  Returns the contents saved in the LAST X register to the X-register (without lifting the stack).
06 R↓
07 SAVEX
08 R↑
09 SAVEX
10 R↓
11 SAVEX
12 R↑
13 SAVEX
```

These steps alternately roll the stack up and copy the current contents of the X-register into a register in the file STACK. The number \(t\) (that started in the T-register) is copied first, followed by \(z\), \(y\), and \(x\). The pointer advances automatically, placing \(t\) in 000, \(z\) in 001, \(y\) in 002, and \(x\) in 003. This order simplifies the third routine, which restores these values to the stack.

The third routine copies the numbers back into the stack; it is executed after setting the alarm.

```
01 TSTACK
  Places the file name in the Alpha register.
02 CLX
  Places zero in the X-register.
03 SEEKPTA
  Makes STACK the current file and makes register 000 the current register.
```
Recalls $t$ to the X-register, lifts the stack, and advances the pointer.
Recalls $z$ to the X-register, lifts the stack, and advances the pointer.
Recalls $y$ to the X-register, lifts the stack, and advances the pointer.
Recalls $x$ to the X-register, lifts the stack, and advances the pointer.

Text File Operations

Most of the operations covered here move data between a text file and the Alpha register. Any information in the Alpha register—characters from the Alpha keyboard or bytes created by XTOA—can be moved to and from a text file by these operations.

For simple operations it is easier to use the Text Editor described in the next section. If you want to review a text file or edit it using standard characters, lets you see what you're doing while you're doing it. However, any program that automatically manipulates text files must use the operations covered here.

Checking Available Bytes

Before you add data to a text file you can check how many bytes are available, using ASCII room. The text file must be the current file. returns the number of available bytes to the X-register, lifting the stack unless stack lift is disabled. Remember that each new record requires one extra byte for overhead. If there is not enough room, refer to on page 213.

Record Operations

You can append, insert, or delete a record in a text file by using append record), (insert record), or (delete record). The desired file must already be the current file. Both and make the contents of the Alpha register a new record in that file and advance the pointer just past the last character in the new record. This sets the pointer properly for adding characters to the new record.

Appending a Record. Use to append a new record:
1. Be sure that the desired text file is the current file.
2. Place the data for the new record in the Alpha register.
3. Execute APPREC.
Inserting a Record. Use \texttt{INSREC} to insert a new record:

1. Be sure that the desired text file is the current file and that the record pointer is set to the desired position of the new record. (The value of the character pointer doesn’t matter.)

2. Place the data for the new record in the Alpha register.

3. Execute \texttt{INSREC}. 

\begin{itemize}
\item \texttt{INSREC}
\item \textbf{Alpha Register}
\begin{itemize}
\item \texttt{xyz}
\end{itemize}
\item \textbf{Current Text File}
\begin{itemize}
\item \texttt{pointer = rrr.ccc}
\item \begin{align*}
\text{rrr} & \quad \begin{array}{l}
abc \\
defg \\
h
\end{array} \\
\text{....}
\end{align*}
\item \begin{align*}
\text{rrr} & \quad \begin{array}{l}
abc \\
xyz \\
defg
\end{array} \\
\text{....}
\end{align*}
\end{itemize}
\item \texttt{DELREC}
\end{itemize}
Deleting a Record. Use [DELREC] to delete a record:

1. Be sure that the desired text file and record are the current file and record. (The value of the character pointer doesn’t matter.)
2. Execute [DELREC].

The record pointer value is unchanged, but the current record is now the record that previously followed the deleted record. The character pointer is set to 000.

Character Operations

You can append, insert, or delete characters in a record by using [APPCHR] (append characters), [INSCHR] (insert characters), or [DELCHR] (delete characters). The desired record must already be the current record in the current text file. Both [APPCHR] and [INSCHR] add the contents of the Alpha register to the record and advance the pointer just past the last character added. This allows you to repeat either function immediately after placing new data in the Alpha register.

Appending Characters. Use [APPCHR] to append characters to a record:

1. Be sure that the desired text file and record are the current file and record. (The value of the character pointer doesn’t matter.)
2. Place the characters to be appended into the Alpha register.
3. Execute [APPCHR].

Inserting Characters. Use [INSCHR] to insert characters in a record:

1. Be sure that the desired text file and record are the current file and record, and that the character pointer is set to the desired position for insertion.
2. Place the characters to be inserted into the Alpha register.
3. Execute [INSCHR].
Deleting Characters. Use DELCHR to delete characters in a record:

1. Be sure that the desired text file and record are the current file and record, and that the first character to be deleted is the current character.
2. Place in the X-register the number of characters to be deleted.
3. Execute [DELCHR].

The character pointer value is unchanged, but the current character is now the character that previously followed the last deleted character.
Searching a File

You can search a text file for a particular string of characters by using \texttt{POSFL} (position in file) as follows:

1. Make sure that the file to be searched is the current file.
2. Set the pointer to the position where you want the search to begin.
3. Place the target string in the Alpha register.
4. Execute \texttt{POSFL}.

If the target string is found:

- The pointer is set to the first character of the string.
- This pointer value is returned to the X-register.

If the target string is not found:

- The text pointer is unchanged.
- A value of $-1$ is returned to the X-register.

In either case the Alpha register is unaltered, and the stack lifts unless stack lift is disabled. If the target string was found, you can recall that part of the file to the Alpha register using the following functions.

Copying Data into the Alpha Register

\texttt{GETREC} (get record) and \texttt{ARCLREC} (Alpha recall record) copy characters from a text record into the Alpha register. They differ only in whether they first clear the Alpha register.

- \texttt{GETREC} clears the Alpha register before copying characters.
- \texttt{ARCLREC} appends the copied characters to the previous contents of the Alpha register.

Otherwise, the two functions follow the same procedures.

- Both start with the current character in the current record in the current file.
- Both copy sequential characters until the last character in the record is copied or until the Alpha register is full. (This means that \texttt{ARCLREC} does nothing if the Alpha register is already full.)
- Both clear flag 17 if the last character in the record is copied or set set flag 17 if not. (For certain HP-IL peripherals, this flag controls whether sequential outputs are considered separate lines.)
- Both advance the character pointer just past the last character copied.

To execute \texttt{GETREC} or \texttt{ARCLREC}, make sure that the desired file is the current file and that the pointer is set as intended, and then execute the function. After you have processed the recalled data in the Alpha register, you can test flag 17 to check whether there are more characters to be copied in that record.
Accessing Mass Storage Files

You can make permanent copies of text files with a mass-storage device controlled by an HP 82160A HP-IL Module. **SAVEAS** *(save ASCII)* copies a text file from extended memory to mass storage, and **GETAS** *(get ASCII)* copies the file from mass storage back to extended memory. The following rules apply to saving and recalling files:

- The destination file must exist before the source file can be copied to it. To create the destination file on the mass storage medium, use **CREATE** (a function in the HP-IL module) to create a data file. It will become a text file when you execute **SAVEAS**.

- If the destination file is smaller than the source file, as much data as possible is copied before an **END OF FL** error stops program execution. You can set flag 25 (Error Ignore) if you intend to make an incomplete copy of the source file.

- Specify the source and destination files, separated by a comma, in the Alpha register.

**Alpha Register**

```
source-file name,destination-file name
```

If the two files have the same name, you can place just that name in the Alpha register.
Section 14

The Text Editor

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Introduction

This section tells you how to use the Text Editor, a tool for working with text (ASCII) files. The discussion here assumes that you are familiar with the creation, deletion, and memory requirements of text files as described in section 13.

Adjusting the record/character pointer was integral to the use of the text-file operations (like APPREC, APPCHR, and INSCHR) described in section 13. This is because these operations use the Alpha register as an intermediary, passing up to 24 characters between you and the text file. *They do not allow you to read the text file itself.*
The Text Editor lets you view text files directly. It provides the means to directly type in, edit, and view the contents of text files. The Text Editor greatly simplifies the writing and modification of text files. However, there are two limitations to the Text Editor: its operations cannot be programmed (while functions like [DELCHR] can be), and you cannot use it to enter characters not on the Alpha keyboard (which you can with [APPCHR] or [INSCHR]).

The Text Editor's complete operation is described in section 8, “Storing Text, Data, and Programs in Files.” Therefore, this section is organized for easy reference, with very short explanations. There is also an entry for [ED] in the Function Table “Extended Memory Functions,” on page 426.

**The Text Editor Display**

**The Window**

When you execute [ED], the display becomes a 12-character window into a record within the specified text file. The cursor (underscore) blinks alternately with a character or blank; the position of the cursor and the record shown are determined by the current value of the record/character pointer.

**The Record Number.** For convenience, the left end of a record display shows a two- or three-digit record number. This is not part of the record itself.

**The Empty-Record Indicator (†).** An empty record is shown by a record number followed by the “raised T” empty-record indicator, †. This symbol appears in a newly created record, as well as in a record that loses its last character.

**Punctuation.** A punctuation character (".", ",", or ";") appears to the right of a regular character position. Therefore, a punctuation mark does not count as one of the 12 character spaces, unless there are two or more punctuation marks in a row. (Adjacent punctuation marks are separated by the width of a character.) Since the cursor is a full character (the underscore), it cannot occupy the same position as a punctuation mark—so when the record/character pointer is at a punctuation mark, the punctuation mark just blinks, with no cursor.

**The Cursor.** Except when the display shows the beginning or end of a record, the display window surrounds the cursor and the current character in the approximate center of the window. The cursor can be moved right as far as one character position past the end of the record. This is its position when you are adding characters to the end of a record.

---

* [ED], which activates the Text Editor, is programmable, but none of its operations are. See “Using [ED] in a Program,” page 233.
† To enter a nonstandard character (like @) in a text file, you need to enter it first into the Alpha register by using [XTOA] and then enter it into the text file by using [APPCHR] or [INSCHR].
‡ The empty-record indicator is actually a “dummy character”: it is like a character except that it can’t be deleted when it is marking an otherwise empty record. The † uses one byte of memory (like any other character), so an empty record is not strictly empty. (The function [ASROOM] will count two bytes for each empty record: one for overhead and one for the empty-record indicator.)
Annunciators

The annunciators appearing in the display are redefined for the Text Editor:

- **1** indicates that Insert mode is active (page 232).
- **ALPHA** indicates that the regular Alpha keyboard (with the Text Editor control keys) is active; no ALPHA means the numeric keypad is active (page 232).
- **SHIFT** and **BAT** have their usual meanings.
- All other annunciators remain off, regardless of their status upon entering the Editor. Their prior status is restored upon leaving (exiting) the Editor.

Text Editor ([ED]) Operations

Entering and Exiting the Text Editor

To access a text file with the Text Editor:

1. If it doesn’t already exist, create a file of a specific name and size using **CRFLAS**. (See page 212.)
2. With the name of the desired file in the Alpha register, execute **ED** (*editor*). An empty Alpha register specifies the current file.
3. The display will show the cursor on the current character in the current record (determined by the record/character pointer). A new file starts with one empty record (numbered 000).

To exit the Text Editor, press the **ON** toggle key ([EXIT] on the [ED] keyboard). An automatic exit occurs if you try to put more than 254 characters (the limit) in a record, or after a few minutes of inactivity. Exiting restores all annunciators that were redefined by **ED**.

Default Conditions

Each time you activate the Text Editor manually, the Alpha (rather than Numeric) keyboard is active (**ALPHA** on), and Replace mode is active (new characters write over old ones). If **ED** is executed from within a program, the status of the Alpha flag (48) remains as it was before **ED** was executed so that the program can control which keyboard is active.

The Keyboard

An annotated diagram of the Text Editor ([ED]) keyboard is on page 231. The backplate of the HP-41CX has a diagram of the Text Editor keyboard, and the Quick Reference Guide also contains one. This keyboard is composed of two basic types of keys: the Alpha character keys (including digits), and the control keys, which supply the editing functions.
Section 14: The Text Editor

The Text Editor Keyboard

1. Empty Record Indicator
2. Record Number (rrr in pointer rrr.ccc)
3. Cursor Indicates Character (ccc in pointer rrr.ccc)
4. Exit From Text Editor
5. Move Cursor Right
6. Alpha Keyboard Indicator
7. Move Cursor Left
8. Alpha/numeric Keyboard Toggle
9. Insert Mode Indicator
10. Go to Record nnn
11. Go to Previous Record
12. Go to Next Record
13. Delete Record
14. Delete Character
15. Insert New Record Before Current Record
16. Insert New Record After Current Record

Numeric Keypad (ALPHA off)
The character set on the Text Editor keyboard matches the Alpha character set, including the shifted characters and digits. This is the default character set when you execute \texttt{ED} manually.

**The Numeric Keypad**

Using the \texttt{[ALPHA]} toggle key to extinguish the Alpha annunciator will set the numeric keypad, shown as an insert on the keyboard diagram. The numeric keypad is for convenience when entering numbers: it makes the digit keys, \texttt{[1]}, and \texttt{[CHS]} the primary, unshifted keys.\textit{ All other character keys become inactive.} Upon exiting the Text Editor, the status of the Alpha annunciator (flag 48) will be restored to what it was before you entered the Editor.

**The Character Control Keys**

The annotation on the keyboard diagram (page 231) indicates all of the control keys.

**Cursor Control.** \texttt{[\downarrow 1]} (\texttt{USER}), \texttt{[\rightarrow 1]} (\texttt{PRGM}), \texttt{[\rightarrow 12]} (\texttt{[USER]}), and \texttt{[\rightarrow 12]} (\texttt{[PRGM]}). The cursor represents the record/character pointer. You cannot move the cursor beyond the beginning of the record; you cannot move the cursor any further than one character position past the end of the record.

The sequence \texttt{[REC]} \texttt{[REC]} or \texttt{[REC]} \texttt{[REC]} will instantly move the cursor to the beginning of a long record.

**Character Addition.** \texttt{[\leftarrow]} (\texttt{LBR}) toggles between Replace (character) and Insert (character) modes. The default condition is Replace; no annunciator lit. Insert mode is signified by the \texttt{1} annunciator.

In Replace mode (the default mode), any character you key in writes over the character indicated by the cursor. In Insert mode, a character typed in is inserted ahead of the cursor.

**Character Deletion.** \texttt{[\rightarrow]} deletes the character indicated by the cursor; the characters on the right shift left to fill the gap. If the cursor is past the last character in the record, pressing \texttt{[\rightarrow]} deletes the last character. If there is only one character left and it is deleted, the \texttt{T} (the empty-record indicator) appears.

**The Record Control Keys**

**Record Addition.** \texttt{[\uparrow REC]} (\texttt{VIEW}) and \texttt{[\downarrow REC]} (\texttt{R/S}) insert an empty record before or after the current record. The \texttt{T} (the empty-record indicator) is displayed. \texttt{[\uparrow REC]} and \texttt{[\downarrow REC]} also terminate Insert mode if it was active.)

* The \texttt{[\leftarrow]} key will record either \texttt{.} or \texttt{,} depending on the current radix mark convention (flag 28).
Record Deletion. \( \text{REC} (-) \) (CLx) deletes the current record. The cursor (the record/character pointer) moves to the first character of the next record unless the deleted record was the last one, in which case the cursor moves to the first character of the previous (now the last) record.

Moving Among Records. \( \text{REC} \uparrow \) (SST) and \( \text{REC} \downarrow \) (BST) move the cursor (the pointer) to the first character of the next or previous record, respectively. The cursor will not move beyond the first or last record (the display just blinks if you try).

\( \text{GTO} \) \( nnn \) moves the cursor to the first character of the indicated record, which must be specified by three digits. Like the usual \( \text{GTO} \), this is a parameter function that cues you for a three-digit input.

To locate the last record quickly, use a very large number with \( \text{GTO} \), such as \( \text{GTO} 999 \).

Errors

**NO ROOM** (with a beep) occurs when there is no more memory space in the file to add more characters or records. This is just a warning message, lasting about 1 second. There is no other effect. If you need more room in the file, allocate more registers using \( \text{RESZFL} \), page 213.

**REC TOO LONG** occurs if you try to exceed the maximum record length (254 characters). This causes the HP-41 to exit the Text Editor. (Just re-execute \( \text{ED} \) to recover your place.)

**FL NOT FOUND** occurs if you execute \( \text{ED} \) when the contents of the Alpha register do not correspond to the name of an existing file.

**NAME ERR** occurs if you execute \( \text{ED} \) when the Alpha register contains an illegal name, such as “ ” or seven bytes of decimal value 255 (EEEEEEE).

**FL TYPE ERR** occurs if you execute \( \text{ED} \) when the contents of the Alpha register specify a non-text file.

Using \( \text{ED} \) in a Program

As mentioned in the beginning of this section, \( \text{ED} \) is programmable, though its control operations are not. Therefore, to use \( \text{ED} \) in a program there must be a user present to respond and enter or edit the necessary text when the program executes \( \text{ED} \).
All you need to do in the program is put the name of the desired file in the Alpha register and execute [ED]. Program execution will automatically stop, showing the Text Editor display. (If there is no response within a couple of minutes, the Text Editor will time-out—that is, be cancelled, and the program will continue running.)

However, it is more complete to ensure as well that the Alpha keyboard is on ([AON]), if having it on is desirable, and that the cursor (alias record/character pointer) is at the desired location. Lines 06 and 07 set the record/character pointer to record 000, character 000. (Pointer operations are in section 13.)

A program that executes [ED] will stop to wait for input. When text entry or modification is complete, press [EXIT] to continue the program, not [R/S]. Remember that [R/S] means [REC+] to the Text Editor.

To make an automatic, programmed modification to a text file, you must use programmable functions like [INSCHR] and [APPREC]. (See section 13.)
Part IV
Time Functions in Detail
Included within the HP-41CX is a crystal-based clock and a variety of time-based functions. The clock runs even when the computer is off. This section covers those time functions related to clock time and dates. Many of these functions are discussed with examples in section 6; the discussion in this section is structured for ease of reference and for completeness. These functions are also summarized in the Function Table “Time Functions.” Many of the time functions are used in section 22, “Programs for Keeping Time Records.”
The clock is maintained separately from the rest of the computer functions and Continuous Memory. Therefore, clearing Continuous Memory does not reset the time or stopwatch, though it does clear all alarms and the month/date format. The details are listed under “Effects of Clearing Memory, Power Interruption, and Low Power” in appendix F.

There are two important appendices that elaborate on aspects of the time functions: appendix B, “More About Past-Due Alarms,” and appendix F, “Time Specifications.” Appendix B is of interest if you set many alarms, and appendix F is of interest regarding the accuracy of the timer and the variables of power consumption.

**Setting and Adjusting the Clock Time**

1. Use SETIME to initially set the clock time. Use SETDATE to set the date.

2. Use T+X to account for errors made with SETIME and time zone changes. (If it is necessary, this will change the date, too.)

3. Wait at least a week, then use CORRECT to correct for time “drift” (inaccuracy).

If setting or adjusting the time or date causes any alarms in memory to be bypassed, then two tones sound and those alarms become past-due. Refer to “Past-Due Alarms,” section 16.

**Setting the Time With SETIME**

The function SETIME sets the internal clock with a precision to hundredths of a second. While setting the hours, use the conventions shown in the table to the right.

To set the time:

1. Place the time in the form ±HH.MMSSss into the X-register.

2. Execute SETIME.

The time is set when you release the last key that executes SETIME. The maximum precision in manually setting the time is about 0.1 second. For greater precision, you can adjust the time using T+X, below.

<table>
<thead>
<tr>
<th>Clock Time</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midnight</td>
<td>0</td>
</tr>
<tr>
<td>1 (a.m.)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Noon</td>
<td>±12</td>
</tr>
<tr>
<td>1 p.m. or 13:00</td>
<td>−1 or 13</td>
</tr>
<tr>
<td>2 or 14</td>
<td>−2 or 14</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>10 or 22</td>
<td>−10 or 22</td>
</tr>
<tr>
<td>11 or 23</td>
<td>−11 or 23</td>
</tr>
<tr>
<td>Midnight</td>
<td>0</td>
</tr>
</tbody>
</table>
Adjusting the Time With \texttt{[T+X]}

The \texttt{[T+X]} \textit{(time plus X)} function increments or decrements the current time according to the number in the X-register. Use \texttt{[T+X]} to alter the time due to local time changes (time zones, daylight savings) or inadequate \textit{precision} in setting the time. Do \textit{not} use \texttt{[T+X]} to accommodate \textit{inaccuracy} in the timekeeping of the timer. To correct accumulated error in the time, use \texttt{[CORRECT]}, below.

\textbf{To increment or decrement the time:}

1. Place the time change (positive or negative) in the form $\pm \text{HHH.HMMSSss}$ into the X-register.
2. Execute \texttt{[T+X]}.

If the time change specified moves the current time into a different day, \texttt{[T+X]} also changes the date. ("Setting the Date" is discussed later in this section.)

Adjusting the Accuracy With \texttt{[CORRECT]}

The \texttt{[CORRECT]} \textit{(correct accuracy factor)} function both corrects the time setting and adjusts the accuracy factor. The accuracy factor compensates for time deviations due to normal variations in power, temperature, and manufacture, and continues to make those adjustments in the future. Therefore, \texttt{[CORRECT]} is not for correcting one-time anomalies in the time (see \texttt{[T+X]}, above). (In order to reduce the error introduced by keystroke imprecision, the time span between uses of \texttt{[CORRECT]} should be 1 week or more.)

The mechanics of this function are explained in detail in appendix F ("Time Specifications"), but the basic operation is:

1. Place the correct time in the form \texttt{HH.MMSSss} in the X-register.
2. Execute \texttt{[CORRECT]} at the appropriate instant. (The time you specify (step 1) will become the corrected time at the instant that \texttt{[CORRECT]} is executed.)

This sets the time and adjusts an internally calculated accuracy factor based on previous executions of \texttt{[SETIME]}, \texttt{[CORRECT]}, and other functions. The clock runs from the corrected time at a rate regulated by the newly calculated accuracy factor. (See appendix F.)

Displaying the Clock

Turning the Clock On (\texttt{[CLOCK]} and \texttt{[ON]})

- Pressing \texttt{[ON]} or executing \texttt{[CLOCK]} will display the running clock. Only \texttt{[CLOCK]} is programmable.
- The sequence \texttt{[ON]} turns the HP-41CX off before displaying the clock. This resets flags 12 through 20, as explained in section 12.
- Pressing \texttt{[ON]} clears the clock display and returns the display to the X-register. Pressing most other keys (including \texttt{[ON]}) clears the clock display and executes that function.
The exact composition of your clock display depends on the various clock-display formats, discussed under the next heading.

**Note**: The clock display consumes a higher than usual amount of power. See “Power Consumption” and “Low Power” in appendix G.

As mentioned in section 19, the user flags 12 to 20 are reset each time the computer is turned on. Executing \[ \text{ON} \] affects these flags in the same way as turning on the computer because the computer turns off momentarily before displaying the clock. However, \[ \text{CLOCK} \] does not shut the HP-41 off, so if you want to avoid the resetting of flags 12 to 20, use \[ \text{CLOCK} \]. For convenience, \[ \text{CLOCK} \] can be assigned to a User key.

**Clock Display Formats** (\[CLK24\], \[CLK12\], \[CLKT\], \[CLKTD\])

You can choose the format of the clock display. The settings you choose are maintained even when Continuous Memory is reset, and until there is an interruption in power (like prolonged battery removal). The default display shows the time only, using a 12-hour clock (using a.m. and p.m.). These conventions can be changed as follows:

**12- Versus 24-Hour Clock.** Executing \[ \text{CLK24} (\text{clock}, 24\text{-hour}) \] sets a 24-hour clock display. Executing \[ \text{CLK12} (\text{clock}, 12\text{-hour}) \] sets a 12-hour clock display. Note that these functions do not affect how you must input clock-time values, nor how time values for time calculation functions are output. See the chart “Time Settings” on page 237. In other words, these functions affect the format of the clock display but not that of the X-register.

**Time Only Versus Time and Date.** Executing \[ \text{CLKT} (\text{clock time}) \] sets the clock display to show the time only. Executing \[ \text{CLKTD} (\text{clock time and date}) \] sets the clock display to show the time and the date. The exact display of the date depends on the month-and-day convention, as explained under “Date Formats,” later in this section.

For instance, assuming a month/day format for 3:15 p.m. on a January 21st:

<table>
<thead>
<tr>
<th>Format</th>
<th>[CLKT]</th>
<th>[CLKTD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLK12</td>
<td>3:15:00 PM</td>
<td>3:15 PM 01/21</td>
</tr>
<tr>
<td>CLK24</td>
<td>15:15:00</td>
<td>15:15 01/21</td>
</tr>
</tbody>
</table>

The date display suppresses the seconds portion of the time display.

**Note**: A time-date display (\[CLKTD\]) consumes less power than a time-only display (\[CLKT\]) because the time-date display updates itself only once a minute, while the time-only display updates itself every second.
Manipulating Time Values

A value representing the current time can be recalled to the X-register using **TIME**. A number already in the X-register can be converted to a time display format and appended to the Alpha register using **ATIME** or **ATIME24**.

Recalling the Current Time Value (**TIME**)

The function **TIME** places a number representing the current time into the X-register, lifting the stack (unless stack lift is disabled). The number is given in a 24-hour format, with six decimal places (hundredths of seconds): **HH.MMSSss**. You need to set **FIX** 6 to see all six places. Midnight is zero.

In addition, if **TIME** is executed manually, you see a message display showing the time value according to the 12-hour or 24-hour format in effect (this is not the X-register). Pressing « clears the message display and displays the X-register.

At 5:05:24 p.m. (**FIX** 6), executing **TIME** manually, followed by «, results in:

<table>
<thead>
<tr>
<th>Format</th>
<th><strong>TIME</strong> (temp. display)</th>
<th>« (X-register)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLK12</td>
<td>5:05:24 PM</td>
<td>17.052400</td>
</tr>
<tr>
<td>CLK24</td>
<td>17:05:24</td>
<td>17.052400</td>
</tr>
</tbody>
</table>

Appending a Number in Time Format to the Alpha Register (**ATIME**)

The **ATIME** (Alpha time) function appends the number in the X-register to the contents of the Alpha register in the current clock display format: **CLK12** or **CLK24**. This function is useful for programs involving the time of day.

To indicate a value for elapsed time, use **ATIME** with **CLK24**, or use **ATIME24** (the following topic). In these cases, there will be no **AM** or **PM** or alteration of numbers from 13 to 23.

The integer (hours) part of the number in the X-register determines how the number is formatted in the Alpha register:

- **ATIME** accepts any number in the range $-100 < x < 100$. The negative sign is ignored except for $-1$ through $-11$, which are interpreted as post-meridian times, as indicated in the chart “Time Settings” on page 237.
- If $|x| \leq 23$, the number is formatted according to the current **CLK12** or **CLK24** format setting.
- If $|x| \geq 24$, no **AM** or **PM** are used. (A minus sign is ignored.) This is so you can output a value for an elapsed time, such as 30:12:00 (30 hours and 12 minutes).
For instance, assuming \textbf{FIX} 6:

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\textbf{Value in X-Register} & \textbf{Appends to Alpha Register} & \\
\hline
\textbf{in CLK12} & \textbf{in CLK24} & \\
\hline
$-11$ & $11:00:00.00$ PM & $23:00:00.00$ PM \\
$-15.25$ & $3:25:00.00$ PM & $15:25:00.00$ PM \\
$30.125633$ & $30:12:56.33$ & $30:12:56.33$ \\
\hline
\end{tabular}
\end{center}

- The number appended to the Alpha register is truncated (not rounded) according to the current numeric display setting:

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\textbf{FIX, SCI, ENG} & \textbf{Appends to Alpha Register} & \textbf{Example: 10.0637} \\
& & (10:06:37 AM in CLK12) \\
\hline
0 & $HH$ & 10 AM \\
1 or 2 & $HH:MM$ & 10:06 AM \\
3 or 4 & $HH:MMSS$ & 10:06:37 AM \\
5 or more & $HH:MMSSss$ & 10:06:37.00 AM \\
\hline
\end{tabular}
\end{center}

If there is not enough space left in the Alpha register to accommodate its existing contents plus the characters appended by \textbf{ATIME}, the leftmost characters in the Alpha register are lost to make room for the new characters appended on the right.

If the X-register contains a number outside the range $-100 < x < 100$, executing \textbf{ATIME} causes a \textbf{DATA ERROR}.

\section*{Appending a 24-Hour Time Value to the Alpha Register (\textbf{ATIME24})}

The function \textbf{ATIME24} (Alpha time, 24-hour) operates like \textbf{ATIME} except that the number appended to the Alpha register is always expressed either in 24-hour format or as elapsed time. The current clock display format has no effect.

\section*{Setting and Manipulating the Date}

Functions included in this topic are date formatting, setting the date, recalling the date, and appending a number in date form to the Alpha register.
Date Formats (MDY, DMY)

The default setting for the date format is month/day/year. The formatting functions MDY (month/day/year) and DMY (day/month/year) set the date format to the month/day or the day/month convention. This setting is the only time format to be reset when Continuous Memory is reset.

The following table shows how the computer interprets numeric input as dates and how date output is formatted.

<table>
<thead>
<tr>
<th>Format Setting</th>
<th>X-Register Input/Output</th>
<th>Display and Printer Output</th>
<th>Flag 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDY</td>
<td>MM.DDYYYY</td>
<td>MM/DD or MM/DD/YY</td>
<td>Clear</td>
</tr>
<tr>
<td>DMY</td>
<td>DD.MMYYYY</td>
<td>DD.MM or DD.MM.YY</td>
<td>Set</td>
</tr>
</tbody>
</table>

When entering dates you can omit leading and trailing zeros. For example, a number representing May 6, 1990 can be entered as 5.06199. The appropriate leading and trailing zeros do appear in message-type displays of the date.

Setting the Date ([SETDATE])

To set the date:

1. Put the date in the X-register according to the current date format (see above), using the form MM.DDYYYY or DD.MMYYYY. As mentioned above, you can omit leading and trailing zeros.
2. Execute [SETDATE].

The HP-41 can be set to any date from January 1, 1900 to December 31, 2199.

If the format of the date you enter does not correspond to the current month-and-day setting, no error message will result unless the date interpreted from your input is actually an invalid date. If setting the date causes any alarms to become past-due, two tones will sound. Refer to “Past-Due Alarms” in section 16.

Recalling a Current Date Value ([DATE])

The function [DATE] returns a number representing the current date to the X-register, lifting the stack (unless stack lift is disabled).

- The number recalled to the X-register will be in the form MM.DDYYYY or DD.MMYYYY, depending on the date format setting.
- In addition, if [DATE] is executed manually, a message display shows the date and day of the week in the form MM/DD/YY DAY or DD.MM.YY DAY, where DAY is a three-letter abbreviation for the day of the week. (For the years 2000 to 2199, the date display is MM/DD/YYYY:DA or DD.MM.YYYY DAY.)
Press \( \Rightarrow \) to return the X-register to the display.

**Appending a Number in Date Format to the Alpha Register** ([ADATE])

[ADATE] (Alpha date) appends the number in the X-register in date format to the current contents of the Alpha register.

- The input should be of the form \( MM.DDYYYY \) or \( DD.MMYYYY \), depending on the date format. The valid input range is \(|x| < 100\), so that you can represent periods of elapsed calendar time up to 99.999999 (months or days).
- The appended number is converted to the form \( MM/DD/YYYY \) or \( DD.MM.YYYY \). (A minus sign is ignored.) Leading and trailing zeros are shown.
- The appended number is truncated (not rounded) according to the current numeric display setting:

<table>
<thead>
<tr>
<th>Appends to Alpha Register</th>
<th>Example: 6.11196 (June 11, 1960 in [MDY])</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( MM ) or ( DD ) 06</td>
</tr>
<tr>
<td>1 or 2</td>
<td>( MM/DD ) or ( DD.MM ) 06/11</td>
</tr>
<tr>
<td>3 or 4</td>
<td>( MM/DD/YY ) or ( DD.MM.YY ) 06/11/60</td>
</tr>
<tr>
<td>5 or more</td>
<td>( MM/DD/YYYY ) or ( DD.MM.YYYY ) 06/11/1960</td>
</tr>
</tbody>
</table>

Notice that when only two year digits appear, they are the last two year digits.

**Calculations With Dates**

There are three functions that perform calculations with dates.

- \([\text{DATE+}]\) adds or subtracts a number of days from a given date and determines the resulting date.
- \([\text{DDAYS}]\) calculates the number of days between two given dates.
- \([\text{DOW}]\) calculates the day of the week for a given date.

**Valid Dates**

- The only valid input and output dates for these calculations are from October 15, 1582 (the beginning of the Gregorian calendar) through September 10, 4320.
- The input (\( MM.DDYYYY \) or \( DD.MMYYYY \)) must be positive. If there are any digits after the \( YYYY \), they must be zeros.

The errors DATA ERROR and DATA ERROR Y can result if data input is invalid. An invalid result for \([\text{DATE+}]\) will cause OUT OF RANGE.
Date Arithmetic ([DATE+])

[DATE+] (date plus) calculates a new date given the old date (in the Y-register) and the number of days to add or subtract (in the X-register).

1. Enter the known date (MM.DDYYYY or DD.MMYYYY).
2. Enter the number of days to add to or subtract from that date. Use a positive number for addition, a negative number for subtraction. Only the integer part of this number is used.
3. Execute [DATE+]. The stack drops, placing the resulting date in the X-register in the form MM.DDYYYY or DD.MMYYYY. (The previous contents of X are saved in the LAST X register.)

The Number of Days Between Dates ([DDAYS])

Given a date in the X-register and a date in the Y-register, [DDAYS] (delta days) finds the difference, in days, between those two dates. The date in Y is subtracted from the date in X.

1. Enter the first (earlier) date (MM.DDYYYY or DD.MMYYYY), then the second one. (If the first date entered is the later one, the result will be negative.)
2. Execute [DDAYS]. The stack drops, placing the number of days of difference into the X-register. (The second date is saved in the LAST X register.)

Day of the Week ([DOW])

The function [DOW] (day of week) converts the date in the X-register (MM.DDYYYY or DD.MMYYYY) into a value for its day of the week.

1. Enter the date.
2. Execute [DOW].
3. The value in the X-register is converted to a number from 0 (Sunday) to 6 (Saturday). (The date is saved in the LAST X register.)

If this function is executed manually, a message display appears with a three-letter abbreviation for the day of the week. To see the X-register (with the numeric day-of-week value), press [«].
Limits and Errors

Limits

All time and date functions except [ON] are programmable.

Clock Time: Minute-values (MM) and second-values (SS) are valid from 00 to 59 only. (Values for hundredths of a second (ss) run from 00 to 99, as usual.)

Dates: The date setting can be any date from January 1, 1900 (the default date) to December 31, 2199.

Calendar Functions: For calculations involving dates, any date from October 15, 1582 (the beginning of the Gregorian calendar) through September 10, 4320 is valid.

Display: Since the time is kept to hundredths of a second, a [FIX] 6 display format is necessary to see the full result of some functions.

Errors

DATA ERROR occurs if the input for a time function is not in the proper format or is not within the valid range. ([DATE], [ATIME], [ATIME24], [CORRECT], [DOW], [SETAF], [SETDATE], [SETIME], [SETSW], [T+X])

The error OUT OF RANGE occurs if the result of a time function would fall outside the valid range. ([T+X], [DATE+])
Section 16

Alarm Functions

Contents

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Alarm operations in the HP-41CX are quite versatile: depending on the parameters you supply, an alarm can be simply a personal reminder (an audible alarm with a message), or it can be a sophisticated control device to start the execution of a program at a certain time. In any case, an alarm will not interrupt the execution of a function in progress, but waits until that one function (including a function being executed by a program) is finished before going off.*

There are three distinct types of HP-41 alarms, but they are all set in a similar manner. Once set, alarms are stored in main memory along with programs and key assignments. Section 6, “Time Functions”, offers an introduction to alarms, with examples. These functions are summarized in the Function Table “Time Functions”.

A program executed by an alarm can affect the status of the flags or the various registers, as any other program can. This means you might want to make provisions in the called program to restore affected data you might need for other calculations.

**Types of Alarms: Message, Control (↑↑), Conditional (↑)**

The three different alarm types and their operation are outlined in the flowchart on page 249. Of these three alarms, one is used like an alarm clock (the message alarm) and two are used to execute programs (the control alarm and the conditional alarm, the latter being a “non-interrupting” control alarm).

**Message Alarms**

A message alarm is handy as an appointment reminder. This type of alarm produces a series of tones and flashes the message placed in the Alpha register when the alarm was set. The message can be up to 24 characters long. If the alarm is set with an empty Alpha register, a display of the current time and date flashes instead.

This kind of alarm goes off whenever its time arrives—whether the computer is on or off or executing a program. Remember, however, that no alarm interrupts the function currently in progress.

A message alarm needs to be acknowledged, otherwise it becomes past due (retained in memory as an unacknowledged alarm). (Past-due alarms are discussed fully in this section under “Past-Due Alarms” and in appendix B.) A message alarm replaces any previous message in the display, but otherwise has no effect on the computer’s operation or status, including the stack registers, the data storage registers, and the Alpha register.

---

* This includes the very “long” functions of indefinite duration: running catalogs, catalogs 4 to 6 at all times, the Text Editor ([ED]), and the stopwatch ([SW]). Alarms will not activate during these operations, but will wait and go off afterwards.
Control Alarms (††)

A control alarm executes the program or the programmable catalog-2 function specified by †† global label or †† catalog-2 function name in the Alpha register when the alarm is set.* It will execute a program starting at a global label, or, if no label or name follows the two up-arrows, at the current program line. When the set time arrives, the specified program or function is executed, whether the HP-41 is on or off, as soon as any currently operating function is done.

If a control alarm comes due while a program—including a program started by another control alarm—is running, that currently running program will be temporarily suspended while the program or catalog-2 function referenced by the interrupting, control alarm is executed.† The computer runs the called program as a subroutine of the interrupted one, using one subroutine level. (Subroutines and subroutine levels are explained in section 20, “Branching”.)

A control alarm does not get acknowledged; it simply activates and then clears or resets itself.

Conditional Alarms (†)

A conditional alarm, like a control alarm, will execute the program or programmable catalog-2 function specified in the Alpha register. However, it is a non-interrupting control alarm in that it will only take effect if the computer is off or the clock is displayed.

- If a program is running when a conditional alarm comes due, the alarm sounds a pair of tones and becomes past due.
- If the computer is on (no program running, no clock displayed) when the alarm comes due, the alarm becomes a message alarm, and does not execute the specified program or function. (The alarm becomes past due if it is not acknowledged, just like a message alarm.)

Therefore, whether a conditional alarm acts like a control alarm is dependent upon the computer being off. This is useful if you want a program to be automatically executed anytime except when you’re in the process of performing other calculations or programs on the HP-41. A conditional alarm that acts as a control alarm does not get acknowledged; a conditional alarm that becomes a message alarm needs acknowledgment.

---

* For a description of catalog-2 functions, refer to “Cataloguing the New Functions” in appendix I.
† Program interruption occurs following execution of whatever function is in the process of being executed when the alarm comes due. Also, the alarm will not interrupt until stack lift is enabled.
The alarm type is determined by the presence in the Alpha register of two, one, or no up-arrows (↑) when executed. This chart shows what each type does when it comes due.

Below are comments on possible outcomes:

An alarm that has come due is either cleared from memory, reset according to its repeat interval, or becomes past due.

A control alarm will always be cleared (or reset if it is a repeating alarm). It will never become past due.

A repeating alarm will be reset only if it causes program execution or is acknowledged. An alarm which is past due will not be reset.

If a program was interrupted for an alarm, the interrupted program now resumes.
Setting Alarms (XYZALM)

The single, programmable function (XYZALM) (X, Y, Z alarm) is used to set all three types of alarms. The function uses the data present in the X-, Y-, and Z-registers and the Alpha register. Time values can be as precise as tenths of a second.

1. Load the X-, Y-, Z- and Alpha registers with the required parameters (see below). The contents of the Alpha register will determine whether the alarm is of type message, control, or conditional.

2. Execute XYZALM.

An illegal input results in a DATA ERROR message, specifying the register with the faulty data (DATA ERROR X, etc.). A pair of tones sounds if the alarm is set to a past time, or if any bypassed past-due alarms are in memory.

Parameters for XYZALM

<table>
<thead>
<tr>
<th>T</th>
<th>Z</th>
<th>Y</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>Alpha</td>
<td>Alpha</td>
<td></td>
</tr>
<tr>
<td>message or empty</td>
<td>repeat or 0</td>
<td>date or 0</td>
<td>time</td>
</tr>
</tbody>
</table>

**Z-Register: Alarm Repeat Interval.** The interval after which the alarm will repeat itself. 1 second ≤ interval < 10,000 hours. A repeating alarm—an alarm whose repeat interval is not zero—resets its future activation time according to the repeat interval and the original activation time (as also explained under “Activation and Acknowledgment of Message Alarms”, page 253).

For no repetition, the Z-register must contain zero.

**Note:** A repeating control alarm of very short repeat interval (less than 10 seconds) can be difficult to cancel. See “Clearing Alarms from Memory,” page 258.

**Y-Register: Alarm Date.** The date for the alarm to activate. Valid dates are from January 1, 1900 through December 31, 2199.

For the current date, use zero.
X-Register: Alarm Time. The time of day for the alarm to go off ("activate"), from 0 to \( \pm 23.59599 \) (one-tenth second before midnight). (Remember negative numbers from 1 to 11 mean p.m. See the table "Time Settings" in section 15.)

Alpha Register: Message Alarm. An Alpha string of up to 24 characters; an empty Alpha register will produce a time/date display with the alarm.

Alpha Register: Control Alarm. \( \uparrow \downarrow \) global label or \( \uparrow \downarrow \) catalog-2 function name or just \( \uparrow \downarrow \).* The label or name specified can have up to six characters (even though labels in program memory can have up to seven characters)—any more characters are simply ignored (even though the listing in the alarm catalog shows all characters).†

You can have a control alarm execute a program starting other than at a global label by putting only the two up-arrows (\( \uparrow \downarrow \)) in the Alpha register. Then, the alarm will trigger program execution beginning at the current line in the current program at the time the alarm comes due. This type of specification could be used, for instance, to set a program to resume execution at the same point it suspended itself with an [OFF] instruction.

Alpha Register: Conditional Alarm. \( \uparrow \) global label or \( \uparrow \) catalog-2 function name. The label or name specified can have up to seven characters.

As with control alarms, you can set a conditional alarm to start program execution at the current line in the current program—rather than at a global label—by placing only the up-arrow (\( \uparrow \)) in the Alpha register, without a label or function name.

Examples

<table>
<thead>
<tr>
<th>T</th>
<th>empty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>0</td>
</tr>
<tr>
<td>Y</td>
<td>0</td>
</tr>
<tr>
<td>X</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Executing [XYZALM] will set a nonrepeating message alarm for 1:01 a.m. on the current date. The "message" will consist of the time and date.

Will set a nonrepeating message alarm for 10:00 p.m. on August 31, 1990. Will set a 15-minute repeating message alarm, starting at 11:00 a.m. on the current date.

* The \( \uparrow \) is on the Alpha keyboard above the N key (as shown on the backplate).
† To set a control alarm to execute a program or function that has a seven-character label or name, create a short "calling" program to execute the program or function you want, then set the alarm to execute the calling program.
Recalling Alarm Parameters to the Stack ([RCLALM])

The function [RCLALM] (recall alarm) recalls the parameters of a stored alarm to the stack and Alpha registers, from which a program can examine and alter these values. Or, you can save the recalled values in other registers or in mass storage. If you wanted to delete most of your alarms but save a few, you could use [RCLALM] to save particular alarm values before using [CLRALMS] to delete all alarms (“General Clearing Operations”, page 258).

[RCLALM] recalls to the X-, Y-, Z-, and Alpha registers the parameters of the alarm specified by the absolute value of the integer part of the number in the X-register. The number of the alarm corresponds to its chronological order as listed in the alarm catalog (see “The Alarm Catalog” page 255). Legitimate alarm numbers are from 1 to 253. A number greater than the number of existing alarms causes NO SUCH ALM (no such alarm).

The output format is the same as the input format for [XYZALM], except that the time is always returned in a 24-hour format as HH.MMSSss. The month/day format corresponds to the current setting. The contents of each register correspond to the register contents when [XYZALM] was executed for that alarm.

Executing [RCLALM] saves the alarm number (from the X-register) in the LAST X register, and lifts the previous contents of the Y-register into the T-register.
Activation and Acknowledgment of Message Alarms

Message alarms, *including conditional alarms that become message alarms*, follow a characteristic pattern of activation. They *must* be acknowledged (as described below) during the activation cycle, otherwise they become past due.

- Acknowledging a nonrepeating alarm shuts it off and clears it from memory.
- Acknowledging a repeating alarm shuts it off and resets its activation time to its next future occurrence. One or more multiples of the repeat interval are added to the original alarm time, not the time of acknowledgment.

Unacknowledged (past-due) message alarms are retained in memory: they are automatically reactivated when the computer is turned off, and set off warning tones whenever the computer is turned on. (Refer to “Past-Due Alarms.”)

Control alarms, as well as conditional alarms that become control alarms, are self-acknowledging—they simply execute the program or catalog-2 function indicated, and then automatically clear themselves from memory (or reset themselves if they are repeating alarms).

The Activation Cycle

When a message alarm comes due, the following procedure starts:

1. It sounds a pair of tones and displays the first 12 characters of its Alpha string or the time and date (if no Alpha string was given for the alarm). (A conditional message alarm displays `global label` or `function name`.)

   This phase lasts about 1 second, and the keyboard is inactive during this time.

2. The display begins flashing. *Starting now through step 3, you can acknowledge the alarm* (by pressing almost any key—refer to the following topic).

3. After the display flashes five times, the audible alarm starts again, sounding up to 16 pairs of tones.

4. If the alarm is not acknowledged by this time, it becomes past due. (Refer to “Past-Due Alarms.”) If it is a repeating alarm, it is not reset.
When a message alarm is acknowledged, the above activation cycle stops. For a message of more than 12 characters, the ensuing display depends on the method of acknowledgment (below).

### The Acknowledgment Procedure

While the display is flashing, and before the long series of tones is complete, you can acknowledge a message alarm by one of the following methods. Use these same procedures to acknowledge past-due alarms when they are automatically reactivated.

#### Results of Alarm Acknowledgment

<table>
<thead>
<tr>
<th>Key Pressed</th>
<th>STO</th>
<th>Any Other Key</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>+ or ON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halts alarm.</td>
<td></td>
<td>Halts alarm.</td>
</tr>
<tr>
<td>Immediately clears the alarm display.</td>
<td></td>
<td>Display persists for 3 seconds after release of key.*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing key again prolongs the display another 3 seconds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retains the alarm as past-due.</td>
</tr>
<tr>
<td><strong>STO</strong></td>
<td></td>
<td>Halts alarm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Display persists for 3 seconds after release of key.*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing key again prolongs the display another 3 seconds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clears the alarm.†</td>
</tr>
<tr>
<td><strong>Any Other Key</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* If there are more than 12 characters, the first 12 are shown while the key is held down, then the remaining characters are shown for 3 seconds.
† If it is a repeating alarm, it is reset and not cleared.
Be sure to wait until the alarm message has cleared before executing another function. Otherwise, you can delay the clearing of the alarm message.

**Repeating Alarms.** The new setting for a repeating alarm is determined by adding the repeat interval to the alarm time, not to the acknowledgment time.

If you use [STO] to acknowledge a repeating alarm, the alarm will not be reset—just retained as a past-due alarm. (The repeat interval is still maintained in the alarm catalog.) If a past-due repeating alarm is reset, it will not reset to a past time.

To clear from memory (delete) a repeating message alarm during its activation cycle, press [C].

**Delay of Activation.** If an alarm comes due while an earlier message alarm is going off, the second alarm is delayed until the first one has been acknowledged or completes its activation cycle.

**Simultaneous Alarms**

If more than one alarm is set to exactly the same time, each alarm will activate in the order in which it was set. However, a control alarm will interrupt a program triggered by a control or conditional alarm. A message alarm will temporarily suspend the program executed by a previous control alarm (but, as noted in the previous paragraph, it waits for any other alarm activation cycles to finish).

If more than one simultaneous or overlapping alarm is a control alarm, successive alarms will interrupt the programs triggered by preceding alarms and execute their specified programs before the preceding programs can run. A conditional alarm will neither interrupt a program nor wait for completion; it simply sounds a pair of tones and becomes past due. Simultaneous alarms go off in the same sequence as past-due alarms, as explained in appendix B.

**The Alarm Catalog ([ALMCAT](#), [CATALOG](#) 5)**

The alarm catalog and the Alarm Catalog keyboard (the keyboard redefined for specific alarm catalog operations) are activated by either executing [ALMCAT] (alarm catalog) or pressing [CATALOG] 5. Only [ALMCAT] is programmable. For manual execution, [CATALOG] 5 is faster to execute.

The features of the alarm catalog are:

- It provides a list of all alarms currently kept by the HP-41 in memory (including past-due alarms).
- It lists the alarms in order of activation time, from earliest to latest. (The position of a repeating alarm is adjusted each time it is reset.)
- Each alarm listing shows first the time and date of the alarm, then any Alpha string (a message or `t`/`t` label call).
- When it finishes listing the last alarm, it exits the alarm catalog and returns to a display of the X-register.
The Active Keys on the Alarm Catalog Keyboard

2:00 P.M. 08/27

HEWLETT PACKARD 41CX
• Its execution enables stack lift.

• Like other catalogs, it can be stopped and restarted with \[R/S].* Once stopped, you can step through the catalog entries using \[SST\] or \[BST\] (the display just blinks when you hit the end/beginning of the catalog with \[SST]/\[BST\]).

• While the alarm catalog is stopped, the keyboard is redefined as the Alarm Catalog keyboard.

The following keys are defined to perform the following operations on the Alarm Catalog keyboard while the alarm catalog listing is interrupted. These keys do not represent characters from the Alpha keyboard, so do not use \[ALPHA\]. Notice that the letter keys relate to the meaning of their Alarm Catalog function; for example, \[T\] for time.

<table>
<thead>
<tr>
<th>Key(s)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>[T]</td>
<td>Returns the activation time of the currently displayed alarm.</td>
</tr>
<tr>
<td>[T]</td>
<td>Returns the current time.</td>
</tr>
<tr>
<td>[D]</td>
<td>Returns the activation date of the currently displayed alarm.</td>
</tr>
<tr>
<td>[R]</td>
<td>Returns the repeat interval of the currently displayed alarm.</td>
</tr>
<tr>
<td>[R]</td>
<td>Resets the currently displayed alarm to its next future occurrence as determined by its repeat interval.</td>
</tr>
<tr>
<td>[M]</td>
<td>Displays the Alpha string (message or (\pm) label call), if any, of the currently displayed alarm.</td>
</tr>
<tr>
<td>[C]</td>
<td>Clears (deletes) the currently displayed alarm from memory.</td>
</tr>
<tr>
<td>[\rightarrow]</td>
<td>Exits the alarm catalog and Alarm Catalog keyboard and returns to a display of the X-register.</td>
</tr>
<tr>
<td>[ON]</td>
<td>Turns the computer off; cancels the alarm catalog.</td>
</tr>
</tbody>
</table>

If the computer is halted in the alarm catalog, and no key is pressed for about 2 minutes, the computer automatically exits the alarm catalog.

Although \[ALMCAT\] is programmable, the individual Alarm Catalog keyboard operations are not. If \[ALMCAT\] is executed from a program, that program resumes after the alarm catalog has been exited.

* General aspects of operation common to all catalogs are given in section 9. Pressing any other key besides \[R/S\] or \[ON\] during the running catalog will speed up the listing.
Clearing Alarms From Memory

Control alarms (including conditional alarms that become control alarms) clear themselves automatically after going off. Message alarms (including conditional alarms that become message alarms) are cleared by acknowledging them. In addition, there are general clearing operations for clearing one or more future and/or past-due alarm. Finally, agility is needed to cancel a repeating control alarm that has a very short repeat interval.

Clearing a Message Alarm as It Goes Off

If a message alarm is going off, acknowledging it will halt it and clear it from memory, unless it is a repeating alarm. In the case of a repeating message alarm in the process of going off, \( \square \) \( \text{C} \) will halt it and clear it from memory.

General Clearing Operations

There are various ways to delete any future and past-due alarms (that is, alarms that are not currently going off), as well as repeating control alarms.

- The easiest way to delete any one such alarm is with \( \square \) \( \text{C} \) on the Alarm Catalog keyboard (catalog 5; see the previous topic), but this method is not programmable.

The other alarm-clearing functions—\([\text{CLRALMS}], [\text{CLALMA}], \text{and } [\text{CLALMX}]\)—are programmable. The latter two are especially useful if you want to have a program set a repeating alarm and then clear it later.

Clearing All Alarms (\([\text{CLRALMS}]\)). \([\text{CLRALMS}]\) (clear alarms) deletes all alarms from memory. It is sometimes used in conjunction with \([\text{RCLALM}]\) (page 252) to delete all alarms, thereby recovering alarm memory space, after having individually recalled each alarm and stored its parameters.

Clearing an Alarm by Its Alpha String (\([\text{CLALMA}]\)). \([\text{CLALMA}]\) (clear alarm by Alpha) deletes the first alarm whose Alpha string matches the string in the Alpha register.

If there are no alarms with duplicate Alpha strings (that is, messages or \( \# \) \( \# \) label calls), then \([\text{CLALMA}]\) is the most foolproof way to clear an alarm. If more than one alarm has the same Alpha string, then only the first of them (as they are listed in the alarm catalog) will be cleared.

If the Alpha register is empty when \([\text{CLALMA}]\) is executed, then \([\text{CLALMA}]\) deletes the first alarm that has no message.

\text{NO SUCH ALM} \ results if there is no alarm with the given Alpha string.
Clearing an Alarm by Its Ordinal Number ([CLALMX]). [CLALMX] (clear alarm by X) deletes the alarm specified by the number in the X-register. The number refers to the ordinal position of the alarm in the alarm catalog.

Duplicate alarm Alpha strings pose no problem. However, you should keep in mind that an alarm’s number can change (increase or decrease) anytime another alarm is set, reset, goes off, or is cleared. [CLALMX] takes the absolute value of the integer part of the number in the X-register to be the alarm number. If, for example, the contents of X are 5.1 when [CLALMX] is executed, then the fifth alarm in the catalog would be cleared.

If $x = 0$ or $x > 999$, then DATA ERROR results when [CLALMX] is executed. NO SUCH ALM results if there is no alarm of the given number.

Clearing Repeating Control Alarms

Usually, a repeating control alarm can be cleared using the above methods. However, if a control alarm has a repeat interval shorter than about 10 seconds (1 second is the minimum), it can be difficult to delete it from memory because of the time it takes to do so. That is, the alarm might be able to repeat and reset itself before you could cancel it, although [CATALOG] 5 can be executed quickly.

There are two other ways around this time limitation:

- Assign [ALMCAT] to a key on the User keyboard, so that it can be executed with one keystroke. The alarm catalog condition is all part of one function, so no alarm will interrupt it. You can then use [C] to cancel the alarm in question.

- Use the “two-key rollover” technique to execute [CATALOG] 5 or another clearing function. By depressing the next key before releasing the previous key, the HP-41 keyboard is kept operating without a break. The alarm will not go off because it keeps waiting for the break between functions or keys. Using two-key rollover, there is always a function or key execution in progress. (The alarm keeps waiting for the end of a function, so it does not become past due.)

In a program, use an alarm-clearing function ([CLALMA] or [CLALMX]) to clear any repeating control alarm.

Past-Due Alarms

A past-due alarm is any alarm in memory having an alarm time that is earlier than the current time. The following information provides a basic description of past-due alarm operation. When more than one past-due alarm accumulates, there are rules governing the order of their automatic activation. These are described in appendix B, “More About Past-Due Alarms.”
Creating Past-Due Alarms

A past-due alarm normally results if:

- A message alarm activates (goes off) without being acknowledged, or is acknowledged using [STO].
- A conditional alarm (†) activates while the HP-41 is running a program.
- A conditional alarm (†) activates as a message alarm (because the HP-41 is not off), which is then not acknowledged.

Note that a control alarm cannot normally become a past-due alarm since it always activates when its time comes due, then automatically clears or resets itself. However, a control alarm can become past due if its time is bypassed.

Bypassed Past-Due Alarms

A bypassed (also called unactivated) past-due alarm results if:

- Any future alarm is bypassed due to a change in the time.
- Any alarm is initially set to a past time.

This type of past-due alarm should be rare. It is the only type of past-due alarm for control alarms.

Automatic Reminder of Past-Due Alarms

Whenever you turn the HP-41 on, a pair of tones will sound if any past-due alarms exist. This is strictly a reminder; the alarms are not activated—so they have no effect—and they cannot be acknowledged.

The automatic reminder also sounds if you change the time or execute [XYZALM] when any bypassed past-due alarms exist or are created.

Activation of Past-Due Alarms

Whenever you try to turn the HP-41 off or use [ON] (not [CLOCK]), the HP-41 automatically activates past-due alarms.*

Automatic activation starts with the earliest alarm:

- Past-due message alarms go off.
- Past-due control alarms execute their designated programs.†

* After executing [CLOCK], subsequently pressing [ON] will not activate any remaining past-due alarms.
† The automatic activation of a control or conditional alarm momentarily turns off the HP-41 first. For this reason, no other past-due alarms—except bypassed ones—will activate subsequently, until you press [ON] or [CLOCK] again. See appendix B.
A past-due conditional alarm activates automatically as a control alarm (if there are no preceding past-due control alarms).* In this way, if the end of a program automatically turns off the HP-41 (using the OFF instruction), then any conditional alarm that came due while the program was running will automatically be executed when the program shuts off the computer.

Refer to appendix B for information about the automatic activation of multiple past-due alarms.

**Automatic Clearing/Reset of Automatically Activated Past-Due Alarms.** When a past-due message alarm is automatically activated, acknowledging it will clear it from memory—or reset it if it has a repeat interval. ([ON] will halt but not clear/reset an activating past-due alarm. See “Halting the Activation of Past-Due Alarms,” below.)

A past-due control or conditional alarm that is automatically activated will also automatically clear (or reset, if it’s a repeating alarm) itself. A repeating alarm is reset to the future using multiples of the repeat interval added to the original alarm time.

After acknowledgment of past-due message alarms, the HP-41 will complete the function that triggered the automatic activation; that is, it will shut off or display the clock.

**Halting the Automatic Activation of Past-Due Alarms.** If you press [ON] during the automatic activation cycle of a past-due message alarm, this aborts the entire series and cycle of past-due alarm activation. The alarm is not acknowledged. The unacknowledged and unactivated past-due alarms remain past due.† This provides a means of stopping what could be a long activation series so you can regain control of the computer but save the alarms. (This is also handy if you inadvertently set the time ahead and your future alarms become past due.)

If you press [ON] during the activation of a past-due control or conditional alarm, this will shut the HP-41 off, stopping whatever program that a control or conditional alarm had started. (This will trigger the activation of any remaining past-due alarms.) The interrupted control/conditional alarm will be cleared or reset, since it was activated.

**Activating a Past-Due Conditional Alarm ([ALMNOW]).** You can activate a single past-due conditional (or control) alarm—the earliest (oldest) one in memory—by executing [ALMNOW] (alarm now).

While a program is running, it is possible for a conditional (↑) alarm to come due and therefore become past-due. You can check for and activate one such alarm—or have the program do it—by executing [ALMNOW], provided there are no other past-due conditional or control alarms in memory. If executed from a program, [ALMNOW] operates as a subroutine.

---

* The automatic activation of a control or conditional alarm momentarily turns off the HP-41 first. For this reason, no other past-due alarms—except bypassed ones—will activate subsequently, until you press [ON] or [ON] again. See appendix B.

† Using [ON] to halt an automatic activation cycle will also cancel the activation of any other alarm that happened to come due (for the first time) during the automatic, past-due activation cycle.
Application Programs for Setting Alarms

To use the following programs, first key them from the listings into program memory. There are barcode versions of these programs in appendix J, “Bar Code for Programs.” If you have an HP 82153A Wand, you can record these programs quickly from the bar code.

Using a Program to Set an Alarm (SETALM)

If you have trouble remembering exactly how to set a particular alarm, then the following program, SETALM, will help you. SETALM provides an easy way to set any kind of alarm, prompting you for the necessary input and placing that information into the correct register.

Input (when prompted): The alarm time, a message (for a message, control, or conditional alarm), the alarm date, and the alarm repeat interval, if any.

Result: A message, control, or conditional alarm will be set.

User Instructions:

1. Execute SETALM ([SETALM]).
2. In response to the prompt TIME?, enter the alarm time in HH.MMSS format. (If no response, the program ends.)
3. In response to the display MESSAGE?, enter a message (for a message alarm), or [+] global label (for a control alarm), or global label (for a conditional alarm). If you want a message alarm to display only the time and date, just press [R/S].
4. In response to the display DATE?, enter the date in MM.DDYYYY or DD.MMYYYY format. If you want the current date, just press [R/S].
5. In response to the display RESET?, enter the repeat interval in HHHH.MMSS format. If you do not want a repeating alarm, just press [R/S].

This program will alter any information you had in the stack and the Alpha register before running this program, and it clears flag 22.

Program Listing

```
01 LBL "SETALM"
02 CF 22  Clears flag 22, the numeric data input flag.
03 "TIME?"  Stops and asks for the alarm time. If you do not enter a time (flag 22 tests clear), then the program ends. (After entering the time, restart the program with [R/S].)
04 PROMPT
05 FC?C 22
06 RTN
```
Stores the message `DATE?` in the T-register and the message `RESET?` in the Y-register.*

Displays the message `MESSAGE?` from the Alpha register and stops for Alpha input. (Clears the Alpha register—`MESSAGE?` still displayed—activates the Alpha keyboard, and stops.) If you enter no message, the alarm will display the time and date since line 13 clears the Alpha register.

Displays `DATE?` and stops for input.*

If you do not enter a date (no numeric input; flag 22 tests clear), 0 is used (current date).

Displays `RESET?` (lifted from Y-register) and stops for repeat interval.*

If no repeat interval entered, 0 is used.

Brings the time (which has been lifted into the Z-register) back to the X-register and sets the alarm.*

### Setting an Alarm Relative to the Current Time (ALMREL)

The following program example illustrates several programming techniques—including extensive stack manipulation—to create an all-purpose program (ALMREL) to set an alarm relative to the current time. This is useful when you want to set an alarm for a certain period of time from the present, rather than for a particular clock time.

**Input (when prompted):**

1. The time “offset” (the number of hours, minutes, seconds from the present) as `HHHH.MMSS`. Note this can represent more than one day.
2. Alpha string for alarm (message or `tt/t` label call).

**Result:** A message, control, or conditional alarm.

---

* The functions `[ASTO]`, `[AVIEW]`, and `[X<>]` are parameter functions, and display two input cues when executed: for example, `X<> __`. Press `[Z]` to specify the Z-register as a parameter.
User Instructions:

1. Execute ALMREL ([ALMREL]).
2. In response to the display + HH.MMSS?, enter the time offset HHHH.MMSS, then press [R/S].
3. In response to the display MESSAGE?, enter alarm Alpha string (or nothing), then press [R/S].

Program ALMREL begins to calculate the alarm time when you press [R/S] after MESSAGE?. The time offset can be as short as 0000.0003 (3 seconds) or as long as 9999.595999. The program checks for and rejects non-numeric or negative input for HH.MMSS. (Flag 22 is set when numeric data is entered.)

This program will alter any information you had in the stack and the Alpha register before running this program, and it clears flag 22.

Program Listing

```
01 LBL "ALMREL"
02 CF 22
03 "+ HH.MMSS?" STOP
04 PROMPT
05 FC?C 22
06 RTN
07 X<0? STOP
08 RTN
09 "MESSAGE?" STOP
10 AVIEW
11 CLA
12 AON
13 STOP
14 AOFF
15 TIME
16 HMS +
17 ENTER†
18 ENTER†
19 24
20 /
21 INT
22 DATE
23 X<>Y
24 DATE +
```

Clears flag 22 so it can be tested later.

Stops and prompts for time offset. (Restart the program with [R/S]).

Tests for non-numeric input.
If non-numeric (flag 22 is clear), start over!

Tests for negative input.
If negative, start over!

Stops after asking for input for the alarm’s Alpha string. The program clears the Alpha register and activates the Alpha keyboard (AON), then deactivates it (AOFF) when you restart the program. If you want a message, just type it in and press [R/S]. If not, just press [R/S].

Recalls current time.
Adds current time to offset time.

Puts sum (the new time, in hours) in X-, Y-, and Z-registers.

Finds the number of whole days away the new time is (the whole days of time offset).

Recalls the current date.
Days of offset in X; current date in Y.
Finds the new date for the alarm: the sum of the current date and the number of offset days.
Recalls the number of offset days and converts that figure to hours. That figure is then subtracted from the total number of offset hours in Z, yielding the number of hours of offset beyond whole days. This value represents the time for the alarm.

Puts zero in the X-register and copies zero into the T-register. After the roll-down, this will represent the repeat interval (none) in Z. The new time (from Z) moves into Y; the new date (from Y) moves into X.

Date into Y; time into X. The stack is now set up to set the alarm.
The stopwatch function, \([\text{SW}]\) (or \([\text{SWPT}]\)), encompasses an entire mode of operation. It turns the HP-41 into a stopwatch and redefines the keyboard for stopwatch operations. The internal timer used for the stopwatch is separate from the clock. The stopwatch can run even when it’s not displayed, and even when the HP-41 is off. It can continue to run unimpeded while you execute other functions or programs.

An introduction to stopwatch operation, with examples, is presented in section 6. These functions are also summarized in the Function Table “Time Functions.”

**The Stopwatch Keyboard (\([\text{SW}]\))**

The HP-41CX comes with a keyboard overlay, which marks all the active functions on the Stopwatch keyboard. A diagram of the keyboard is also included below and in the Quick Reference Guide. Any key not identified on the overlay and diagram is inactive as long as the Stopwatch keyboard is in effect.
• Executing \[ \text{SW} \] or \[ \text{SWPT} \] activates the stopwatch display and redefines the keyboard. \[ \text{SW} \] resets the register pointers to zero and sets the display to show regular splits; \[ \text{SWPT} \] sets the pointers as you specify them (page 274).

• Pressing \[ \text{EXIT} \] deactivates the Stopwatch keyboard, but does not automatically stop a running stopwatch. The display returns to the X-register. This operation is not programmable.

• \[ \text{ON} \] will turn the HP-41 off (and deactivate the Stopwatch keyboard), even if the stopwatch is still running. It will not stop the stopwatch.

Although \[ \text{SW} \] and \[ \text{SWPT} \] are programmable, none of the operations on the Stopwatch keyboard are programmable. There are other programmable stopwatch functions discussed later in this section.

**The Stopwatch Display**

While the Stopwatch keyboard is active, the display has the form:

```
HH:MM:SS.ss Rnn
```

- Elapsed Time (to hundredths of a second)
- Register Address (for storage of next split)

*Note:* The stopwatch display consumes as much power as a running program. Refer to “Power Consumption” in appendix G. *The HP-41CX will not automatically turn off (time out) as long as the Stopwatch keyboard is active.*

The elapsed time shown in the display does not clear whenever you activate and deactivate the Stopwatch keyboard. (Just as deactivating the Stopwatch keyboard does not stop a running time, either.) However, activating the Stopwatch keyboard with \[ \text{SW} \] does reset the pointer display to \(+\text{R00}\).

Pressing \[ \text{CLEAR} \] resets the stopped stopwatch to 00:00:00.00. When the stopwatch time passes 99:59:59.99, it automatically starts again from zero. There is no stopwatch function to clear stored times (splits). A time stored in a register will *replace* any previously stored value there. To put zero in a register, store a zero time in it, or, outside of the stopwatch, use \[ \text{CLRGX} \] to clear more than one register.

Pressing any undefined Stopwatch key will freeze the display while the key is depressed without halting the stopwatch itself. This will show you the elapsed time to tenths of a second. Only when the stopwatch is halted does it show the full eight digits.
Stopwatch Keyboard Operations

The following operations comprise the Stopwatch keyboard, which is activated by the execution of [SW] or [SWPT]. In addition, executing [SW] resets both storage (\(^h\)) and recall (\(=\)) pointers to zero, and makes Regular Split Storage mode the default mode of operation (\(^hR00\)).

### The Stopwatch Keyboard

<table>
<thead>
<tr>
<th>Key</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>R/S</td>
<td><em>Run/stop.</em> Starts and stops the stopwatch; does not reset the stopwatch or the register pointers. (Also cancels Recall mode.)</td>
</tr>
<tr>
<td>CLEAR</td>
<td>Resets a halted stopwatch to 00:00:00.00. Does not affect the register pointer. (If Recall mode is set, [CLEAR] cancels it and does not reset the stopwatch.)</td>
</tr>
<tr>
<td>EXIT</td>
<td>Deactivates the Stopwatch keyboard. <em>This will not stop a running stopwatch.</em></td>
</tr>
<tr>
<td>SPLIT</td>
<td>Stores the current stopwatch time in the indicated data storage register ((^hRnn)), and increments the pointer. (Also cancels Recall mode.)</td>
</tr>
<tr>
<td>RCL</td>
<td><em>Recall.</em> Toggles between Recall mode and Storage mode. Recall mode displays the split stored in the indicated register ((=Rnn)). (Recall mode is also cancelled by [R/S], [SPLIT], and [CLEAR].)</td>
</tr>
<tr>
<td>ΔSPLIT</td>
<td><em>Delta split.</em> Toggles between Delta Split mode (D) and Regular Split mode (R). Delta Split mode displays the difference between the most recent split and the split in the preceding register. This display changes with each execution of [SPLIT]. Can also be used in Recall mode. Delta Split mode is also cancelled when Stopwatch keyboard is deactivated.</td>
</tr>
<tr>
<td>Digit Keys*</td>
<td>Used only to specify storage register addresses (nn, or nnn with [Rnnn]). Keying in a number moves the register pointer to that address. Be sure to specify both or all three digits, as required.</td>
</tr>
<tr>
<td>SST *</td>
<td><em>Single step.</em> Moves the register pointer to the next register without taking a split.</td>
</tr>
<tr>
<td>BST *</td>
<td><em>Back step.</em> Moves the register pointer to the previous register without taking a split.</td>
</tr>
<tr>
<td>REG#</td>
<td><em>Register number.</em> Suppresses/restores the display of the register pointer. Toggle switch.</td>
</tr>
<tr>
<td>Rnnn</td>
<td>Changes the register-pointer display from two digits to three digits (and back) in order to display (R_{(100)}) to (R_{(319)}). Toggle switch.</td>
</tr>
<tr>
<td>Any Other Key</td>
<td>Pressing any other key freezes the last stopwatch time in the display for as long as the key is depressed. The stopwatch itself continues to run.</td>
</tr>
</tbody>
</table>

* These functions will change the register pointer whether the stopwatch is running or halted.
The Active Keys on the Stopwatch Keyboard
The Register Pointers

The register pointers, represented in the display as \( R_{nn} \) and \( D_{nn} \), give the address, \( nn \), of the current data storage register.

The \( R \) means regular split; the \( D \) means delta split (the difference between two splits). The \( \downarrow \) means splits will be stored; the \( \equiv \) means splits (or delta splits) will be displayed.

The Current Register. The register pointers always reset to 00 following the execution of \( [SW] \) (even though the time does not reset to zero). The current register, \( nn \), has the following functions:

- With \( \downarrow R_{nn} \) (storing regular splits), \( nn \) represents the register into which the next split taken ([SPLIT]) will be stored.
- With \( \downarrow D_{nn} \) (storing delta splits), \( nn \) represents the storage register for the next split and it represents the second of two successive registers whose difference will be found and displayed (using [SPLIT]).
- With \( \equiv R_{nn} \) (recalling regular splits), \( nn \) represents the register whose contents are currently being displayed. (The display is static, though the stopwatch itself might be running.)
- With \( \equiv D_{nn} \) (recalling delta splits), \( nn \) represents the second of two successive registers whose difference is being displayed. (The display is static, though the stopwatch might be running.)

Changing the Register Pointers. The \( \downarrow \) (storage) register pointer advances automatically every time you take a split. You can also change it manually, using \([SST],[BST]\), and the digit keys as shown in “The Stopwatch Keyboard”. The \( \equiv \) (recall) register pointer is changed manually only.

Note: The register pointers for split Storage (\( \downarrow \)) and Recall modes (\( \equiv \)) are maintained separately, while the Regular Split (\( R \)) and the Delta Split modes (\( D \)) are different display modes for the same register pointer. Both the \( \downarrow \) and the \( \equiv \) register pointers are reset to 00 by \( [SW] \).

Three-Digit Display of the Register Pointer (\( R_{nnn} \)). The register-pointer display will automatically switch from two digits to three digits when it advances from \( R_{99} \) to \( R_{100} \). To switch the display manually between the two- and three-digit display, use \( R_{nnn} \). (If you switch back to a two-digit pointer display when the current register has three digits, the leftmost register digit will be dropped.) A three-digit pointer display suppresses the rightmost digit in the display of the stopwatch time, though it is retained internally.

Suppression of the Register-Pointer Display. Pressing \( [REG\#] \) suppresses (and restores) the display of the register pointer, though the register pointer is maintained internally. This allows you to view the obscured rightmost time digit in the cases when the register pointer has three digits or the stopwatch time is negative.
General Stopwatch Operation With Splits

Splits (stopwatch timings) taken on the HP-41 are automatically stored in sequential *data storage registers*, the same registers you use for regular data storage. Sequential splits are stored as *accumulated times* unless you reset the stopwatch to zero ([CLEAR]). You can store as many splits as you have storage registers available. Any other data already in the current register is replaced when a split is taken, just as any stored splits can be accessed and replaced when you use those same registers without the Stopwatch keyboard.

Splits are displayed as **HH:MM:SS.s** or **HH:MM:SS.ss**, but they are stored as **HH.MMSSss**. Therefore, if you have stored a split in a register, then exit the Stopwatch keyboard, the contents of that register will be **HH.MMSSss**. Conversely, if a register contains a value that is not a split, and those contents are recalled with the Stopwatch keyboard, the HP-41 will attempt to display that value in the form **HH:MM:SS.ss**. If it can’t—because **HH** > 99—then ERROR =Rnn results. (Values of **MM** and **SS** greater than 59 do not cause errors.) To clear ERROR =Rnn, move the pointer to a register with a valid split. Pressing [CLEAR] will cancel Recall mode.

There is a diagram of the modes of stopwatch operation on page 76 in section 6.

The Display During Split-Taking

While the [SPLIT] key is held down during Regular Split mode (Rnn), the stopwatch display shows the split that was just taken and the register it was stored into. (The stopwatch itself does not stop.) When you release [SPLIT], the running display resumes and the register pointer advances.

If Delta Split mode is active (Dnn), [SPLIT] operation is the same as usual. However, the display while [SPLIT] is being held down is different: it shows the difference between the split just taken and the split in the previous storage register. The register shown is the location of the split just taken. (Refer also to “Viewing Delta Splits,” below.)

Register-Pointer Limit

If the current register-pointer (Rnn or Dnn) is moved—either automatically or manually (but not with [BST])—to the last available data storage register or beyond, the HP-41 beeps. (This is true whether the stopwatch is running or not.)

Furthermore, if the stopwatch is in Recall mode (escaped) when the pointer is moved to a nonexistent register, this will cancel the Stopwatch keyboard and display NONEXISTENT. This also occurs during Storage mode (STO) if the execution of [SPLIT] attempts to store a split in a nonexistent storage register.
Recalling Splits ([RCL])

Pressing [RCL] toggles the stopwatch and its display between Recall mode (\( \downarrow \)) and Storage mode (\( \uparrow \)). In Recall mode, the display shows the contents stored in the indicated register. A running stopwatch will continue to run during Recall mode. To view the splits stored in other registers, just change the register pointer (using [SST], [BST], or the digit keys).

When you press [RCL] again, or press [SPLIT], [R/S], or [CLEAR], the display returns to the regular stopwatch. Remember that the register pointers for split storage and split recall are maintained separately, so as the display transfers between Storage (\( \uparrow \)) and Recall (\( \downarrow \)) modes, the respective pointer address (nn or nnn) will take up where you last left it. (Refer to “The Register Pointers.”) This allows you, for instance, to take several splits, switch to Recall mode (with the stopwatch running or stopped) to review the splits you just stored, then switch back to regular Storage mode to resume storing splits in the register that follows the last one you used for split storage.

Viewing Delta Splits ([ASPLIT])

Pressing [ASPLIT] activates Delta Split mode: the stopwatch display shows delta splits (D) rather than regular splits (R).

- A *delta split* is the difference between the current split (the one in Dnn) and the split in the immediately preceding register.
- If the register pointer is D00, then the delta-split display just shows the current split.

Delta Split mode allows you to display the difference between two splits without interrupting a running stopwatch. It can be used during split Storage (\( \uparrow \)Dnn) or split Recall (\( \downarrow \)Dnn) modes.

Using Delta Split mode with either [SPLIT] or [RCL] allows you to compare quickly the difference between two related time measurements. Using delta splits also allows you to take timings that do not overlap at all but are too close together to have time to reset the stopwatch. For instance, you could store both the start- and the stop-times of a series of closely spaced, non-overlapping events, so that you would end up with a series of paired start- and stop-times. By recalling the split difference, you’d see the actual time of the event.

Storage Versus Recall. Delta splits are neither stored nor recalled, they are calculated. Pressing [SPLIT] takes regular splits even when Delta Split mode is active (\( \uparrow \)Dnn), but the frozen display (while the [SPLIT] key is down) *shows* delta splits. “Recalling” splits in Delta Split mode (\( \downarrow \)Dnn) does not really recall delta splits, it displays delta splits calculated from stored splits.

Therefore, Delta Split mode does not alter the operation of either [SPLIT] or [RCL] (Recall mode); it just means that any static display you see represents a delta split and not a regular split. (The running stopwatch display is not affected.)
Negative Delta Splits and Errors. If the second of two adjacent splits is not larger than the first, then the display depends on whether splits are being stored or recalled: if splits are being stored (-Dnn), then the delta-split display shows just the contents of the current register; if delta splits are being recalled (-Dnn), then ERROR -Dnn results.

Note: To clear ERROR -Dnn or ERROR -Rnn, change the register pointer address. (Pressing CLEAR will cancel Recall mode without clearing the error condition.)

If, during Recall mode in Delta Split mode (-Dnn), one of the two registers involved contains a value that does not fit the form HH.MMSSss (see page 271), then ERROR -Dnn results.

Programmable Stopwatch Functions

There are six programmable stopwatch functions: the two that activate the Stopwatch keyboard ([SW] and [SWPT]) and four others ([RUNSW], [STOPSW], [SETSW], and [RCLSW]) to manipulate the stopwatch when the stopwatch keyboard is not active. You can use these latter four functions to set up the stopwatch or run an internal timer during the execution of a program. (You cannot execute these functions from the Stopwatch keyboard.)

Any stopwatch times that you put into or recall into the X-register should be of the form ±HH.MMSShh.

Starting and Stopping the Stopwatch ([RUNSW], [STOPSW])

Run Stopwatch. [RUNSW] starts the stopwatch running.

Stop Stopwatch. [STOPSW] stops the stopwatch.

Setting and Recalling the Current Stopwatch Time ([SETSW], [RCLSW])

Set Stopwatch. [SETSW] sets the stopwatch to the time (+HH.MMSSss) specified in the X-register.

Any specified time outside the range −99.595999 to +99.595999 is invalid and will cause a DATA ERROR. Any digits beyond the ss places are just ignored.

[SETSW] will not stop a running stopwatch, but it will reset its time as specified.

Recall Stopwatch. [RCLSW] recalls the current stopwatch time to the X-register in the form HH.MMSSss, lifting the stack (unless stack lift is disabled).
Setting Up the Stopwatch and the Stopwatch Pointers ([SWP])

The function **SWP** *(stopwatch and pointers)* acts like **SW**, but in addition sets the stopwatch pointers. This allows a program to set the pointers to avoid taking splits that will write over other data stored by the program.

Using **SWP**:
- Upon activating the Stopwatch keyboard, the storage register-pointer *(Rnn, Dnn)* and the recall register-pointer *(=Rnn, =Dnn)* are set as specified by the sss.rrr value in the X-register.
- Upon deactivating the Stopwatch keyboard, the current pointer values are returned to the X-register in the form sss.rrr. The input sss.rrr value is saved in the LAST X register.

The output value of sss can be used to figure how many splits were taken, *assuming splits were taken in sequential registers* and the split-storage register pointer was not manually changed.

**Combined Pointer Value in X-Register**

\[
\pm \text{sss.rrr}
\]

<table>
<thead>
<tr>
<th>Pointer Address</th>
<th>Pointer Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>for Split Storage</td>
<td>for Split Recall</td>
</tr>
<tr>
<td>(1, 2, or 3 digits)</td>
<td>(must be 3 digits)</td>
</tr>
</tbody>
</table>

A *positive or zero value* specified for sss.rrr sets Regular Split mode *(Rnn)*; a *negative value* for sss.rrr sets the stopwatch to Delta Split mode *(Dnn)*.

(To set the stopwatch to Delta Split mode and also set both pointers to zero, specify a number between \(-0.001\) and zero. If, when the Stopwatch keyboard is deactivated, both pointers are set to zero and Delta Split mode is in effect, the value \(-0.0000001\) will be returned to the X-register.)

In the unlikely case that upon deactivating the Stopwatch keyboard one pointer is undefined, the pointer value *(sss or rrr)* returned to the X-register will be zero. (This can happen if the Stopwatch keyboard is deactivated while the register pointer address is incomplete.)

The Stopwatch as a Countdown Timer

If the stopwatch is set to a *negative time* *(use SETSW)* and then runs, it will set off a timer alarm when it reaches 00:00:00.00.

- If the Stopwatch keyboard and display are not active, the timer alarm will sound like a message alarm and display **TIMER ALARM**. You can stop the alarm by pressing any key, but acknowledgment is not necessary as this alarm is not stored in memory and cannot become past due.
- If the Stopwatch keyboard *is* active, then the timer alarm will merely sound two tones (the stopwatch display is not interrupted).
In neither case will the running stopwatch automatically stop; the stopwatch starts counting up after passing through zero. To stop the stopwatch, use $\text{STOPSW}$ (not from the Stopwatch keyboard) or $\text{R/S}$ (from the Stopwatch keyboard).

**Printing Stored Splits**

If you have an HP 82143A Printer or an HP 82162A HP-IL Printer and want to print out a stored split, you can do so with the $\text{ATIME24}$ function (section 15) in conjunction with the $\text{PRA}$ function ($\text{print Alpha}$; see your printer or HP-IL manual). You cannot print out splits while the Stopwatch keyboard is active.

Since split differences (delta splits) are not stored, they must be recalculated if you want to print them out. You can do this using the $\text{HMS-}$ function (not from the Stopwatch keyboard):

1. Recall the later split value from its storage register.
2. Recall the earlier split value from its storage register.
3. Execute $\text{HMS-}$.
4. Clear the Alpha register, if desired.
5. Execute $\text{ATIME24}$.
6. Execute $\text{PRA}$.

To print out regular splits, just skip steps 1 through 3 and recall the desired split value.

**Example—A Stopwatch Program (SPLITS)**

The following program sets up the stopwatch in preparation for taking timed splits, activates the Stopwatch keyboard, and—when the Stopwatch keyboard is deactivated—prints out a specified group of stored splits. (A printer must be attached for this program.) The splits are printed out in the format $\text{HH:MM:SS.ss}$. The value recalled from each register must be less than 100, otherwise an error results.

To use the following program, first key it from the listing into program memory. There is a bar-code version of this program in appendix J, “Bar Code for Programs.” If you have an HP 82153A Wand, you can record this program quickly from the bar code.

**Input (when prompted):**

1. The number of the first register from which you want a split to be printed.
2. The number of the last register from which you want a split to be printed.

**Result:** A list of each storage register, from the first to the last, and the value stored in it. The value will be printed in time format.
User Instructions:

1. Execute SPLITs (SPLITS).

2. In response to the stopwatch display, start taking as many splits as desired. You can start from any register you want, but the splits must be taken in sequential registers.

3. When done taking splits, press [EXIT].

4. In response to the message FIRST REG?, enter the first register whose contents (split) you want printed. If you want to start from R₀₀, you don’t have to enter a number. Press [R/S].

5. In response to the message LAST REG?, enter the last register whose contents you want printed. Then press [R/S].

Program Listing

```
01 LBL “SPLITS”
02 STOPSW
03 0
04 SETSW
05 SW
06 “FIRST REG?”
07 PROMPT
08 “LAST REG?”
09 PROMPT
10 ADV
11 RCLFLAG
12 X<> 2
13 LBL 00
14 FIX 0
15 CF 29
16 “R”
17 100
18 X< =Y?
19 GTO 01
20 “├ ”
21 SQRT
22 X>Y?
23 “├ 0”
```

Makes sure stopwatch is stopped.

Resets stopwatch to 00:00:00.00.

Turns on Stopwatch keyboard. After the desired number of splits is taken and the Stopwatch keyboard is cancelled, the program continues.

If no other number is entered, the first register will be R₀₀ (owing to the zero in line 03).

Moves printer paper.

Saves the current flag settings in the Z-register.

No fractional part for a register number.

In combination with [FIX] 0, this suppresses the radix mark.

Starts to form output string (R for register).

Lines 17 through 23 are for the output format: if the register number is less than 100, then insert a space between the R and its number. If the register number is less than 10, then add a zero in front of the register number. This will result in a printed output with all register numbers and their contents aligned.
Brings number of first register into X.
Takes the register number in X and appends a copy of that number to the string in the Alpha register.

Recalls the value from the register whose address is in X.
Appends that value in time format to the Alpha register.
Prints the entire string in the Alpha register.
Increments the number of the first register by one and continues the program if the number of the first register is still less than or equal to the number of the last register.

Restores the original flag settings, which include the display formats.
Clears the X-register.

Sample Output: Following is an example of a printer output for splits taken in registers $R_{00}$ through $R_{10}$.

```
XEQ "SPLITS"
FIRST REG?  RUN
  10.0000  RUN

R 00 =00:00:07.62
R 01 =00:00:09.35
R 02 =00:00:10.20
R 03 =00:00:12.24
R 04 =00:00:13.99
R 05 =00:00:07.06
R 06 =00:00:08.90
R 07 =00:00:10.54
R 08 =00:00:12.76
R 09 =00:00:13.77
R 10 =00:00:17.89
```
Part V: Programming in Detail
Section 18

Programming Basics

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Loading a Program

Keying In a Program

1. Press \( \textbf{PRGM} \) to select Program mode.
2. Press \( \textbf{GTO} \) to set the computer to the bottom of program memory.
3. Press \( \textbf{LBL} \) followed by a global label.
4. Key in instructions using the Normal, User, and Alpha keyboards just as you would in Execution mode.
5. Press \( \textbf{GTO} \) to complete the program (optional).
Pressing \texttt{GTO} \texttt{[} \texttt{]} \texttt{]} has the following effects:

- Main memory is packed, ensuring that the maximum number of registers will be available for the next program, key redefinition, or alarm.

- An \texttt{END} instruction is inserted to complete the last program, creating a null program (consisting of the permanent \texttt{.END.}) at the bottom of program memory. (One reason to press \texttt{GTO} \texttt{[} \texttt{]} \texttt{]} after loading a program is to give the program its own \texttt{END} instruction, so that catalog 1 will display the number of bytes in the program.)

- The computer is positioned to this null program and displays \texttt{00 REG nnn} where \texttt{nnn} indicates the number of registers available for a new program. As you key in instructions, they become a new program at the bottom of program memory.

The number of available registers also appears with the permanent \texttt{.END.}. If the last program line is displayed, you can press \texttt{SST} to see \texttt{.END. REG nnn}. To then continue adding instructions, simply key them in. To then review your program:

- Press \texttt{SST} to set the computer to the first line of your program.
- Press \texttt{BST} to set the computer back to the last line keyed in.

### Copying a ROM Program

If you want to alter a program that is in ROM (read-only memory) such as an application module, you must first copy the program into program memory. To do so, execute \texttt{COPY} and specify any global label in the ROM program. A copy of the ROM program is then added to the bottom of program memory.

### Enlarging Program Memory

If there is not enough room in memory to store an instruction being added or a program being copied, the computer displays \texttt{PACKING} and then \texttt{TRY AGAIN}. If you try again but \texttt{TRY AGAIN} appears a second time, do one or more of the following steps to increase the number of registers available for program instructions:

- Check how many registers are allocated to data storage using \texttt{SIZE?}, and then allocate fewer registers using \texttt{SIZE} or \texttt{PSIZE}.
- Delete complete programs, using \texttt{CLP} or \texttt{PCLPS}. (You can first use \texttt{SAVEP} to save copies of these programs in extended memory.)
- Clear one or more alarms.
- Cancel User-keyboard assignments other than global labels listed in catalog 1, then execute \texttt{PACK} or \texttt{GTO} \texttt{[} \texttt{]} \texttt{]}.
Executing a Program

You can execute a program by ensuring that the computer is in Execution mode and then performing one of the following:

- Pressing [XEQ] and specifying a global label in the program. Execution starts with that global label.
- Assigning a global label to a key and then pressing that key when the User keyboard is active. Execution starts with that global label.
- Positioning the computer to the beginning of the program and then pressing [R/S]. Execution starts with the current program line.
- Positioning the computer to the beginning of the program and then pressing [SST]. Only the current program line is executed and the computer is positioned to the next program line. This single-step execution is most useful when you’re trying to isolate an error in a program. By checking the result after each instruction is executed, you can find where the program goes wrong.
- Positioning the computer to the beginning of the program, setting flag 11, and turning off the computer. When you next turn it on, the computer automatically runs the program starting at the current program line.
- Setting a control alarm to execute the program at a specified time.

The PRGM annunciator appears in the display while a program is running. Unless a function like [AVIEW] displays a message, or a function like [ED] activates a special keyboard and display, the program execution indicator (-) appears in the display; each time the program executes a label, the program execution indicator moves one position to the right.

Program Lines

In Program mode the computer displays one line of program memory at a time. Lines are created automatically as you key in instructions. Each line is assigned a number to indicate its position within the program, and each separate program has its own set of line numbers. Each line contains a complete instruction consisting of:

- A function.
- An Alpha string of up to 15 characters.
- A complete number of up to 10 digits, or up to 10 digits plus a two-digit power of 10.

For details about keying in Alpha strings and numbers, refer to section 9, “The Keyboard and Display.”

In a displayed program line, the symbol T indicates that the characters following comprise an Alpha string or (if preceded by XEQ, GTO, or LBL) a global label. To enter a function into a program line using its Alpha name you must press [XEQ] first. Otherwise, the computer won’t recognize the Alpha characters as a function name, but will treat them as an Alpha string and enter them into the Alpha register when it executes that program line.
Nonprogrammable Operations

The following operations are not programmable, but some can be accomplished by other means. Programmable alternatives are shown in parentheses following the nonprogrammable operation.

- **Destructive operations:**
  - \(\text{\+} \), \(\text{DELP} \).
  - \(\text{\+L} \) (but \(\text{PCLPS} \) is programmable).

- **Positioning operations:**
  - \(\text{GTO} \), \(\text{GTO} \), \(\text{SST} \), \(\text{BST} \).

- **All catalogs (but \(\text{EMDIR} \) and \(\text{ALMCAT} \) are programmable).**

- **Toggle keys:**
  - \(\text{ON} \) (but \(\text{OFF} \) is programmable).
  - \(\text{PRGM} \).
  - \(\text{USER} \) (but a program can set or clear flag 27).
  - \(\text{ALPHA} \) (but \(\text{AON} \) and \(\text{AOFF} \) are programmable).

- **Other nonprogrammable functions:**
  - \(\text{COPY} \), \(\text{ON} \), \(\text{PACK} \), \(\text{R/S} \) (to run a program).
  - \(\text{ASN} \) (but \(\text{PSAN} \) is programmable).
  - \(\text{SIZE} \) (but \(\text{PSIZE} \) is programmable).

Positioning Within Program Memory

There are several methods of positioning the computer within Program memory. Some enable you to go to any program in memory (that is, to any global label) while others enable you to go to any line within a program. Some work only in Execution mode, while others work only in Program mode. Only one function, \(\text{GTO} \) \(\times\), can do either job in either mode.

**Using \(\text{GTO} \) \(\times\)**

In Program or Execution mode:

- To position the computer to any global label, press \(\text{GTO} \) \(\times\) and specify the global label. The search for the label begins with the last global label (as listed by catalog 1) and proceeds upward in memory, stopping at the first matching label encountered.

- To position the computer to line number \(nnn\) of the current program, press \(\text{GTO} \) \(\times\) \(nnn\). If \(nnn\) exceeds the line number of the last line in the program, the computer is positioned to the last line. To position the computer to line 1\(nnn\) (the line number exceeds 999), press \(\text{GTO} \) \(\times\) \(EEX\). When the computer displays \(\text{GTO} \) \(\times\), key in \(nnn\).
Using Catalog 1

In a few cases you can’t use \texttt{GTO} \texttt{\textendash} to position the computer to the desired program. Such cases include:

- The program contains no global labels.
- The desired label is duplicated later in program memory, so that \texttt{GTO} \texttt{\textendash} always finds the duplicate label first.
- You’ve forgotten the exact spelling of the global label.

You can position the computer to any global label or \texttt{END} statement in program memory using catalog 1 in Program or Execution mode as follows:

1. Press \texttt{CATALOG 1} to display all global labels and \texttt{END} statements in program memory.
2. To speed up the listing, press any key other than \texttt{ON} or \texttt{R/S}.
3. Press \texttt{R/S} to halt the listing at the desired global label or \texttt{END} statement.
4. To display the next item or the previous item in the catalog listing, press \texttt{SST} or \texttt{BST}.
5. Press \texttt{F} to position the computer to the displayed item.

If a program doesn’t contain any global labels, follow the five steps above to position the computer to the program’s \texttt{END} statement. (When two \texttt{END} statements appear sequentially, the second \texttt{END} statement belongs to a program without global labels.) You should then insert a global label at the start of the program by pressing \texttt{GTO} \texttt{\textendash} 000 and then (in Program mode) keying in the global label.

Single Step and Back Step

In Program mode you can position the computer to the next program line or to the previous program line by pressing \texttt{SST} or \texttt{BST}.

- Press \texttt{SST} to position the computer to the next program line. If the current program line is the last program line, pressing \texttt{SST} positions the computer to the first program line (line 01).
- Press \texttt{BST} to position the computer to the previous program line. If the current program line is the first program line (line 01), pressing \texttt{BST} positions the computer to the last program line.

Pressing \texttt{SST} when the computer is positioned at the bottom of the program moves the calculator back to the beginning of this program. Pressing \texttt{BST} when the computer is positioned at the top of the program moves the calculator to the end of this program.
**Other Methods**

When the computer is in Execution mode you can position it within program memory by using any of the following methods:

- **Positioning to a Global Label.** Press \[GTO\] and specify the global label.
- **Positioning to an Assigned Global Label.** If a global label is assigned to a key, hold down that redefined key while you press \[R/S\], and then release the redefined key.
- **Positioning to a Numeric Label in the Current Program.** To position the computer to \[LBL\] \(nn\), press \[GTO\] \(nn\). The computer searches for \[LBL\] \(nn\) (as described in section 20, “Branching”) and stops at the first matching label encountered.
- **Positioning to the Top of the Current Program.** To position the computer to line 00, press \[RTN\]. The computer displays \(00\ REG\ nnn\), indicating that there are \(nnn\) registers available; if you key in an instruction, that instruction becomes line 01. This is the easiest way to add an instruction at the very beginning of a program.

**Editing a Program**

All program editing—both deleting and inserting instructions—takes place in Program mode.

**Deleting Instructions**

- **Deleting Single Lines.** To delete a single instruction, position the computer to the desired program line, and then press \[\leftarrow\]. That program line is deleted, the computer is positioned to the previous line, and the line number of each subsequent instruction is reduced by one.

When deleting a few lines, start with the last (largest-numbered) line to be deleted. In the example below, suppose that you want to delete lines 02 through 04. At left, the computer is positioned to line 04. Pressing \[\leftarrow\] deletes line 04 and positions the computer to line 03; pressing \[\leftarrow\] again deletes line 03 and positions the computer to line 02; and pressing \[\leftarrow\] a third time deletes line 02 and positions the computer to line 01.

<table>
<thead>
<tr>
<th>Current Program Line (displayed)</th>
<th>01 LBL^AREA</th>
<th>02 (x^2)</th>
<th>03 PI</th>
<th>04 (x)</th>
<th>05 END</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 LBL^AREA</td>
<td>02 (x^2)</td>
<td>03 PI</td>
<td>04 (x)</td>
<td>05 END</td>
<td></td>
</tr>
<tr>
<td>01 LBL^AREA</td>
<td>02 (x^2)</td>
<td>03 PI</td>
<td>04 END</td>
<td>02 END</td>
<td></td>
</tr>
</tbody>
</table>
Deleting Multiple Lines. To delete a long sequence of instructions:

1. Position the computer to the first (smallest-numbered) line to be deleted.
2. Execute [DEL] (delete).
3. Specify the number of lines to be deleted. To delete more than 1000 lines, press [EEX]. When the computer displays DEL 1____, key in the remaining three digits.

In the previous example, lines 02, 03, and 04 are deleted one by one. Alternatively you could position the computer to line 02 and execute [DEL] 003. This deletes lines 02, 03, and 04, leaving the computer positioned to the previous line (line 01). The line number of each subsequent instruction is reduced by three.

If you execute [DEL] nnn when there are fewer than nnn program lines following the current line, the current line and all subsequent lines except [END] are deleted.

Inserting Instructions

To insert an instruction in a program, position the computer to the existing line that you want the new line to follow, and then key in the new instruction. (If you just deleted an instruction using [+] and now you’re replacing it, the computer is already properly positioned.) The new instruction becomes the current line, and the line number of each subsequent instruction is increased by one.

When inserting several instructions, start with the first (smallest-numbered) line to be inserted. Suppose that you want to restore the instructions deleted in the previous example. At left, the computer is positioned to line 01. As each instruction is keyed in, it is inserted after the previous current program line and becomes the new current program line.

Clearing Programs

There are two functions that clear programs. [CLP] (clear program) clears one program and is not programmable; [PCLPS] (programmable clear programs) can clear several programs and is programmable.
Using \textbf{CLP}

Execute \textbf{CLP} and specify any global label in the program to be cleared. The computer then:

1. Searches upward through program memory for the specified global label, beginning with the last global label (as listed by catalog 1).

2. Deletes all instructions (line 01 through \textbf{END}) in the first program encountered that contains the specified global label.

3. Packs main memory.

Executing \textbf{CLP} and pressing \textbf{ALPHA} \textbf{ALPHA} without specifying a global label clears the current program.

Using \textbf{PCLPS}

To clear a program and all subsequent programs in program memory:

1. Place any global label from the program into the Alpha register.

2. Execute \textbf{PCLPS}.

Executing \textbf{PCLPS} when the Alpha register is empty clears the current program and all subsequent programs.
Introduction

A flag has only two states, set and clear. These states can be interpreted as “on/off” (like a switch), as “yes/no” (like a decision), or as “1/0” (like a binary digit, or bit). The computer has 56 flags, grouped into three types according to use.

User Flags. You can both test and alter user flags. Their status is altered only by your instructions.

Control Flags. You can both test and alter control flags. The computer resets some control flags to default status each time you turn it on, and alters some in the course of operation.

System Flags. You can test system flags but you can’t alter them.

You can set and clear flags 00 through 29, which are the user and control flags.

• To set a flag, press [SF] and then specify the flag number.
• To clear a flag, press [CF] and then specify the flag number.

You can test flags 00 through 55 by pressing [FS?] and then specifying the flag number. The display shows YES if the flag is set, or NO if the flag is clear. Flag tests like [FS?] are used primarily to control program execution, as described in section 20, “Branching.”
Types of Flags

User Flags (00 through 10)

The user flags are solely for your own use; what they mean depends entirely on how you use them. For example, a program can ask whether the user wants English or metric units, and then store the user's response as the status of one user flag. Afterwards, whenever the program needs to check which units to use, it can test that user flag.

The state of each user flag is maintained by Continuous Memory. Once you set or clear a user flag, its status is fixed until you alter it. When any of the first five flags is set, the corresponding annunciator (0, 1, 2, 3, or 4) appears in the display.

The first eight flags (00 through 07) can be interpreted as the eight bits in a byte, and that byte can be transformed into a number in the X-register. This process is discussed after the control and system flags.

Control Flags (11 through 29)

The control flags have specific meanings to the computer, listed below. The status of these flags represent certain operating conditions and options. You can alter these flags to indicate your choice of options; the computer alters some of these flags to indicate conditions, which you can then check by testing the flags.

Flag 11: Automatic Execution. Flag 11 allows a program to run automatically. If you set flag 11 before you turn off the computer, the following will happen when you next turn it on:

- A tone sounds.
- Program execution begins from the current program line.
- Flag 11 is cleared.

Flags 12 through 20: External Device Control. These flags direct the operation of external devices that are controlled by the computer. All flags for external device control are cleared each time you turn on the computer. The precise meaning of these flags depends on the particular devices that are present; refer to the appropriate manuals for details.

Flag 21: Printer Enable. Flag 21 allows your program to control how functions like VIEW and AVIEW are executed, depending on whether an output device is present. For details, refer to appendix D, “Printer Operation.”
Flags 22 and 23: Data Input. These flags allow a program that prompts for input to determine the user’s response.

- Flag 22 is set when numbers are keyed into the X-register.
- Flag 23 is set when characters are keyed into the Alpha register.

These flags are cleared automatically only when you turn on the computer. If you intend to test these flags, you should clear them before prompting for the response.

Flags 24 and 25: Error Ignore. Normally, an error condition halts program execution. These flags allow you to avoid unnecessary program halts and to use error conditions as a programming tool.

- If flag 24 is set, the computer ignores all OUT OF RANGE errors. This error normally results from any calculation (except statistical accumulations) that produces a number \( x \) such that \( |x| > 9.999999999 \times 10^{99} \). If flag 24 is set, \( \pm 9.999999999 \times 10^{99} \) is returned as an approximation to the correct answer, and program execution continues.

Flag 24 is cleared each time you turn on the computer. Once you set flag 24, it remains set until you explicitly clear it or turn off the computer. If you want to branch to your own error subroutine rather than use \( \pm 9.999999999 \times 10^{99} \) as an approximation, use flag 25.

- If flag 25 is set, the computer ignores only one error of any kind and then clears flag 25. The command that caused the error is not executed. Flag 25 is cleared each time you turn on the computer.

If both flags 24 and 25 are set, an OUT OF RANGE result will be handled by flag 24—flag 25 will not be cleared. Note that if flag 25 is set but not flag 24, an OUT OF RANGE result will not cause \( \pm 9.999999999 \times 10^{99} \) to be placed in the appropriate register.

You can detect an error by setting flag 25 just before a command and, just after the command, testing if flag 25 was cleared. (Generally you should test and clear flag 25—it’s dangerous to ignore unanticipated errors.) This enables a program to branch rather than stop execution in case of an error.

Flag 26: Audio Enable. When flag 26 is set, [BEEP], [TONE], alarms, and the stopwatch produce audible tones. Flag 26 is set each time you turn on the computer. (This is the only control flag whose default status is set.) You can silence the computer by clearing flag 26.

Flag 27: User Keyboard. Flag 27 is set when the User keyboard is active—that is, when the USER annunciator is displayed. A program can check or alter this flag exactly as you can check the annunciator or press [USER]. Flag 27 is maintained by Continuous Memory.

Flags 28 and 29: Display Punctuation. These flags control the use of periods and commas in numeric displays and are maintained by Continuous Memory. For details, refer to “Display Format” in section 9.
Program Examples. The programs TR and Σ in section 22 use flags 22 and 23 (Data Input) when prompting the user with default values for time, date, or job name. The user can either key in an alternative value and then press \([R/S]\), or else confirm the displayed value by simply pressing \([R/S]\). To determine whether the user keyed in an alternative value, the programs clear the appropriate Data Input flag before prompting and then test it afterwards. If the user keyed in an alternative value before pressing \([R/S]\), the Data Input flag will be set.

The programs use flag 25 (Error Ignore) when accessing records in the text file TRECS. To access all records without knowing the number of records in advance, the programs contain loops that act on one record, set flag 25 before accessing the next record, and then test flag 25 afterwards. If there isn’t another record, an error occurs and flag 25 is cleared, so the program can tell whether to exit the loop by testing flag 25.

System Flags (30 through 55)

The system flags are primarily for internal use by the computer; their utility to the user is limited. You can test system flags, but several always test clear. You can’t directly alter individual system flags, but you can save and restore the status of those that represent user options. Listed below are ways you can use some of the system flags.

Flags That Represent Options. You can save and restore certain options that are encoded by the computer as flags. This allows a program that sets options to restore the previous conditions when it is completed. The functions to do so, [RCLFLAG] and [STOFLAG], are described at the end of this section.

Some external devices controlled by the computer use system flags to represent options relating to those devices; refer to the appropriate manuals for details. The following system flags represent options in the computer:

- Flag 31 represents the date format, described on page 242.
- Flags 36 through 39 represent the number of displayed digits, described on pages 160 and 161.
- Flags 40 and 41 represent the display format, described on pages 160 and 161.
- Flags 42 and 43 represent the angular mode, described on page 186.

Flags That Represent Conditions. The following flags provide information that is useful for some programs:

- Flag 44 is set when \(\text{ON}\) (continuous on) is executed.
- Flag 48 is set when the Alpha keyboard is active—that is, when the ALPHA annunciator is displayed.
• Flag 49 is set (and the BAT annunciator is displayed) when battery power is low. A long-running program can occasionally test flag 49 and execute [OFF] if flag 49 is set. Otherwise, if a program continues to run when battery power is low, the memory contents of the computer can be affected.

• Flag 50 is set when a message is displayed.

• Flag 55 is set if a printer is present. This flag works with flag 21 (Printer Enable); their interaction is described in appendix D, “Printer Operation.”

Summary of Flag Status

The chart on the next page indicates flag status when Continuous Memory has been cleared (“Reset”) and whenever you turn on the computer (“Turn-On”). In addition to clear and set, there are two flag states coded as follows:

\[ M = \text{Maintained by Continuous Memory.} \]
\[ ? = \text{Dependent on other conditions.} \]

Flags and the X-Register

There are three reasons to move data between the flags and the X-register:

1. To save and restore options such as display format, which are encoded by the computer as control or system flags.

2. To keep multiple copies of a group of user flags, with only one copy active as flags at one time.

3. To transform information represented by user flags into a number, and vice versa.

There are two ways to move data between the flags and the X-register:

- [X<>F] (X exchange flags) exchanges the status of flags 00 through 07 with a number from 0 through 255 in the X-register. Thus, the status of flags 00 through 07 can be saved as a number and later restored (by [X<>F] again), or the number can be used in other ways (like calculations or branching). However, [X<>F] cannot affect control or system flags.

- [RCLFLAG] (recall flags) and [STOFLAG] (restore flags) can save and restore flags 00 through 43, so they can handle user, control, or system flags. However, they can’t transform flag status into a number.

In summary, only [RCLFLAG] and [STOFLAG] can save and restore control and system flags, and only [X<>F] can transform the status of user flags into a usable number, but either can be used for multiple copies of user flags. First described is [X<>F] and its use for multiple copies of user flags, followed by [RCLFLAG] and [STOFLAG] and a comparison of their use for multiple copies of user flags.
### Summary of Flag Status

<table>
<thead>
<tr>
<th>Flag Number</th>
<th>Flag Name</th>
<th>Status at Reset, at Turn-On</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-10</td>
<td>User Flags</td>
<td>Clear</td>
</tr>
<tr>
<td>11</td>
<td>Automatic Execution</td>
<td>Clear</td>
</tr>
<tr>
<td>12-20</td>
<td>External Device Control</td>
<td>Clear</td>
</tr>
<tr>
<td>21</td>
<td>Printer Enable</td>
<td>?</td>
</tr>
<tr>
<td>22</td>
<td>Numeric Data Input</td>
<td>Clear</td>
</tr>
<tr>
<td>23</td>
<td>Alpha Data Input</td>
<td>Clear</td>
</tr>
<tr>
<td>24</td>
<td>Range Error Ignore</td>
<td>Clear</td>
</tr>
<tr>
<td>25</td>
<td>Error Ignore</td>
<td>Clear</td>
</tr>
<tr>
<td>26</td>
<td>Audio Enable</td>
<td>Set</td>
</tr>
<tr>
<td>27</td>
<td>User Keyboard</td>
<td>Clear</td>
</tr>
<tr>
<td>28</td>
<td>Display Punctuation</td>
<td>Set</td>
</tr>
<tr>
<td>29</td>
<td>Separator Mark</td>
<td>Set</td>
</tr>
<tr>
<td>31</td>
<td>Date Format</td>
<td>Clear</td>
</tr>
<tr>
<td>36</td>
<td>Number of Digits</td>
<td>Clear</td>
</tr>
<tr>
<td>37</td>
<td>&quot;</td>
<td>Set</td>
</tr>
<tr>
<td>38</td>
<td>&quot;</td>
<td>Clear</td>
</tr>
<tr>
<td>39</td>
<td>&quot;</td>
<td>Clear</td>
</tr>
<tr>
<td>40</td>
<td>Display Format</td>
<td>Set</td>
</tr>
<tr>
<td>41</td>
<td>&quot;</td>
<td>Clear</td>
</tr>
<tr>
<td>42</td>
<td>Angular Mode</td>
<td>Clear</td>
</tr>
<tr>
<td>43</td>
<td>&quot;</td>
<td>Clear</td>
</tr>
<tr>
<td>44</td>
<td>Continuous On</td>
<td>Clear</td>
</tr>
<tr>
<td>48</td>
<td>Alpha Keyboard</td>
<td>Clear</td>
</tr>
<tr>
<td>49</td>
<td>Low Battery</td>
<td>?</td>
</tr>
<tr>
<td>50</td>
<td>Message</td>
<td>Clear</td>
</tr>
<tr>
<td>55</td>
<td>Printer Existence</td>
<td>?</td>
</tr>
</tbody>
</table>
Flags and Numbers as Bytes

A byte, as a quantity of information, is the key to the correspondence between flags and numbers. A byte comprises eight bits, or binary digits: 00010100, 10001100, 00100000, and 00001111 are examples of bytes.

- A byte can be interpreted as eight flags, each 0 or 1 being the status of a particular flag.
- A byte can also be interpreted as a number, the sum of powers of 2.

By interpreting flags 00 through 07 as a byte and then interpreting that byte as a number, you can translate the status of eight flags into a unique number from 0 through 255. Conversely, you can specify the status of all eight flags at once by specifying a number from 0 through 255 and then translating it into the status of flags 00 through 07.

<table>
<thead>
<tr>
<th>Flag Number</th>
<th>07</th>
<th>06</th>
<th>05</th>
<th>04</th>
<th>03</th>
<th>02</th>
<th>01</th>
<th>00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flag Status</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
<td>Set or Clear</td>
</tr>
<tr>
<td>Binary Value</td>
<td>$2^7$ or Zero</td>
<td>$2^6$ or Zero</td>
<td>$2^5$ or Zero</td>
<td>$2^4$ or Zero</td>
<td>$2^3$ or Zero</td>
<td>$2^2$ or Zero</td>
<td>$2^1$ or Zero</td>
<td>$2^0$ or Zero</td>
</tr>
<tr>
<td>Decimal Value</td>
<td>128 or Zero</td>
<td>64 or Zero</td>
<td>32 or Zero</td>
<td>16 or Zero</td>
<td>8 or Zero</td>
<td>4 or Zero</td>
<td>2 or Zero</td>
<td>1 or Zero</td>
</tr>
</tbody>
</table>

**Example.** Below are four particular bytes, each shown with its corresponding flag status and decimal value. Any flag from 00 through 07 that is not indicated as set is clear.

<table>
<thead>
<tr>
<th>Flags That Are Set</th>
<th>Byte</th>
<th>Decimal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>04, 02</td>
<td>00010100</td>
<td>$16 + 4 = 20$</td>
</tr>
<tr>
<td>07, 03, 02</td>
<td>10001100</td>
<td>$128 + 8 + 4 = 140$</td>
</tr>
<tr>
<td>05</td>
<td>00100000</td>
<td>$32$</td>
</tr>
<tr>
<td>03, 02, 01, 00</td>
<td>00001111</td>
<td>$8 + 4 + 2 + 1 = 15$</td>
</tr>
</tbody>
</table>
Using \( \text{X<>F} \)

When you execute \( \text{X<>F} \):

- The status of flags 00 through 07 is transformed into a number from 0 through 255 and placed in the X-register.
- The number in the X-register, which must be from 0 through 255, is transformed into the status of flags 00 through 07. The sign and fractional part of the number in the X-register are ignored.

### Multiple Copies of Flags

You can effectively increase the number of user flags by saving and restoring the status of the actual flags. When you save the current status of the actual flags, you create a "frozen" copy of those flags. You can later restore the actual flags to the status that was frozen in the copy, even though you might have used the actual flags for something entirely different in the meantime. In particular, you could have cleared the flags, encoded a new set of data in them, and saved the resulting flag status. This would give you two copies of the flag status, representing two distinct sets of data.

The following steps demonstrate this process. The first set of data is encoded by setting flags 00 and 02 ("first flag status") and is saved in \( R_{00} \); the second set of data is encoded by setting flags 01 and 03 ("second flag status") and is saved in \( R_{01} \).

```
01 0
02 X<>F
03 SF 00
04 SF 02
05 0
06 X<>F
07 STO 00
08 SF 01
09 SF 03
10 RCL 00
11 X<>F
12 STO 01
```

- Clear flags 00 through 07.
- Set the first flag status.
- Move the first flag status to the X-register and clear flags 00 through 07.
- Save the first flag status in \( R_{00} \).
- Set the second flag status.
- Recall the first flag status to the X-register.
- Move the second flag status to the X-register and restore the first flag status.
- Save the second flag status in \( R_{01} \).

This doubles the effective number of flags by encoding twice as much information, and you can create more copies as needed for additional sets of data. However, you can access only one set of data at a time. When you need to access a different set of data, you must store the current flag status and recall the desired flag status before you can test or manipulate the actual flags.
Example. Suppose that a program calls five subroutines and that each subroutine employs several flags. Before calling any subroutines, the program can create a copy of the initial flag status for each subroutine and store each copy in a separate register. Then whenever a subroutine is called, it can start by restoring its own flag copy, test and manipulate the flags, and finally save the current flag status as its updated flag copy. In this way, the program can call subroutines in any order and any number of times, and the subroutines won’t interfere with each other’s operation.

Example. Suppose you’re analyzing the incomes of individuals by sex, age, and education. This can be encoded by flags as follows:

- **Sex**: Flag 00 set = female, clear = male.
- **Age**: Flag 01 set = age < 20.
  - Flag 02 set = 20 ≤ age < 35.
  - Flag 03 set = 35 ≤ age < 50.
  - Flag 04 set = 50 ≤ age.
- **Education**: Flag 05 set = High school.
  - Flag 06 set = College.
  - Flag 07 set = Graduate Studies.

Each individual can now be characterized by two numbers: by a number from 0 through 255 representing the status of flags 00 through 07; and by income.

To accumulate statistical data on a subset of the entire group of individuals, a program can test the flag copy for each individual in succession, accumulating only the incomes of those in the subset. For example, if the subset is defined as all men—regardless of age and education—you would restore the actual flags to correspond to the flag copy for each individual, test flag 00, and accumulate that individual’s income if flag 00 is clear.

However, suppose that the subset is defined as women between 35 and 50 with a graduate degree. Because this definition involves all eight flags, you don’t need to test separate flags; you can simply test the number that represents the status of all 8 flags. “Woman between 35 and 50 with a graduate degree” corresponds to flags 00, 03, and 07 set, which corresponds to a decimal value of 137. You would test the decimal value for each individual’s flag copy and accumulate that individual’s income if the decimal value equals 137.

**Using **\texttt{RCLFLAG}** and **\texttt{STOFLAG}**

You can save the status of flags 00 through 43 using \texttt{RCLFLAG} (recall flags) and then restore some or all of them using \texttt{STOFLAG} (restore flags). These two functions are useful only as a pair; the result of \texttt{RCLFLAG} can be used only by \texttt{STOFLAG}, and \texttt{STOFLAG} works only on data obtained by \texttt{RCLFLAG}.

**Using **\texttt{RCLFLAG}.** When you execute \texttt{RCLFLAG}, the status of flags 00 through 43 is recalled to the X-register. This flag data can then be stored in a register in main or extended memory. (The display of the status data is meaningless.) Like \texttt{RCL}, \texttt{RCLFLAG} raises the stack unless stack lift is disabled.
Using \texttt{STOFLAG}. You can use \texttt{STOFLAG} to restore all or some of flags from 00 through 43:

- To restore flags 00 through 43, recall the flag-status data to the X-register and execute \texttt{STOFLAG}.
- To restore a block of flags $bb$ (begin) through $ee$ (end), recall the flag status data as above and then place the control number $bb.ee$ in the X-register. (This lifts the flag status data to the Y-register.) Then execute \texttt{STOFLAG}.

Like \texttt{STO}, \texttt{STOFLAG} doesn’t change the stack. If $bb \geq ee$, only flag $bb$ is restored.

**Example.** Suppose that a program rounds numbers to the nearest integer (requiring a \texttt{RND} instruction and a display format of \texttt{FIX} 0), but you want the user’s choice of display formats to be in effect otherwise.

1. After input is completed with the user’s choice of display format, use \texttt{RCLFLAG} to recall the status of flags 00 through 43 to the X-register, and then use \texttt{STO} $nn$ to store the flag-status data in $R_{nn}$.
2. Use \texttt{FIX} 0 to specify “no decimal places.”
3. Use \texttt{RND} to round the number in the X-register.
4. Before starting output, execute \texttt{RCL} $nn$ to recall the flag data, enter 36.41 to specify flags 36 through 41 (the display format flags), and then execute \texttt{STOFLAG} to restore flags 36 through 41 to their previous status.

This allows input and output to occur in any display format, while the \texttt{FIX} 0 format is in effect as required.

**Multiple Copies of Flags.** You can use \texttt{RCLFLAG} and \texttt{STOFLAG} rather than \texttt{X<>F} to handle multiple copies of flags, with the following differences.

- Each flag group can be any block of the user flags, including the entire block of flags 00 through 10. (For \texttt{X<>F} each flag group must be flags 00 through 07.)
- You can’t use the flag data obtained by \texttt{RCLFLAG} except to restore the actual flags to their previous status. (The last example for using \texttt{X<>F} illustrated a way to directly use the number obtained by \texttt{X<>F}).
Branching occurs whenever program execution jumps to an instruction other than the next program line—that is, whenever program steps are not executed sequentially. Two types of functions cause branching:

- Executing \texttt{GTO label} or \texttt{XEQ label} causes program execution to branch to the specified label.
- Executing a flag test, comparison, or loop control function can cause program execution to skip the next program line, depending on whether a certain condition is true.

Often these two types of functions are used together: a flag test can be followed by \texttt{GTO label}, so that the status of the specified flag determines whether program execution branches to the specified label. This section describes the use of \texttt{GTO} first, \texttt{XEQ} next, conditional functions (flag tests and comparisons) next, and looping last.
Branching to a Label

The only purpose of labels is to serve as targets for branching instructions. The two basic types of labels are global labels, which can be accessed from any program in program memory, and local labels, which can be accessed only from inside their own program. Any label other than a local Alpha label can be specified indirectly as well as directly.

Global Labels

Global labels consist of up to seven Alpha characters including digits. Commas, periods, and colons are not allowed. Single letters from A through J and from a through e are called local Alpha labels and can’t be used as global labels. However, other single letters or digits are legal global labels. Global labels require four bytes of program memory plus one additional byte for each character.

Programs are identified by their global labels. Functions that act on entire programs (like [CLP] and [SAVEP]) require a global label to specify the program. At the same time, a global label also identifies a particular line in a program—namely itself. You can branch to different parts of a program from outside that program if it contains several global labels; any one of these global labels can serve to identify the entire program.

Global Label Searches

When the computer executes [GTO] followed by a global label, it first searches within program memory. The search begins with the last global label (as listed by catalog 1) and proceeds upward through program memory, stopping at the first label that matches the specified label. The search is in the opposite order from the catalog 1 listing. If there are two global labels using the same characters, the higher label (listed first by catalog 1) is never found because the search always stops at the lower label.

If the computer reaches the top of program memory without finding the specified label, it then searches in catalog 2. If a program in a plug-in module or peripheral device includes the specified global label, execution is transferred to the module or device and continues from that label.

Local Labels

Local labels are the internal markers in a program, used for branching within the current program. The three types of local labels are described first, followed by how the computer searches for local labels.

Local Numeric Labels. There are two types of numeric labels, one for branching a limited distance and another for branching any distance within a program.

- Labels 00 through 14 are short-form numeric labels, requiring only a single byte of program memory. Use them only when the distance in program memory from the [GTO] instruction to the label is 112 bytes or less.
- Labels 15 through 99 are long-form numeric labels, requiring two bytes of program memory. They can be used for branching any distance within a program.
Local Alpha Labels. Local Alpha labels require two bytes of program memory and can be used for branching any distance within a program. They are designed for manual execution: when the User keyboard is active, a local Alpha label is automatically assigned to each key on the top two rows (as described in “The Top Two Rows” in section 9). You can then use these keys to execute the corresponding local Alpha labels in the current program.

Program Example. The program Σ in section 22 displays CLEAR D, J? E, which is a menu offering three alternatives. You can press [D] to clear days, press [J] to clear a job, or press [E] to exit. When you press one of these keys, program execution starts at the corresponding local Alpha label.

Local Label Searches

Searches for local labels occur only within the current program. To find a local label, the computer first searches sequentially downward through the current program, starting at the [GTO] instruction. If the specified label is not found before reaching the end of the program, the computer continues the search from the beginning of the program.

A local label search can consume a significant amount of time, depending on the length of the current program. To minimize the search time, the computer records the distance in program memory from the [GTO] instruction to the specified local label when the [GTO] instruction is first executed. This eliminates the search time for subsequent executions of that [GTO] instruction.

Program Example. To conserve program memory, the program Σ in section 22 uses short-form local numeric labels wherever possible. Because there are 15 short-form labels and 28 places to use them, Σ uses short-form labels 00 through 03 more than once. This is made possible by restricting the use of labels 00 through 03 to forward branches (where the [GTO] instruction precedes the [LBL] instruction). Although LBL 00 appears in five distinct program lines, each GTO 00 is intended for the next LBL 00 in the program and so no confusion occurs.

In contrast, short-form labels 04 through 14 are used for reverse branches (where the [GTO] instruction follows the [LBL] instruction). Because the computer must search from the [GTO] instruction to the bottom of the program and then from the top of the program to the [LBL] instruction, each of these labels appears only once to avoid confusion.

Bytes for a [GTO] Instruction

The number of bytes of program memory required by a [GTO] instruction depends on which type of label is specified:

- A [GTO] instruction specifying a long-form numeric label or a local Alpha label requires three bytes.
- A [GTO] instruction specifying a short-form numeric label or an indirect address requires two bytes.
**Calling a Subroutine**

A program instruction consisting of \([\text{XEQ}]\) followed by a label is a special type of branch named a **subroutine call**. \([\text{XEQ}] \text{ label} \) and \([\text{GTO}] \text{ label} \) are similar in that:

- Both transfer program execution to the specified label.
- All types of labels that can be specified for \([\text{GTO}]\) can also be specified for \([\text{XEQ}]\).

A subroutine call is special because of what occurs after \([\text{XEQ}]\) has transferred execution to the specified label: the next \([\text{RTN} \text{ or END}]\) instruction executed will return program execution to the instruction that follows the \([\text{XEQ}]\) instruction, as illustrated below.

Program ABC branches to program DEF, so execution stops when the \([\text{END}]\) instruction is encountered at the end of DEF.

Program ABC calls program DEF as a subroutine, so execution returns to ABC when the \([\text{END}]\) instruction is encountered at the end of DEF.

Using subroutines saves space in program memory. The instructions in the subroutine appear only once, but they can be executed any number of times both within a program and (if the subroutine begins with a global label) from any number of programs.

Either \([\text{RTN}] \text{ or END} \) causes execution to return to the instruction following the subroutine call. However, \([\text{END}]\) marks the end of the program and thus affects local label searches and functions that act on entire programs; \([\text{RTN}]\) marks only the end of a subroutine within a program. In the following program \([\text{END}]\) terminates the subroutine and \([\text{RTN}]\) terminates program execution. (In practice, there would be no reason to execute lines 22 through 29 as a subroutine because they are executed only once.)
If you call ABC as a subroutine from another program, execution returns to the calling program when 20 RTN is executed. That is, if a program calls a subroutine that calls a second subroutine, the second subroutine is completed and execution returns to the first subroutine; then the first subroutine is completed and execution returns to the calling program.

Alternatively, you can ensure that execution will stop at line 20, even if ABC is called as a subroutine, by entering 20 STOP. Press [R/S] in Program mode to enter a [STOP] instruction.

The Subroutine Return Stack

When an XEQ instruction calls a subroutine, the computer remembers the location in program memory of that XEQ instruction, so that execution can return there when the subroutine is completed. While the subroutine is being executed, this return location is stored in the subroutine return stack. When the subroutine is completed and execution returns to the XEQ instruction, the location of the XEQ instruction is removed from the subroutine return stack.

Subroutine Limits. When a subroutine calls another subroutine, all pending return locations in the subroutine return stack are "pushed up" in the stack. The subroutine return stack can hold six pending return locations, so the computer can return from subroutines up to six levels deep.

Loss of Subroutine Returns. Pending return locations are lost from the subroutine return stack under the following conditions.

- If there are already six pending return locations in the subroutine return stack when a subroutine is called, the earliest return location is lost from the stack. In this case, program execution never returns to the XEQ instruction that called the first subroutine; instead, execution halts when the first subroutine is finally completed because there are no further return locations in the stack.

- All pending return locations are lost when you manually execute a program. Therefore, if you stop a program ABC in the middle of a subroutine and manually execute a program DEF, it will be impossible to resume ABC. This rule also applies if an alarm executes DEF while ABC is stopped. Whether executed by an alarm or by you, DEF need not be a different program from ABC; for example, executing a local Alpha label by pressing a key on the User keyboard clears the subroutine return stack.
Global-Label Subroutine Searches

When the computer executes [XEQ] followed by a global label, it first searches the contents of program memory just as it does for [GTO]. However, if the specified label isn’t found in program memory, the next stages of the search caused by [XEQ] differ from the search caused by [GTO]. The order of the complete search caused by [XEQ] corresponds to the numbers of catalogs 1, 2, and 3.

Searching Catalog 1. The search begins with the last global label (as listed by catalog 1) and proceeds upward through program memory, stopping at the first label that matches the specified label. Execution then resumes at that matching label.

Searching Catalog 2. If the specified label isn’t found in program memory, the computer then searches catalog 2 for a global label or function name that matches the specified label. (Refer to appendix H for a detailed explanation of the contents of catalog 2.) Execution then resumes at that matching label, or the function with the matching name is executed.

Searching Catalog 3. If the specified label isn’t found in catalog 2, the computer then searches catalog 3 for a function whose name matches the specified label. If such a function is found, it is executed; otherwise a NONEXISTENT error occurs.

Bytes for an [XEQ] Instruction

The number of bytes of program memory required by an [XEQ] instruction depends on which type of label is specified.

- An [XEQ] instruction specifying a global label of n characters requires 2 + n bytes.
- An [XEQ] instruction specifying a local label requires three bytes.
- An [XEQ] instruction specifying an indirect address requires two bytes.

Conditional Functions

Flag tests and comparisons are conditional functions. They express a proposition that is true or false depending on current conditions, and their effect depends on whether the proposition is currently true or false.

- If you manually execute a conditional function, the computer displays YES if the proposition is currently true or NO if the proposition is currently false.
- If a program executes a conditional function, the result follows the rule: DO IF TRUE. The program line that follows the conditional function is executed if the proposition is currently true, or else is skipped if the proposition is currently false. That is, DO the next instruction IF the proposition is TRUE.
Is Flag 01 Set?

If YES (flag 01 is set):
Continue with the next line.
(Do If True.)

If NO (flag 01 is clear):
Skip one line before resuming execution.

Flag Tests

The following functions can test any flag.

- **FS? nn** Is flag nn set? (00 ≤ nn ≤ 55)
- **FC? nn** Is flag nn clear? (00 ≤ nn ≤ 55)

Two functions test and then clear a flag. They can’t act on system flags (30 through 55) because you can’t alter system flags.

- **FS?C nn** Is flag nn set? Clear flag nn. (00 ≤ nn ≤ 29)
- **FC?C nn** Is flag nn clear? Clear flag nn. (00 ≤ nn ≤ 29)

Comparisons

Comparing X with Zero. The following five functions compare the number in the X-register with zero:

- **X < 0?**
- **X ≤ 0?**
- **X = 0?**
- **X ≠ 0?**
- **X > 0?**

Comparing X with Y. The following five functions compare the number in the X-register with the number in the Y-register.

- **X < Y?**
- **X ≤ Y?**
- **X = Y?**
- **X > Y?**
- **x > y?**

Two of these functions, **x = y?** and **X ≠ Y?**, can compare Alpha data as well as numeric data. Executing any of the three other functions with Alpha data in the X- or Y-register causes an **ALPHA DATA** error.
Comparing X with Indirect Y. There are six functions that compare the contents of the X-register with the contents of a register specified in the Y-register. The specified register can be any main memory register (R_00 through R_319) or the stack or LAST X registers. Place the address from 00 through 319 or the single letter X, Y, Z, T, or L in the Y-register. The functions are:

- \( X < NN? \)
- \( X \leq NN? \)
- \( X = NN? \)
- \( X \neq NN? \)
- \( X \geq NN? \)
- \( X > NN? \)

These functions can compare any combination of Alpha and numeric data. Alpha strings are compared on the basis of character codes, allowing Alpha data to be alphabetized. Alpha data are considered to be strictly greater than numeric data.

Looping

A loop is a sequence of instructions that starts with a label and ends with a branch back to that label. The simplest case is an infinite loop such as the following program.

```
01 LBL'LOOP
02 BEEP
03 GTO'LOOP
04 END
```

Once started, this program would run until the batteries expired. Infinite loops should generally be avoided, but loops that repeat themselves until some condition is met are a powerful programming tool.

Looping Using Conditional Functions

When you want to perform an operation until a certain condition is met but you don’t know exactly how many times to repeat the operation, you can create a loop with a conditional function just before the \( \text{GTO} \) instruction. For example, the following program subtracts one from a number, tests the result, and repeats the loop if the result is positive. As soon as the number is reduced to zero (assuming that the original number was positive), the program exits the loop and beeps.

```
01 LBL'ABC
02 1
03 -
04 X>0?
05 GTO'ABC
06 BEEP
07 END
```
**Program Example.** The sample programs TR and Σ in section 22 use loops with conditional functions to access extended memory. When many records in the file TRECS need to be processed in a certain way but the number of records in the file varies, the loop that processes each record uses the Error Ignore flag (flag 25) to exit when all records have been processed.

- After each record is processed, flag 25 is set. This means that when the next error occurs, the computer will clear flag 25 but will not halt program execution.
- With flag 25 set, the program attempts to access the next record, and then tests flag 25. If flag 25 has been cleared, this means that there are no further records (an END OF FL error occurred) and so the program exits the loop. If flag 25 is still set, this means that the next record does exist and so the loop is repeated to process this record.

One particular example of this technique can be found in the program Σ. Lines 351 through 362 form a loop that accesses each time record. Within this loop, lines 354 through 360 attempt to set the pointer to the next time record; if on line 358 causes an error, GTO 12 on line 360 terminates the loop.

**Loop-Control Functions**

When you want to execute a loop a specific number of times, you can use special functions for that purpose instead of the conditional functions in the previous examples. These special functions are **ISG** (increment, skip if greater) and **DSE** (decrement, skip if equal). Both functions use a control number in a register to control looping. This register can be a data register in main memory, a stack register, or the LAST X register; it can be specified indirectly as well as directly.

The format of the loop-control number is iiii.fffcc, where:

- **iiiii is the current counter value.** Each time ISG or DSE is executed, iiii is incremented (for ISG) or decremented (for DSE) by the value of cc. The part iiii can consist of one through five digits.

- **fff is the final counter value.** Each time ISG or DSE increments or decrements iiii, the resulting value of iiii is compared with the value of fff. The part fff must consist of three digits like 100, 020, or 009.

- **cc is the increment/decrement value.** If cc is 00 (or unspecified), the computer uses a default value of 01 instead. If specified, cc must consist of two digits like 30 or 03.

When the computer executes ISG, it first increments iiii by cc, and then tests if the resulting value of iiii is greater than fff. If it is, the computer skips the next instruction.

When the computer executes DSE, it first decrements iiii by cc, and then tests if the resulting value of iiii is equal to (or less than) fff. If it is, the computer skips the next instruction.
**Program Example.** The program Σ in section 22 uses loops with loop-control functions to access a block of sequential data registers. When the registers are filled with data recalled from extended memory, they are accessed in order of increasing addresses. When the data are displayed, the registers are accessed in order of decreasing addresses. (The order of the data must be reversed to display the data chronologically).

To fill the registers in order of increasing addresses, Σ uses \texttt{ISG} (on line 213) to increment the loop-control number (in \texttt{R05}). To display the data in the reverse order, Σ uses \texttt{DSE} (on lines 231 and 259) to decrement the loop-control number.

Σ defines the initial and final counter values to be the addresses of the first and last registers in the block. Then each time the loop is executed, the integer part of the loop-control number is the address of the register to access. This use of the loop-control number for indirect addressing (on lines 209, 212, 228, and 254) depends on the following initial value for the loop-control number:

- \texttt{iiii} is equal to the address of the first register to be indirectly addressed.
- \texttt{fff} is equal to the address of the last register to be indirectly addressed.
- No value is specified for \texttt{cc}, so a default value of 01 will be used.
Introduction

This section covers two aspects of the Alpha register: advanced manipulations of data in the Alpha register, and the interaction between the user and a program.

- Advanced Alpha register manipulations enhance the standard uses of the Alpha register (such as messages to be displayed and data for text files), and also provide additional characters and the ability to store arbitrary bytes of data.
- Interaction between the user and a program involves the functions that display a message and the functions that interpret the user’s response.
The Alpha and X-Registers

There are three ways to move data between the Alpha register and the X-register:

1. Executing **ARCL X** copies the contents of the X-register into the Alpha register; **ASTO X** copies six characters from the Alpha register into the X-register. (Digits placed in the X-register by **ASTO** are characters and cannot be used in computations.) The functions **ARCL** and **ASTO**, which in general access data registers, are discussed in section 12, “Main Memory.”

2. Executing **XTOA (X to Alpha)** translates a number in the X-register into a character in the Alpha register, and executing **ATOX (Alpha to X)** translates the Alpha character back into its decimal equivalent in the X-register.

3. Executing **ANUM (Alpha number)** searches the Alpha register for a string of digits and returns the string to the X-register as a number. This is the only way to retrieve digits from the Alpha register in a form usable in computations.

Translating Characters and Numbers

The Alpha register can hold a greater variety of characters than can be displayed by the computer, and the display can show a greater variety of characters than you can key in from the Alpha keyboard. The functions **ATOX** and **XTOA** enable you to use the full capabilities of the Alpha register and the display.

Numbers and Characters as Bytes. Recall from section 19 that a byte corresponds both to the status of flags 00 through 07 and to a number from 0 through 255. A byte also corresponds to a character in the Alpha register. Although some bytes cannot be distinguished as characters in the display, they are distinct in the Alpha register itself. The ability of the computer to work with bytes is particularly valuable for controlling peripheral devices.

The null byte 00000000, which corresponds to the decimal value 0, has a special meaning in the Alpha register. Because of this, under some circumstances you can’t retrieve a null byte from the Alpha register. These restrictions are discussed in appendix C, “Null Characters.” All other bytes can be freely stored, manipulated, and recalled from the Alpha register.

Using **XTOA**. With a number from 0 through 255 in the X-register, execute **XTOA** to append the corresponding byte to the right-hand end of the Alpha register. The X-register is unchanged. If the X-register contains an Alpha string, executing **XTOA** appends that string to the Alpha register. Note that a string of Alpha digits in the X-register is appended as those digits, not as the corresponding byte.

The following table shows all the characters that can be displayed, some of which are not available from the Alpha keyboard. To append any of these characters to the Alpha register, place the decimal value in the X-register and execute **XTOA**. All decimal codes from 128 through 255 produce the “starburst” display (all display elements lit). The table also shows the ASCII display characters (but not control characters) for the corresponding decimal values.
### Character Codes

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Using **ATOX**. When you execute **ATOX**, the decimal value of the leftmost byte in the Alpha register is placed into the X-register. This byte is then lost as the contents of the Alpha register shift left, and the stack lifts unless stack lift is disabled. If the Alpha register is empty, executing **ATOX** returns a value of zero.

Any null bytes at the left-hand end of the Alpha register are ignored by **ATOX**. A null byte embedded in an Alpha string will effectively disappear when shifted or rotated into the leftmost position. However, you can detect when a null byte disappears by comparing the length of the Alpha string before and after shifting or rotating the Alpha register, as described in “Finding the Length of a String” below.

**Program Example.** The programs TR and Σ in section 22 use **XTOA** and **ATOX** to encode the number of hours worked each day on a job. Bytes with decimal values from 1 through 240 represent from .1 through 24.0 hours. This is a very compact way to store data; seven bytes, representing a week’s data, consume one extended-memory register in the text file TRECS. The alternative of storing each day’s hours in one register of a data file would offer greater accuracy but would consume seven times the memory.

**Retrieving a Number from the Alpha Register**

The **ANUM** function scans the Alpha register for Alpha digits. If a string of digits is found, it is placed in the X-register and flag 22 (Numeric Data Input) is set. The result in the X-register is a number usable for calculations. If no digits are found, the X-register and flag 22 are unchanged.

If you place two numbers in the Alpha register without separating them, **ANUM** might not distinguish them. For arbitrary characters in the Alpha register, **ANUM** first identifies and then evaluates the digit string.

The string is identified as follows:

- **ANUM** searches from the left end of the Alpha register.
- Characters are ignored until a digit is encountered. If there are immediately preceding radix marks (as currently defined by flag 28) or minus signs, they are considered as part of the string.
- All subsequent minus signs, radix marks, and up to 10 digits are considered as part of the string.
- E’s (for “exponent”) are considered as part of the string only if there are subsequent digits in the string.
- The separator mark (as currently defined by flag 28) is considered as part of the string only if flag 29 (digit grouping) is set.
- **ANUM** considers the string to be complete when any character not considered as part of the string is encountered.
- **ANUM** stops searching when it encounters the null byte if digits have been encountered.
When a string is identified, evaluates it as follows:

- A simple string of digits, for instance 12345, is simply that number, 12345.
- The first E encountered causes the subsequent (one or two) digits to be considered as an exponent. All subsequent E’s are ignored. If there are already more than eight digits in the string, an E is ignored unless there is a radix mark preceding the eighth digit.
- The resulting number in the X-register is positive if there are an even number of minus signs in the string and negative if there are an odd number of minus signs. If an E defines an exponent, this rule applies separately to the exponent string.
- The first radix mark encountered divides the integral and fractional parts of the number in the X-register. All subsequent radix marks are ignored. All radix marks after an E are ignored.
- All separator marks are ignored. (Separator marks are considered as part of the string—and ignored—only if flag 29 is set; if flag 29 is clear, considers the string complete if a separator mark is encountered.)

Manipulating Alpha Strings

There are many sources for the characters in the Alpha register. The information might come from your own text files, from an HP-IL peripheral device, or from the Alpha keyboard. Whatever the source, you can combine the fundamental operations described below to perform complex manipulations on that information.

Searching and Rotating the Alpha Register

Recall that the three functions that move data from the Alpha register to the X-register all work from the left end of the Alpha register:

- ASTO X copies the six leftmost bytes into the X-register.
- ATOX translates the leftmost byte into a number in the X-register.
- ANUM identifies the leftmost complete digit string and translates it into a number in the X-register.

To use all the data in the Alpha register, you can rotate the contents to place a specific byte or string at the left end. To do so, first locate the desired data using (position in Alpha) and then relocate that data to the left end using (Alpha rotate).

Searching the Alpha Register. searches the Alpha register for a target specified in the X-register. A number representing the position of the target is returned to the X-register; the target specification is saved in the LAST X register. The Alpha register is unchanged.
The target can be:

- The decimal value of a byte (0 through 255); or
- An Alpha string placed in the X-register by \texttt{ASTO X}.

Positions in the Alpha register are counted from left to right, starting with position 0. The position of an Alpha string is defined as the position of the first character in the string. If the target is found, the number representing the target’s position replaces the target specification in the X-register. If the target is not found, a value of $-1$ replaces the target specification in the X-register.

Executing \texttt{POSA} finds only the first occurrence of a target. If the target is the null byte (decimal value 0), only a null byte that follows a non-null byte will be found.

**Rotating the Alpha Register.** Executing \texttt{AROT} rotates the contents of the Alpha register by the number of positions given in the X-register. Rotation is to the left if the number in the X-register is positive, or to the right if the number is negative. Only the current contents are rotated, not all 24 positions in the Alpha register. Note that executing \texttt{AROT} immediately after \texttt{POSA} rotates the target to the left end of the Alpha register (assuming the target was found).

Any null bytes that are rotated to the left end of the Alpha register effectively disappear. You can check if null bytes have disappeared by keeping track of the length of the string in the Alpha register.

**Finding the Length of a String**

Executing \texttt{ALENG} returns the number of characters in the Alpha register to the X-register. The Alpha register is unchanged, and the stack lifts unless stack lift is disabled. The following situations suggest ways to use \texttt{ALENG} in conjunction with other Alpha manipulations:

- If you are rotating the Alpha register several times to retrieve numbers with \texttt{ANUM}, you can use \texttt{ALENG} to determine when you’ve completed one full rotation. When the total number of positions rotated equals the number of characters, the contents have returned to their original order.
- If you are moving bytes to the X-register with \texttt{ATOX} and processing them with a subroutine, you can use \texttt{ALENG} first to determine the required number of iterations.
- If you shift or rotate Alpha strings that contain embedded null bytes, you can use \texttt{ALENG} to detect how many (if any) null bytes disappear. Compare the length of the string before and after you shift or rotate the string; if there are fewer characters afterwards, one or more null bytes have disappeared.
Example of Alpha Manipulations

Suppose that a peripheral device places two digit strings, separated by a space, into the Alpha register. This example shows how to retrieve the two numbers, placing the first digit string in the X-register and the second in the Y-register. The comments on the right assume a combined digit string of “123.45 678.90” in the Alpha register.

The first digit string, 123.45, is placed in the X-register. The contents of the Alpha register are unchanged.

The decimal value for a space, 32, is placed in the X-register to be the operand for the next two steps. 123.45 is lifted into the Y-register.

A space is appended to the end of the second digit string. This ensures that the two digit strings won’t be joined when the contents rotate. The Alpha register now contains “123.45 678.90”.

The number 6, the position of the space separating the two digit strings, replaces 32 in the X-register.

The contents of the Alpha register rotate 6 positions to the left. The Alpha register now contains “678.90 123.45”.

The second digit string, 678.90, is placed in the X-register. 6 is lifted into the Y-register and 123.45 is lifted into the Z-register.

The number 123.45 is recalled to the X-register and 678.90 is lifted into the Y-register.

Requesting Input

There are several functions and combinations of functions that request input from the user. In comparing the alternatives there are two issues:

1. Is program execution stopped until a response is given, or does execution eventually continue even if no response is given?
2. What types of response are possible?

The alternatives below are described in terms of these two issues.

Using |PROMPT|

When |PROMPT| is executed, the computer displays the contents of the Alpha register and stops execution. The displayed message should indicate the type of response that is expected: numeric input, Alpha input, a procedure, a keystroke that the program will interpret, or many other possibilities. Before considering the specific examples below, note that there are only two ways to restart program execution:
• You can press [R/S] to restart execution beginning with the program line that follows [PROMPT]; or
• You can branch to a local Alpha label by pressing the corresponding key in the top two rows. Execution resumes at the local Alpha label.

Program Examples. The programs TR and Σ in section 22 use [PROMPT] for a variety of purposes. The most common purpose is to ask you to confirm a displayed number (time or date) or Alpha string (job name). You can respond in two ways: either key in an alternative value and press [R/S], or simply press [R/S] to confirm the displayed value. The programs use flags 22 and 23 to determine whether you keyed in an alternative value.

• If you key a number into the X-register, flag 22 (Numeric Data Input) is set. This flag can be tested later to check whether a number was entered.
• If you key an Alpha string into the Alpha register, flag 23 (Alpha Data Input) is set. This flag can be tested later to check whether an Alpha string was entered.

For example, when TR asks which job you’re starting (lines 135 through 146), it clears flag 23 before prompting and later tests whether flag 23 was set. In addition, the program executes [AON] (Alpha on) before [PROMPT], and [AOFF] (Alpha off) after [PROMPT], so that the Alpha keyboard will be active while execution is halted.

When TR attempts to enlarge the text file TRECS but there are no extended memory registers available, it uses [PROMPT] to display NEED ROOM and halt execution (lines 230 and 231). Your response should be a procedure, namely reducing the size of some other file. After you do so and press [R/S], TR tries again to enlarge TRECS.

The program Σ uses [PROMPT] to display CLEAR D, J? E and halt execution (lines 303, 304, and 305). When you press [D], [J], or [E], execution resumes at the corresponding local Alpha label (LBL D on line 341, LBL J on line 308, or LBL E on line 363).

Using [PSE]

You can use [PSE] (pause) much like [PROMPT], but with the following differences:

• [PSE] delays execution for slightly less than a second. Keying in a number or Alpha string during a pause causes the pause to be repeated; executing a function halts program execution.
• Normally, [PSE] displays the X-register. To display a message that is in the Alpha register, either [AVIEW] or [AON] must precede [PSE].

A string of consecutive [PSE] instructions allows more time to begin a response. Each time [PSE] is executed, the PRGM annunciator blinks once. Digit and character entry are terminated at the end of each pause; if you key in a few digits, wait for more than a second, and then key in more digits, the two groups of digits will be treated as two separate numbers.
Keycodes for **GETKEY** and **GETKEYX**

**GETKEY** returns a positive keycode to the \textit{X-register}. Pressing \textsuperscript{[1]} returns a keycode of 31.

**GETKEYX** returns a positive or negative keycode to the \textit{Y-register}. Pressing \textsuperscript{[1]} first returns a negative keycode for the second key pressed.
Responding to a Pressed Key

Two functions, \texttt{GETKEY} and \texttt{GETKEYX}, wait for you to press a key and then return a keycode representing the key you pressed. The diagram on the facing page shows the keycode for each key.

**Using \texttt{GETKEY}**

Executing \texttt{GETKEY} delays program execution up to 10 seconds. If you press a key within 10 seconds, \texttt{GETKEY} returns the appropriate keycode to the X-register, lifting the stack unless stack lift is disabled. If you don’t press a key, \texttt{GETKEY} returns zero. To display a message while waiting, a program can place the message in the Alpha register and execute \texttt{AVIEW} before executing \texttt{GETKEY}.

Note that all values returned by \texttt{GETKEY} are valid values for local numeric labels. You can use \texttt{GETKEY} and \texttt{XEQ} \texttt{IND X} to branch to the subroutine appropriate to the user’s response. This technique is somewhat like local Alpha labels, but it doesn’t clear the subroutine return stack. First associate each response with a letter and find the keycode of that letter’s key. Then start each response’s subroutine with a numeric label that is the keycode for that letter’s key. If you want the user to press \texttt{Y} for “yes” or \texttt{N} for “no,” start the subroutine for “yes” with \texttt{LBL} 71 and the subroutine for “no” with \texttt{LBL} 41. Then follow \texttt{GETKEY} with \texttt{XEQ} \texttt{IND X}. When \texttt{GETKEY} is executed and the user presses \texttt{Y} or \texttt{N}, either 71 or 41 is returned to the X-register and \texttt{XEQ} \texttt{IND X} will execute the appropriate subroutine.

**Using \texttt{GETKEYX}**

\texttt{GETKEYX} is similar to \texttt{GETKEY} but includes the following features:

**Variable Interval.** A number \(SS.s\) in the X-register, \(|SS.s| \leq 99.9\), specifies how many seconds \texttt{GETKEYX} waits for a response.

**Shifted and Unshifted Keycodes.** \texttt{GETKEYX} returns a keycode to the Y-register. Pressing \texttt{\downarrow} followed by another key produces a negative value of the second key’s keycode. Pressing \texttt{\downarrow} restarts the specified interval; if you don’t press a second key within the second interval, \texttt{GETKEYX} returns zero indicating that no key was pressed.

**Character Codes.** \texttt{GETKEYX} returns a character code (if appropriate) to the X-register, according to the table on page 310. If flag 48 is set (the Alpha keyboard is active), a character code is returned for keys with characters on the Alpha keyboard. If flag 48 is clear, a character code is returned for the digit keys, the radix-mark key, and \texttt{CHS}. For all other cases \texttt{GETKEYX} returns zero to the X-register. Note that a key has different character codes depending on flag 48: keycode 52 corresponds to the letter R (character code 82) on the Alpha keyboard, and to the digit 7 (character code 55) on the Normal keyboard.
**Action on Key Up or Key Down.** The sign of the number $SS.s$ in the X-register determines whether the computer will act when the key is pressed or when the key is released:

- If $SS.s \geq 0$, the computer acts when the key is released. This is the simpler option; the function on the key is never executed and there will be one response each time a key is pressed.

- If $SS.s < 0$, the computer acts when the key is pressed down, making repeating keys possible. For example, a program can contain a loop that places $-.01$ in the X-register, executes \[ \text{GETKEYX} \], calls a subroutine according to the user's response, and then starts over. Executing \[ \text{GETKEYX} \] with a small negative value for $SS.s$ asks, Is there a key down now? If the user holds down a key, the loop containing \[ \text{GETKEYX} \] would call the appropriate subroutine over and over until the key is released.

Releasing the key produces the normal effect of pressing the key; but remember that only [R/S] and [ON] have any effect while a program is running.

\[ \text{GETKEYX} \] lifts the contents of the Y- and Z-registers into the Z- and T-registers, and moves the interval $SS.s$ from the X-register to the LAST X register, as illustrated below.

![Diagram](image)

**Producing Output**

The following functions allow the computer to display a message and generate audible signals.

**Using [AVIEW]**

When a program executes [AVIEW], the computer displays the contents of Alpha register until [CLD] (clear display) clears the display or another message is displayed. Executing [AVIEW] might also stop program execution, depending on the status of flags 21 (Printer Enable) and 55 (Printer Existence) as described in appendix D.
Using **VIEW**

To display the contents of $R_{nn}$ without recalling the register’s contents to the X-register, execute **VIEW** $nn$. The register to be viewed can also be specified indirectly. When a program executes **VIEW** $nn$, the computer displays the contents of $R_{nn}$ until **CLD** clears the display or another message is displayed. Like **AVIEW**, **VIEW**’s operation is affected by flags 21 and 55.

Using **PSE**

**PSE** can be used to briefly display a message. When **PSE** is executed, program execution halts for slightly less than a second.

- If the display already contained a message (rather than the program execution indicator), this message remains displayed.
- If there was no message in the display and the Alpha keyboard is active, the contents of the Alpha register are displayed.
- Otherwise, the contents of the X-register are displayed.

Using **TONE** and **BEEP**

Executing **TONE** $n$ produces a single audible tone with a pitch specified by the value of $n$. The lowest pitch is produced when $n = 0$, the highest when $n = 9$.

Executing **BEEP** produces a fixed sequence of four tones.
Introduction

This section contains programs that can help you keep track of how you spend your time. Instructions appear below under “Using the Programs” and are followed by an explanation of each program. When you understand what these programs do, you can study the annotated program listings to understand how they work.

Although you may never need to write programs as involved as these, you may find some of the techniques useful in your own applications. Each program is divided into major parts that correspond to major aspects of the program’s operation. Each major part is then divided into routines—sequences of program lines that perform a basic task. You can learn a great deal about the individual functions in a routine by observing how they work together to perform the task, and you may find some of these routines useful in your own programs.
Program Examples

Sections 19, 20, and 21 refer to these programs to illustrate certain programming functions and techniques. The topics discussed in these “Program Examples” include:

- Data Input and Error Ignore flags (“Control Flags” in section 19).
- Local Alpha labels and local label searches (“Local Labels” in section 20).
- Looping using conditional functions and using loop-control functions (“Looping” in section 20).
- Efficient storage of data (“Translating Characters and Numbers” in section 21).
- Program/user interaction (“Using [PROMPT]” in section 21).

Using the Programs

There are four processes involved in keeping track of your time:

- Loading the programs TR (time records) and Σ (summary).
- Creating the files that will hold the information. You will need to do this only once, unless you later clear or purge these files or reset the computer.
- Updating the information. You will need to do this each time you start or stop working on a job.
- Summarizing the information. You can do this whenever you want a record of how you’ve spent your time.

The steps you should follow for each process are given below.

Loading the Programs

This section contains listings for the programs TR and Σ. To key in the programs, follow the instructions under “Loading a Program” in section 18.

Bar code for the programs appear in appendix J, “Bar Code for Programs.” To enter the programs using an HP 82153 Wand, follow the instructions in the owner’s manual for the wand.

Creating the Files

Creating the File LAST. This data file will hold three values describing the situation when you last started or stopped working: last job, the name of the job you started or stopped; last time, the time of day; and last date. To begin keeping time records you need to create this file and give initial values for the time and date.

1. Key LAST into the Alpha register.
2. Key 3 into the X-register.
3. Execute [CRFLD]. This creates a data file named LAST that contains three registers. The pointer is set to the first register.
4. Key 1 into the X-register.
5. Execute \texttt{STO} 02. The initial value for \textit{last time} will be 1.
6. Execute \texttt{DATE}. This returns the current date to the X-register. (The contents of the X-register differ from the resulting display.)
7. Execute \texttt{STO} 03. The initial value for \textit{last date} will be the current date.
8. Key 1.003 into the X-register.
9. Execute \texttt{SAVERX}. This copies the contents of R_{01}, R_{02}, and R_{03} into LAST. (The initial value for \textit{last job} will be the current contents of R_{01}. You will replace this with a real name when you first execute TR.)

Creating the File TRECS (time records). This text file will contain a pair of records for each job that you work on. To begin keeping time records you need only to create this file; the updating program TR will automatically create the necessary records within TRECS.

1. Key TRECS into the Alpha register.
2. Calculate $j (w + 1)$, where $j$ is the number of jobs and $w$ is the number of weeks for which you want to keep records. This is an estimate of the number of registers TRECS will require; it can be a rough estimate because the program TR will automatically add registers to TRECS if necessary. Key this estimate into the X-register.
3. Execute \texttt{CRFLAS}. This creates the text file TRECS containing the estimated number of registers.

Creating the First Records. Next you need to execute TR once to create a pair of records in TRECS for your first job. (One record is for the job's name; the other record is the job's time record.) Unless you're really starting work on that job now, you'll want to repeat TR immediately to indicate that you're stopping. No elapsed time will be recorded if you stop within three minutes of when you started.

1. Execute TR.
2. When the computer displays \textbf{JOB NAME} = ??, key in the name of your first job and press \texttt{R/S}. (You don’t need to press \texttt{ALPHA} before or after keying in the name.)
3. When the computer displays \textbf{START job}?, where job is the job name you just keyed in, press \texttt{R/S} to confirm.
4. When the computer asks \textbf{NEW JOB}?, press \texttt{R/S}. This confirms that the name you keyed in isn’t a misspelled existing name. The computer now creates the pair of new records for your job.
5. When the computer asks \textbf{START NOW}?, press \texttt{R/S} to confirm.

When zero returns to the display, you have successfully completed your first execution of TR. You can indicate that you’re stopping now by repeating TR.

6. Press \texttt{R/S} to start TR again. (Executing TR twice in a row is common when you stop work on one job and immediately start on another.)
7. When the computer displays \textbf{STOP NOW}?, press \texttt{R/S} to confirm.
When zero returns to the display, you’re ready to use TR according to the rules for general use that follow.

**Using TR**

Execute the program TR each time that you start or stop work on a job. The program will offer you different choices depending on whether you’re starting or stopping; these choices are described below under “Starting Work” and “Stopping Work.” The following instructions apply to both situations.

**General Instructions.**

- There are three variables that appear in the instructions for starting and stopping:

  - *Last job* is the name of the job that you started or stopped when you last executed TR. This value changes only when you key in a different job name.
  
  - *Last time* is the time of day that you started or stopped most recently. This value changes each time you execute TR. (The time you start is stored as a negative number; a value of 1 is stored when you stop. When you next execute TR, the sign of the stored value of *last time* indicates whether you started last time and so are stopping now, or vice versa.)
  
  - *Last date* is the date that you started or stopped most recently. This value is handled automatically by TR.

- When the computer displays a question, it is usually indicating a default value for a name or time. To confirm the displayed value, just press [R/S]. To select an alternative value, key in that value before you press [R/S].

- To key in the time of day, you can use either a 24-hour format:

  \[
  HH.MM = HH \text{ hours } (0 \leq HH < 24) \text{ and } MM \text{ minutes } (0 \leq MM < 60)
  \]

  or else you can enter a time between noon and midnight as a negative number:

  \[
  -HH.MM = 12 + HH \text{ hours } (0 \leq HH < 12) \text{ and } MM \text{ minutes } (0 \leq MM < 60)
  \]

- If the computer displays *JOB NAME = ?*, key in a job name and press [R/S]. (You don’t need to press [ALPHA].) The computer now assumes that you’re starting work on that job. This will occur only the first time you execute TR or if you just cleared the pair of records in TRECS for last job.

- If the computer displays *NEED ROOM*, reduce the size of an extended memory file other than LAST or TRECS by two or more registers, and then press [R/S]. This will occur when the computer it is unable to enlarge TRECS because there are no registers available in extended memory.
Starting Work.

1. Execute TR.

2. When the computer displays START last job?, you can either:
   - Press \[ R/S \] to confirm that you’re starting again on the same job as last time. The computer then skips to step 4.
   - Key in an alternative job name and press \[ R/S \]. (You don’t need to press \[ ALPHA \].) If you key in the name of an existing job—one that you’ve already used with TR—the computer skips to step 4.

3. If the computer doesn’t recognize the job name you keyed in, it displays NEW JOB? You can then either:
   - Press \[ R/S \] to confirm that you keyed in the name of a new job. The computer will create a new pair of records in TRECS for this new job.
   - Key in an existing job name and press \[ R/S \]. (You don’t need to press \[ ALPHA \].) If you misspelled the job name in step 2, this is your chance to correct your error.

4. When the computer displays START NOW? you can either:
   - Press \[ R/S \] to confirm that you’re starting now.
   - Key an alternative starting time into the X-register and press \[ R/S \].

The program is done when the display shows zero.

Stopping Work.

1. Execute TR.

2. a. If today’s date is the same as last date, the computer displays STOP NOW? You can then either:
   - Press \[ R/S \] to confirm that you’re stopping work now.
   - Key an alternative stopping time into the X-register and press \[ R/S \].

b. If today’s date differs from last date, the computer displays PAST 24:00? You can then either:
   - Press \[ R/S \] to confirm that you worked past midnight. The computer then updates the job’s time record for the day you started (from last time through midnight); changes the values for last time and last date to indicate that you started work at 00:00 hours on the next day; and then goes back to step 2a or 2b.
   - Key an alternative stopping time into the X-register and press \[ R/S \]. (You would do this if you stopped work the same day you started, but forgot to execute TR.)

3. If you keyed in a stopping time that is earlier than the starting time, the computer displays START > STOP and goes back to step 2a or 2b.

The program is done when the display shows zero. If you’re starting on a different job now, you can press \[ R/S \] to execute TR again.
Using $Σ$

The program $Σ$ has two stages, summarizing and clearing. The computer first asks for the dates you want summarized and produces the summary; then you are offered the options of clearing time records for all jobs before a specified date or else clearing an entire job.

You can summarize any period for which time records exist, including parts of the entire period. For example, suppose that you accumulate time records for a month. During that month you could summarize each week on Monday of the following week. At the start of the following month you could then summarize the past month, clear the time records for that month, and start the cycle again.

Instructions for the two stages appear under “Summarizing Time Records” and “Clearing Time Records.” The following instructions apply to both stages.

General Instructions.

- There are two variables that appear in the instructions for summarizing and clearing.

  $Earliest\ date$ is the date of the oldest time record to be summarized or cleared. The default value is the earliest date for which time records exist. When you're summarizing you can specify a later date (as long as it isn’t later than $most\ recent\ date$).

  $Most\ recent\ date$ is the date of the latest time record to be summarized or cleared. The default value is the most recent date for which time records exist. When you're summarizing or clearing you can specify an earlier date (as long as it isn’t earlier than $earliest\ date$).

- When the computer displays a question involving a date, it is indicating the current value for $earliest\ date$ or $most\ recent\ date$. To confirm the displayed date, just press $\text{[R/S]}$. To select an alternative date, key in that date before you press $\text{[R/S]}$.

- If the computer displays $ILLEGAL\ DATE$, the number you keyed in either represents a date before $earliest\ date$ or after $most\ recent\ date$, or else it isn’t a valid date at all. In the latter case, be sure you're using the date format ([D/M/Y] or [M/D/Y]) currently in effect.

Summarizing Time Records.

1. If you’re using an HP 82143A or HP 82162A printer, switch the printer to MAN (manual mode).
2. Execute $Σ$. ($Σ$ is $\text{[F]}$ on the Alpha keyboard.)
3. When the computer displays $FROM\ earliest\ date?$, you can either:
   - Press $\text{[R/S]}$ to confirm this date.
   - Key a later date into the X-register and press $\text{[R/S]}$. The computer will then repeat this step to confirm the later date.
4. When the computer displays $THROUGH\ most\ recent\ date?$, you can either:
   - Press $\text{[R/S]}$ to confirm this date.
   - Key an earlier date into the X-register and press $\text{[R/S]}$. The computer will then repeat this step to confirm the earlier date.
5. If the computer displays **PACKING** (perhaps very quickly) and **TRY AGAIN**, press \([R/S]\). This will occur if the program attempted to allocate more main memory registers to data storage than the number of free registers available. If the automatic packing freed enough registers, the program will run smoothly after you press \([R/S]\); but if there are still too few free registers available, the computer will repeat the message **TRY AGAIN**. In this case you should either:

- Execute \(\Sigma\) again (starting over with step 1), specifying a shorter summary period than before.
- Clear a program, alarms, or User keyboard assignments; execute **PACK** or **GTO \(\Box \Box \Box \)**; and then execute \(\Sigma\) again (starting over with step 1), specifying the same summary period as before.

6. The computer produces a summary of time records for the period you have specified. The following sample shows a printed summary. If no printer is present, the computer displays each line of the heading for about one second; each subsequent line is displayed until you press \([R/S]\), giving you an opportunity to copy the summary.

<table>
<thead>
<tr>
<th>DATE</th>
<th>HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/01/83</td>
<td>8.2</td>
</tr>
<tr>
<td>07/02/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/03/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/04/83</td>
<td>5.5</td>
</tr>
<tr>
<td>07/05/83</td>
<td>6.5</td>
</tr>
<tr>
<td>07/06/83</td>
<td>6.8</td>
</tr>
<tr>
<td>07/07/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/08/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/09/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/10/83</td>
<td>0.0</td>
</tr>
<tr>
<td>07/11/83</td>
<td>6.3</td>
</tr>
<tr>
<td>07/12/83</td>
<td>3.6</td>
</tr>
<tr>
<td>07/13/83</td>
<td>2.0</td>
</tr>
<tr>
<td>07/14/83</td>
<td>4.5</td>
</tr>
<tr>
<td>07/15/83</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**TOTAL** 44.1

**Mondays**

**Daily hours for JOB 1.**
### JOB 2

<table>
<thead>
<tr>
<th>Date</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/01</td>
<td>0.0</td>
</tr>
<tr>
<td>07/02</td>
<td>0.0</td>
</tr>
<tr>
<td>07/03</td>
<td>0.0</td>
</tr>
<tr>
<td>07/04</td>
<td>3.1</td>
</tr>
<tr>
<td>07/05</td>
<td>1.8</td>
</tr>
<tr>
<td>07/06</td>
<td>1.4</td>
</tr>
<tr>
<td>07/07</td>
<td>8.2</td>
</tr>
<tr>
<td>07/08</td>
<td>8.3</td>
</tr>
<tr>
<td>07/09</td>
<td>0.0</td>
</tr>
<tr>
<td>07/10</td>
<td>0.0</td>
</tr>
<tr>
<td>07/11</td>
<td>1.7</td>
</tr>
<tr>
<td>07/12</td>
<td>5.3</td>
</tr>
<tr>
<td>07/13</td>
<td>6.1</td>
</tr>
<tr>
<td>07/14</td>
<td>3.6</td>
</tr>
<tr>
<td>07/15</td>
<td>7.8</td>
</tr>
</tbody>
</table>

**Total:** 47.3

### Mondays

#### Daily hours for JOB 2.

### SUMMARY

<table>
<thead>
<tr>
<th>Date</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/01</td>
<td>8.2</td>
</tr>
<tr>
<td>07/02</td>
<td>0.0</td>
</tr>
<tr>
<td>07/03</td>
<td>0.0</td>
</tr>
<tr>
<td>07/04</td>
<td>8.6</td>
</tr>
<tr>
<td>07/05</td>
<td>8.3</td>
</tr>
<tr>
<td>07/06</td>
<td>8.2</td>
</tr>
<tr>
<td>07/07</td>
<td>8.2</td>
</tr>
<tr>
<td>07/08</td>
<td>8.3</td>
</tr>
<tr>
<td>07/09</td>
<td>0.0</td>
</tr>
<tr>
<td>07/10</td>
<td>0.0</td>
</tr>
<tr>
<td>07/11</td>
<td>8.0</td>
</tr>
<tr>
<td>07/12</td>
<td>8.9</td>
</tr>
<tr>
<td>07/13</td>
<td>8.1</td>
</tr>
<tr>
<td>07/14</td>
<td>8.1</td>
</tr>
<tr>
<td>07/15</td>
<td>8.5</td>
</tr>
</tbody>
</table>

**Total:** 91.4

### Mondays

#### Daily hours for JOB 1 and JOB 2 combined.

#### Total hours for JOB 2.
Clearing Time Records.

7. When the summary is completed, the computer displays CLEAR D, J? E. This is a menu that offers three choices; indicate your choice by pressing [D], [J], or [E].

[D] = Clear days. When the computer displays THROUGH most recent date? you can either:

- Press [R/S] to confirm the displayed date. The computer will clear the time records for all jobs for this date and earlier, then return to the menu CLEAR D, J? E.
- Key an earlier date into the X-register and press [R/S]. The computer will ask you to confirm the earlier date.

[J] = Clear job. When the computer displays NAME OF JOB?, key in the name of the job to be cleared and press [R/S]. (You don’t need to press [ALPHA].)

- If the computer finds a job with the name you keyed in, it clears both the name and the time record for that job, then returns to the menu CLEAR D, J? E.
- If the computer doesn’t find a job with the name you keyed in, it displays NO SUCH NAME and returns to the menu CLEAR D, J? E.

[E] = Exit. This restores the previous flag status (and the options it represents) and then terminates Σ.

8. Press [GTO] - - or else execute a different program. This is necessary because the [D], [J], and [E] keys will act as described above as long as Σ is the current program and the User keyboard is active.

Files Used To Keep Time Records

Two extended memory files are used to keep time records. One is an text file named TRECS which contains a pair of records for each job. The other is a data file named LAST which contains information from the last time you started or stopped working.
Text File TRECS

TRECS holds the name and time record for each job in a sequential pair of records, as shown in this diagram.

<table>
<thead>
<tr>
<th>Record Number</th>
<th>Record Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>Name of the first job.</td>
</tr>
<tr>
<td>001</td>
<td>Time record for the first job.</td>
</tr>
<tr>
<td>002</td>
<td>Name of the second job.</td>
</tr>
<tr>
<td>003</td>
<td>Time record for the second job.</td>
</tr>
<tr>
<td></td>
<td>:</td>
</tr>
<tr>
<td>n</td>
<td>Name of the ( n/2 + 1 ) job.</td>
</tr>
<tr>
<td>( n + 1 )</td>
<td>Time record for the ( n/2 + 1 ) job.</td>
</tr>
<tr>
<td></td>
<td>:</td>
</tr>
</tbody>
</table>

Each character in a time record is a byte whose decimal value represents the number of hours you spent on that job for a particular day. The first byte represents the hours for the current day and each subsequent byte represents the hours for each preceding day. This arrangement allows time records to be of different lengths—the \( n \)th byte in each time record represents the same day for a different job. The time record for an older job, one for which you have records for a longer period, will be longer than a time record for a newer job. When you create a new job, its pair of records is added to the end of TRECS. This means that the first job in TRECS is the oldest job, and its time record is as long or longer than any other.

The number of hours per day is calculated to one decimal place. This value, multiplied by 10, is the decimal value of the byte that encodes those hours. The following table shows some examples of this system of encoding.

<table>
<thead>
<tr>
<th>Time (hours/minutes)</th>
<th>Time (decimal hours)</th>
<th>Byte (decimal value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 hrs. 20 min.</td>
<td>3.3</td>
<td>33</td>
</tr>
<tr>
<td>5 hrs. 30 min.</td>
<td>5.5</td>
<td>55</td>
</tr>
<tr>
<td>7 hrs. 0 min.</td>
<td>7.0</td>
<td>70</td>
</tr>
<tr>
<td>10 hrs. 42 min.</td>
<td>10.7</td>
<td>107</td>
</tr>
<tr>
<td>13 hrs. 15 min.</td>
<td>13.3</td>
<td>133</td>
</tr>
</tbody>
</table>

There are two bytes that are exceptions to this system.

- Because a null byte (decimal value = 0) can disappear in the Alpha register, “no hours” is encoded by the byte having a decimal value of 254.
- The last byte in each time record is an extra “end of time record” byte having a decimal value of 255.
Data File LAST

The second file used to keep time records is a data file named LAST which holds information about the last time that you started or stopped working on a job.

<table>
<thead>
<tr>
<th>Register Number</th>
<th>Register Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>Last job = Name of the last job started or stopped.</td>
</tr>
<tr>
<td>001</td>
<td>Last time = Time when you last started or stopped.</td>
</tr>
<tr>
<td>002</td>
<td>Last date = Date when you last started or stopped.</td>
</tr>
</tbody>
</table>

_Last job._ Job names are limited to six characters because they must fit in a register. If you start and stop work several times on the same project, you won’t need to specify its name each time you start because its name is stored in LAST. One job’s name shouldn’t be identical to the beginning of another job’s name. For example, if one job is named ABCD, don’t name another job ABC. (However, you can name another job BCD.)

_Last time._ The updating program TR stores a negative value for _last time_ when you’ve started working and a positive value when you’ve stopped. This will indicate whether you’re starting or stopping work when you next execute TR. If you always remember to execute TR when you actually start or stop work, you’ll never need to key in the time.

_Last date._ When the date stored in LAST differs from the current date, “no hour” bytes are automatically added to the time record for each job. This keeps the time records properly ordered by date.

The program TR copies the contents of these three registers in LAST into $R_{01}$ through $R_{03}$ in main memory whenever you start or stop work. The program uses these values in its operation, updates these values, and then copies the updated values back to LAST.

Explanation of TR

The program TR contains several major parts.

- The main routines recall the contents of LAST from extended memory, evaluate what should be done, execute the appropriate routines, and copy the updated values into LAST in extended memory.
- The routines for stopping work ask when you stopped, calculate the number of hours you worked, update the appropriate time record in TRECS, and update _last time_.

• The routines for a new date add a byte representing “no hours” to each time record and update last date.

• The routines for starting work ask which job you’re starting, when you’re starting, and then update last job and last time.

In addition there are three minor subroutines at the end of TR to search TRECS for a specified job name, to convert a time value, and to enlarge the file TRECS.

**Registers and Flags Used by TR**

The program TR uses the following data storage registers and user flags in its operation. Refer to these tables as you read the program listing.

**Registers and Their Contents for TR**

<table>
<thead>
<tr>
<th>Register Number</th>
<th>Register Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Flag status at start.</td>
</tr>
<tr>
<td>01</td>
<td>Last job.</td>
</tr>
<tr>
<td>02</td>
<td>Last time.</td>
</tr>
<tr>
<td>03</td>
<td>Last date.</td>
</tr>
<tr>
<td>04</td>
<td>Decimal value of byte representing number of hours worked.</td>
</tr>
</tbody>
</table>

**Conditions Represented by User Flags in TR**

<table>
<thead>
<tr>
<th>Flag Number</th>
<th>Condition Represented by Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Clear = Job name found in TRECS.</td>
</tr>
<tr>
<td></td>
<td>Set = Job name not found in TRECS.</td>
</tr>
<tr>
<td>02</td>
<td>Clear = Stopping work now.</td>
</tr>
<tr>
<td></td>
<td>Set = Starting work now.</td>
</tr>
<tr>
<td>03</td>
<td>Clear = Same date (last date = current date).</td>
</tr>
<tr>
<td></td>
<td>Set = New date (last date ≠ current date).</td>
</tr>
</tbody>
</table>
Program Listing for TR

Main Routines. These routines recall data from the last time you executed TR, determine what to do this time, execute the appropriate routines, store the updated data, and conclude the execution of TR.

Lines 01 through 26 recall last job, last time, and last date. Lines 02 through 05 ensure that there are at least five registers allocated to data storage. Lines 06 through 09 save a copy of the current flag status before selecting the display format and clearing the Printer Enable flag. Lines 10 through 14 copy last job into R01, last time into R02, and last date into R03. (These values have been stored in the file LAST since you last executed TR.) Lines 15 and 16 select TRECS as the current file in extended memory. Line 17 calls a subroutine on line 194 that checks if TRECS still contains the job name last job and, if so, lines 18 and 19 branch to line 27. If you cleared last job from TRECS since you last executed TR, lines 20 through 23 prompt you for a valid job name. Lines 21 and 23 automatically activate and deactivate the Alpha keyboard. Line 24 changes last name to the name you keyed in, and lines 25 and 26 set last time to indicate that you stopped last time (and so are starting this time).
Lines 27 through 52 direct the remainder of TR's execution. Lines 28 through 31 clear flag 02 if you're stopping work, or else set flag 02 if you're starting work. (If you started work last time, TR stored a negative value for last time; if you stopped work last time, TR stored a value of 1 for last time.) Lines 32 through 36 clear flag 03 if last date is the current date, or else set flag 03 if last date differs from the current date. Lines 37 through 42 direct overall execution of the program. If you're stopping work, lines 37 and 38 call the subroutine which begins on line 58. If one or more days have passed since you last executed TR, lines 39 and 40 branch to a routine beginning on line 106 (which adds another byte to each time record and then branches to line 27). If you're starting work, lines 41 and 42 call the subroutine that begins on line 135. Lines 43 through 51 conclude the execution of TR. Lines 43 through 47 copy the current values for last job, last time, and last date into the file LAST, to be saved until you execute TR again. Lines 48 and 49 restore the previous flag status (and the options it represents), and line 50 clears the flag-status data from the X-register. Line 51 stops program execution and line 52 branches to line 01; this enables you to repeat TR simply by pressing [R/S].

Stopping Work. These routines update the time record for last job when you stop work. Normally only the second and third routines will be executed; the first routine is an error routine, and the fourth routine is executed only when you stop work on a different date from when you started.

Lines 53 through 57 display an error message. If you key in a stopping time that is earlier than the time you started, line 72 branches here to display an error message before beginning again.

Lines 58 through 63 determine the time you stopped work. If you're stopping work on a different day from when you started, lines 59 and 60 branch to line 96. Lines 61, 62, and 63 ask if you're stopping at the current time and then stop execution; if you key in an alternative time, it replaces the current time in the X-register.
Section 22: Programs for Keeping Time Records

Lines 64 through 95 update the byte for last date in last job’s time record. If you keyed in a negative time to indicate “p.m.,” lines 65 and 66 call a subroutine on line 216 that converts the time to a 24-hour format. If the stopping time is midnight, lines 67 and 68 place 24 in the X-register. Lines 69 and 70 subtract the time you started from the time you stopped: line 69 recalls last time, which in this case is the time you started and so is negative; then line 70 adds the time you stopped and (the negative of) the time you started, which calculates the number of hours worked. If the result is negative, lines 71 and 72 branch to an error routine on line 53. Lines 73 through 77 store the number of hours worked as a byte value: lines 73 and 74 convert the number from hours-minutes-seconds format to a decimal number with one decimal place; lines 75 and 76 convert this decimal number to a byte value; and line 77 stores the byte value in R04. Line 78 calls a subroutine on line 194 that locates the time record for last job, and then lines 79 and 80 place in the X-register the decimal value of the first byte, which represents the hours worked previously on last date. To this byte value lines 81 through 85 add the byte value for hours just worked; lines 83, 84, and 85 adjust the result in case the previous byte value was 254 (“no hours”). Lines 86 and 87 place in the Alpha register the byte whose value is in the X-register. Lines 88, 89, and 90 locate the byte for last date, and lines 91, 92, and 93 replace the old byte with the updated byte. Line 94 stores a value of 1 in last time. Line 95 returns execution to line 39 if the updating process is complete; if you worked past midnight and this updates only through midnight, execution returns to line 104.

Lines 96 through 105 ask if you worked past midnight. Line 60 branches here if you’re stopping work on a different day from when you started. Lines 97 through 100 ask if you worked past midnight; if you key in an alternative time, it replaces 24 in the X-register and lines 101 and 102 branch to line 64. Line 103 calls a subroutine on line 64 that updates the byte for last date in last job’s time record, from the time you started until midnight; then lines 104 and 105 give last time a value of zero to indicate starting at midnight.
Adding Bytes for a New Date. When you execute TR for the first time each day, the program executes these routines to add one byte to the start of each job’s time record. This is necessary to maintain the proper correspondence between a byte’s position in a time record and the date it represents.

Lines 106 through 115 ensure that there are enough bytes available in TRECS to add one byte to each time record. Line 107 returns \( n \), the number of available bytes. Suppose that these \( n \) bytes were added to the time records for the first \( n \) jobs; then the \( n + 1 \) job is the first that won’t receive a byte. Lines 108 and 109 return \( 2n \), which is the pointer value for the name of the \( n + 1 \) job. Lines 110 and 111 check if there actually is an \( n + 1 \) job name; if not, there are enough bytes available and lines 112 and 113 branch to line 116. Line 114 calls a subroutine on line 221 that enlarges TRECS, and line 115 branches to line 106.

Lines 116 through 122 prepare to add one byte to each time record. Lines 117, 118, and 119 place the byte for “no hours” in the Alpha register. Lines 120 and 121 set the pointer to the first character position in the first time record. Line 122 sets the Error Ignore flag; the program will execute the loop that follows until an error clears this flag.

Lines 123 through 134 add one byte to each time record. Line 124 inserts the byte for “no hours” at the current pointer position. Lines 125, 126, and 127 attempt to set the pointer to the first character position in the next time record. If there is another time record, lines 128 and 129 branch to line 123. When all time records have received a byte, lines 130 through 133 add one day to last date to reflect the new byte added to each time record. Line 134 branches to line 27. (The updated value of last date will be compared to the current date, and the program will execute these routines again if necessary.)

Starting Work. These routines determine which job and what time you’re starting work. If you’re starting the same job you worked on last time, the first routine is executed. If you key in the name of an existing job—one that you’ve already used with TR—the second and third routines are also executed. If you key in the name of a new job, the fourth, fifth, and sixth routines are also executed. In all cases the last routine is executed to determine the starting time.
Lines 135 through 146 ask if you're starting the same job that you last worked on. Lines 136 through 141 display **START last job?** Lines 140 and 142 automatically activate and deactivate the Alpha keyboard. If you were prompted for a valid job name in the initial routine because the stored value for *last job* wasn't valid, lines 143 and 144 branch to line 149. If you just confirmed that you're starting *last job*, lines 145 and 146 branch to line 183. (If you keyed in an alternative job name now, execution continues with the next routines.)

Lines 147 and 148 make the job name you keyed in the provisional value of *last job*.

Lines 149 through 152 check the alternative job name. Line 150 calls a subroutine on line 194 that clears flag 01 if the job name exists in TRECS. If the name exists, lines 151 and 152 branch to line 183.

Lines 153 through 160 check that you intended to key in the name of a new job. Lines 154 through 157 display **NEW JOB?** Lines 156 and 158 automatically activate and deactivate the Alpha keyboard. If you key in a job name (because you had previously misspelled the name of an existing job), lines 159 and 160 branch to line 147.

Lines 161 through 169 create a record containing the name of the new job. Lines 162 and 163 place the name in the Alpha register. Lines 164 through 167 try to append the name to TRECS and then, if successful, branch to line 170. If there isn’t enough room in TRECS to append the name, line 168 calls a subroutine on line 221 that enlarges TRECS, and then line 169 branches to line 161 to try again.
Lines 170 through 182 create a time record for the new job. Lines 171 through 176 place a “no hours” byte and an “end of time record” byte in the Alpha register. Lines 177 through 180 try to append these bytes to TRECS and then, if successful, branch to line 183. If there isn’t enough room in TRECS to append the new time record, line 181 calls a subroutine on line 221 that enlarges TRECS, and then line 182 branches to line 170 to try again.

Lines 183 through 193 ask you the starting time. Lines 184, 185, and 186 display START NOW?: if you key in an alternative time, that time replaces the current time in the X-register. If you keyed in a negative time to indicate “p.m.,” lines 187 and 188 call a subroutine on line 216 that converts the time to 24-hour format. If you keyed in 24 to indicate midnight, lines 189 and 190 change this value to zero. Lines 191 and 192 make the starting time the new value of last time, negative to indicate it’s a starting time. Line 193 returns execution to line 43.

Searching TRECS for a Job. The program calls this subroutine for two purposes: lines 17 and 150 call it to determine whether a job exists, and line 78 calls it to locate a job known to exist.

Lines 194 through 199 prepare to search TRECS for a job name. Lines 195 and 196 place the job name in the Alpha register. Line 197 sets flag 01 to indicate that the job name hasn’t been found; the next routine will clear flag 01 if it finds the name. Lines 198 and 199 set the pointer to the first character in the first job name in TRECS.
Lines 200 through 215 search TRECS for the job name. Line 201 searches TRECS, starting at the current pointer location. If the job name isn’t found, lines 202 and 203 return execution to line 18 or 151 with flag 01 still set. Lines 204 through 208 set the pointer to the first character in the next record, which generally will be the job’s time record. However, bytes in a time record might spell out the name by coincidence. To check whether line 201 actually found a job name, lines 209 through 212 check whether the pointer value returned by line 201 is the first character in an even-numbered record. If not, line 213 branches to line 199. Lines 214 and 215 clear flag 01 to indicate that the job name exists, and then return execution to line 18, 79, or 151.

Converting to 24-Hour Format.

Lines 216 through 220 convert a negative number (representing a time after noon) into 24-hour format. The program calls this subroutine on lines 66 and 188.

Enlarging TRECS. The program calls this subroutine when there isn’t enough room in TRECS to add a byte to each time record or to append a new record for a new job.

Lines 221 through 233 add one register to TRECS. This subroutine is called by lines 114, 168, and 181. Lines 222 through 225 calculate the desired total number of registers. Lines 226 through 229 try to change the size of TRECS to the desired total and then, if successful, return execution to line 115, 169, or 182. If there isn’t a register available in extended memory, lines 230 and 231 display an error message and stop execution. After you reduce the size of another file and press [R/S], line 232 branches to line 221 to try again.
**Explanation of Σ**

The program Σ first determines the desired summary period and produces the summary, and then enables you to clear an entire job or clear all time records for a specified period.

**Registers and Flags Used by Σ**

The program Σ uses the following data storage registers and flags in its operation. Refer to these tables as you read the program listing.

<table>
<thead>
<tr>
<th>Registers and Their Contents for Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Register Number</strong></td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>R₀₀</td>
</tr>
<tr>
<td>R₀₁</td>
</tr>
<tr>
<td>R₀₂</td>
</tr>
<tr>
<td>R₀₃</td>
</tr>
<tr>
<td>R₀₄</td>
</tr>
<tr>
<td>R₀₅</td>
</tr>
<tr>
<td>R₀₆</td>
</tr>
<tr>
<td>R₀₇</td>
</tr>
<tr>
<td>R₀₈</td>
</tr>
<tr>
<td>···</td>
</tr>
<tr>
<td>Rₙₙ</td>
</tr>
</tbody>
</table>

Each of the numbers in R₀₈ through Rₙₙ has the form xxx.yyy. The integer part is a byte value representing xxx hours for one job. The fractional part is a byte value representing yyy.y hours for all jobs combined.

<table>
<thead>
<tr>
<th>Conditions Represented by User Flags in Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flag Number</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>00</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>01</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Program Listing for $\Sigma$

Lines 01 through 07 form the initial routine. Lines 02 and 03 store the current flag status in R00. Line 04 disables the printer (if present). Lines 05 and 06 place in R01 the pointer value for first job/most recent date. Line 07 indicates that the program is summarizing now.

Determining the Dates. These routines determine the period to summarize. If you later choose to clear days, the program uses most of these routines again to determine the period to clear. The status of flag 00 indicates whether the program is summarizing or clearing.

Lines 08 through 32 calculate the default dates. (When the program is clearing, line 343 calls this part of the program as a subroutine.) Lines 10 through 13 recall last date. If the program is summarizing now, lines 14 and 15 make last date the default value for most recent date in R02; if the program is clearing now, the most recent date summarized remains in R02 as the default value. In either case, last date remains in the stack to calculate earliest date. To make this calculation, lines 16 through 27 locate the “end of time record” byte (decimal value 255) in the first time record and use that character-pointer value to calculate the difference in days between last date and earliest date. (Remember that the first time record is the oldest time record.) Lines 16 through 26 return the number of bytes that precede the end-of-record byte. When line 27 subtracts this number from 1 (left on the stack from line 17), the result is negative to indicate going backwards in time. Line 28 then calculates earliest date. Line 29 makes this date the default value in R03, and line 30 places this date in R04 to appear in the first prompt. If the program is clearing, lines 31 and 32 branch to line 45; if the program is summarizing, execution continues to the next routine.
Lines **33 through 44** prompt you for the earliest date to summarize. Lines **34 through 36** ask if the date in \( R_04 \) is the date you want, calling the subroutine on line 62. If you accept the date in \( R_04 \), lines **37 and 38** branch to line 45. If you key in an alternative date, line **39** calls the subroutine on line 71 to test your date. (This subroutine places your date in \( R_04 \) and then clears flag 01 if your date is legal or else clears flag 01 if your date is illegal.) If your date is legal, lines **40 and 41** branch to line 33 to ask you to confirm your date. If your date is illegal, lines **42, 43, and 44** place the default value in \( R_04 \) again and then branch to line 33.

Lines **45 through 49** link the prompting routines. Lines **46 and 47** replace the default value for *earliest date* with the date you selected. Lines **48 and 49** place the default value for *most recent date* in \( R_04 \) to appear in the first prompt.

Lines **50 through 61** prompt you for the most recent date to summarize or clear. Lines **51 through 53** ask if the date in \( R_04 \) is the date you want, calling the subroutine on line 62. If you accept the date in \( R_04 \), lines **54 and 55** branch to line 93. If you key in an alternative date, line **56** calls the subroutine on line 71 to test your date. If your date is legal, lines **57 and 58** branch to line 50 to ask you to confirm your date. If your date is illegal, lines **59 through 61** place the default value in \( R_04 \) again and then branch to line 50.

Lines **62 through 70** prompt you for dates. This subroutine is called by lines 36 and 53. Lines **63 and 64** display the contents of the Alpha register (*THROUGH* or *FROM*). Lines **65, 66, and 67** place the date and a question mark in the Alpha register. Line **68** clears the Numeric Input flag (so the program can test whether you keyed in an alternative date). Line **69** displays the contents of the Alpha register and stops execution. Line **70** returns execution to line 37 or 54.
Lines 71 through 86 test your date. This subroutine is called by lines 39 and 56. Line 72 clears flag 01. (If your date is illegal, the program will branch to line 87 and set flag 01.) Line 73 places your date in R04. Lines 74, 75, and 76 calculate how many days your date is before last date. If you keyed in a number that doesn’t represent a date, line 76 causes an error and lines 77 and 78 branch to line 87. If your date is later than last date, lines 79 and 80 branch to line 87. Lines 81, 82, and 83 calculate how many days your date is after earliest date. If your date is earlier than earliest date, lines 84 and 85 branch to line 87. If your date passes all three tests, line 86 returns execution to line 40 or to line 57, with flag 01 clear to indicate that your date is legal.

Lines 87 through 92 handle illegal dates. Lines 88, 89, and 90 display an error message and sound a tone. Lines 91 and 92 return execution to line 40 or to line 57, with flag 01 set to indicate that your date is illegal.

Lines 93 through 112 conclude date selection. Lines 94 through 99 update the pointer value in R01 for first job/most recent date, reflecting your choice of the most recent date to summarize or clear. If the program is clearing now, lines 100 and 101 return execution to line 344. Lines 103 and 104 replace last date in R02 with your choice of most recent date. Lines 102, 103, and 105 calculate the difference in days between the earliest and most recent dates to be summarized; this difference defines the block of registers needed for summarizing. Note that R08 is the smallest-addressed register in the block containing daily hours. Lines 106, 107, and 108 place nnn in R04, where Rnnn is the largest-addressed register in the block. Lines 109 through 112 calculate 6.nnn, which represents the block of registers that will contain daily and total hours.
Preparing for the Summary. These routines clear registers and produce the summary heading.

Lines 113 through 123 clear the registers for daily and total hours. Lines 114 and 115 attempt to clear the block of registers. If there are enough registers allocated for the entire block—that is, if $R_{nnn}$ exists—lines 116 and 117 branch to line 124. Otherwise, lines 118 through 121 allocate $nnn + 1$ registers, line 122 returns $6.nnn$ to the X-register, and line 123 branches to line 113.

Lines 124 through 137 begin the summary heading. Lines 125 and 126 select double-width and upper-case print modes. Line 127 sets the Printer Enable flag. Lines 128 and 129 advance the printer two lines. Line 130 places the title in the Alpha register. Line 131 sets the Error Ignore flag to prepare for line 132, \texttt{PRA} (print Alpha), which is a printer instruction. If a printer prints the title, lines 133 and 134 branch to line 138. If no printer is present or if your printer is turned off, line 135 clears the Printer Enable flag (so that \texttt{AVIEW} doesn’t stop execution); and lines 136 and 137 display the title.
Recalling Time Records. These routines test if a job has data for the summary period and then recall those data from extended memory. The program executes the first short routine only once; the second routine, once for each job; and the last two routines, once for each day for each job.

Lines 138 through 154 complete the summary heading. Line 139 selects lower-case print mode. Lines 140 through 145 display (print) from earliest date; lines 146 through 151 display (print) through most recent date. Lines 141, 145, 147, and 151 call a subroutine on line 155 that displays (prints) the contents of the Alpha register. Line 152 selects upper-case print mode. Line 153 sets the Printer Enable flag; this ensures that subsequent AVIEW instructions will either print the summary entries or else stop execution so that you can write down each displayed entry. Line 154 branches to line 161.

Lines 155 through 160 display (print) one line of the heading. This subroutine is called by lines 141, 145, 147, and 151. Line 156 advances the printer (if present). Line 157 displays the contents of the Alpha register; if a printer is present and turned on, the contents of the Alpha register are printed as well. If no printer is present or if your printer is turned off, lines 158 and 159 prolong the display. (Flag 21 was cleared on line 135 if the printer instruction [PRA] caused an error.) Line 160 returns execution to line 142, 146, 148, or 152.

Recalling Time Records. These routines test if a job has data for the summary period and then recall those data from extended memory. The program executes the first short routine only once; the second routine, once for each job; and the last two routines, once for each day for each job.

Lines 161 through 164 prepare to access the first job. Line 162 selects the numeric format for output. Lines 163 and 164 set the pointer in TRECS (the current file) to the first character of the first record, which is the first letter of the first job name.
Lines 165 through 191 prepare to recall one job’s time record from extended memory. Lines 166 through 171 place the loop control number 8.nnn in R05. Lines 172 and 173 clear R06, which will accumulate the total hours for this job. Line 174 recalls the job’s name to the Alpha register. Before displaying (printing) the job’s name, the program checks that this job’s time record contains data for the summary period. Lines 175 through 178 calculate the pointer value for most recent date in this record. (If the record doesn’t contain a byte for most recent date, it doesn’t contain any data for the summary period.) Lines 179 and 180 advance the pointer value one character to ensure that the end-of-time-record byte isn’t mistaken for data. Lines 181 through 184 attempt to set the pointer to this pointer value and, if there isn’t a byte there, branch to line 243. (If this job is too new for the summary period, all jobs that follow are also too new.) Lines 185, 186, and 187 advance the printer twice and display (print) the job’s name. Lines 188, 189, and 190 set the pointer to most recent date, and line 191 recalls up to 24 bytes from this job’s time record to the Alpha register.

Lines 192 through 200 recall and test each byte. This routine and the following one form a loop. Lines 193 and 194 return 254 to the Y-register and the decimal value of a byte to the X-register. (For sequential executions of this routine, line 194 moves bytes from the Alpha register into the X-register in the order that the bytes followed in extended memory.) When the “end of time record” byte (decimal value 255) appears, lines 195 and 196 exit the loop by branching to line 215. Lines 197 and 198 branch to line 201 unless the Alpha register was empty. If the Alpha register is empty and the “end of time record” byte hasn’t appeared, there are more bytes in this time record to recall from extended memory; line 199 recalls up to 24 more bytes and line 200 branches to line 192.
Lines 201 through 214 store each day’s byte value in main memory. Lines 202 and 203 change any “no hour” bytes (decimal value 254) to a decimal value of zero. Lines 204 and 205 add the byte value to $R_{06}$ (total hours for this job) and $R_{07}$ (total hours for all jobs). For a byte value of $nnn$, lines 206, 207, and 208 return $nnn.nnn$ to the X-register. Lines 209 and 210 recall $ppp$, where $ppp$ is the accumulated byte value for all jobs on this day. Lines 211 and 212 place $nnn.qqq$ in the register for this day, where $qqq = nnn + ppp$. Lines 213 and 214 increment the loop-control number and, unless the summary period has been completed, branch to line 192.

Displaying (Printing) Each Job’s Summary. After each job is recalled from extended memory to main memory, the following routines display (print) that job’s summary before recalling the next job.

Lines 215 through 226 prepare to display (print) the daily hours for this job. Line 216 enters a loop-control number representing a single execution of the next routine: accessing only $R_{08}$ (for only most recent date). Lines 217 through 220 calculate how many registers above $R_{08}$ (for days before most recent date) received data for this job. (The job may not have had data for the beginning of the summary period.) The result $m$ is used twice. First, lines 221 and 222 place a loop-control number $(8 + m).007$ in $R_{05}$, where $R_{8 + m}$ is the largest-addressed register that received a byte value for this job. (Line 217 recalls the final value of the loop-control number from the previous routine; the register that the previous routine accessed last will accessed first by the next routine.) Second, lines 223 through 226 subtract $m$ days from most recent date; the result is the earliest date to be summarized for this job.
Lines 227 through 242 display (print) the summary for this job. The program executes a loop from line 228 through line 232 once for each day. Lines 228 and 229 recall the byte value of the hours for this job on this day. Line 230 calls a subroutine on line 264 that displays (prints) the date and hours. Lines 231 and 232 decrement the loop-control number and, if there are more days, branch to line 227. Line 233 recalls the byte value of the total hours for this job, and line 234 calls a subroutine on line 278 that displays (prints) TOTAL and the hours. Lines 235 through 240 attempt to set the pointer in TRECS to the name of the next job. If there is another job in TRECS, lines 241 and 242 branch to line 165.

Displaying (Printing) the Final Summary. After summarizing all jobs, the program displays (prints) a final summary of total hours for each day and total hours for the entire summary period.

Lines 243 through 252 prepare to display (print) the final summary. Lines 244 through 247 store $nnn.007$ in R05, where $R_{nnn}$ is the register containing the daily hours for earliest date. Lines 248 and 249 advance the printer twice. Lines 250 and 251 display (print) SUMMARY. Line 252 recalls earliest date.

Lines 253 through 263 display (print) the final summary. The program executes a loop from line 254 through line 260 once for each day. Lines 254 through 257 recall the byte value of the total hours on this day, and line 258 calls a subroutine on line 264 that displays (prints) the date and hours. Lines 259 and 260 decrement the loop-control number and, if there are more days to summarize, branch to line 253. Line 261 recalls the byte value of the total hours for the entire summary period, and line 262 calls a subroutine on line 278 that displays (prints) TOTAL and the hours.
Subroutines for Displaying (Printing). These three routines display (print) the date, TOTAL, and the hours respectively. The program calls the first and second as subroutines, both of which transfer execution to the third, which finally returns execution to the next line after the subroutine call.

Lines 264 through 277 place the date in the Alpha register. This subroutine is called by lines 230 and 258; it expects the appropriate date in the Y-register and the byte value for the daily hours in the X-register. Lines 265, 266, and 267 place the date in X- and Z-registers, 1 in the Y-register, and the byte value in the T-register. Lines 268, 269, and 270 place the date in the Alpha register. Lines 271, 272, and 273 advance the printer if the date is a Monday. Line 274 rolls 1 into the X-register, the date into the Y-register, and the byte value into the Z-register. Line 275 calculates the succeeding date (preparing for the loop’s next execution). Line 276 returns the byte value to the X-register (where it was before this routine). Line 277 branches to line 280.

Lines 278 and 279 place TOTAL in the Alpha register. This subroutine is called by lines 234 and 262.

Lines 280 through 292 append the hours to the Alpha register and display (print) the combined contents. Lines 281 and 282 convert the byte value to hours and tenths of hours. Lines 283 through 288 ensure that the hours will be printed right-justified. Line 289 appends the hours to the Alpha register and line 290 displays (prints) the combined contents. Line 291 recalls the next date to the X-register (preparing for the loop’s next execution). Line 292 returns execution to the line 231, 235, 259, or 263.
Clearing Days or Jobs.

Lines 293 through 302 prepare to display the clearing menu. Line 294 clears the Printer Enable flag. Lines 295 through 301 cancel any assignments to the D, E, and J keys. Line 302 activates the User keyboard.

Lines 303 through 307 display the clearing menu. Lines 304 and 305 prompt you to press D (clear days), J (clear a job), or E (exit). (When you press one of these keys, execution starts at the corresponding label.) If you mistakenly press R/S, line 306 sounds a tone and line 307 branches to line 303.

Clearing a Job.

Lines 308 through 316 prepare to clear a job. Lines 309 through 312 prompt you for the name of the job that you want to clear. Lines 311 and 313 automatically activate and deactivate the Alpha keyboard. If you press R/S without entering a name, lines 314 and 315 branch to line 303. Line 316 provides the pointer value for the beginning of TREC as an initial value for the next routine.
Lines 317 through 330 locate the job to be cleared. Lines 318 and 319 search TRECS for the job you named in the Alpha register, starting the search at the pointer value in the X-register. If the name doesn’t exist in TRECS, lines 320 and 321 branch to an error routine on line 331. If the pointer value returned by line 319 is valid for a name, lines 322 through 325 branch to line 337. If the pointer value is not valid (that is, if bytes in a time record spell the name by coincidence), lines 326 through 330 calculate the pointer value for the next record and branch to line 317.

Lines 331 through 336 are an error routine. Line 332 sounds a tone; lines 333, 334, and 335 display an error message; and line 336 branches to line 303.

Lines 337 through 340 clear the job from TRECS. Line 338 clears the job’s name and line 339 clears the job’s time record. Line 340 branches to line 303.

Lines 341 through 350 prepare to clear days. Lines 342 and 343 call a subroutine on line 08 that determines the earliest and most recent dates to clear. (The primary purpose of the subroutine on line 08 is to determine the summary period; setting flag 00 modifies the subroutine’s operation to determine the clearing period.) Lines 344 through 347 return 1.ccc, where ccc is the character-pointer value for the most recent date to clear. Line 344 enters the minimum value—at least one day’s byte must be left in each time record—and line 345 recalls the value that corresponds to the most recent date you chose to clear. Lines 346 and 347 place the greater of these values in the X-register. Lines 348, 349 and 350 place 255 in the X-register and the “end of time record” byte in the Alpha register.
Lines 351 through 362 clear days from each job's time record. The program executes this loop once for each time record that contains data for the clearing period. Line 352 clears all bytes in the summary period, and line 353 inserts a new "end of time record" byte. Lines 354 through 358 try to set the pointer to the byte for the most recent date to clear in the next job's time record. If there isn't a byte at that location, lines 359 and 360 branch to line 303. (This will occur when there are no further records or when this and all following jobs have no data for the clearing period.) Line 361 returns 255 to the X-register and line 362 branches to line 351.

Exiting Σ.

Lines 363 through 367 conclude Σ. Lines 364 and 365 return the flags to their previous status. Line 366 clears the flag-status data from the X-register.
Appendices
Appendix A

## Error and Status Messages

This appendix lists all error and status messages given by the HP-41CX.

When an illegal operation is attempted on the HP-41, the operation is not performed and an error message appears in the display. To clear the display, press [+] If the error was caused during a running program, switch to Program mode to see the offending program line.

Some messages are marked as status messages. A status message is for your information and does not indicate an error condition.

The variables \(x\), \(y\), and \(z\) below refer to the contents of the X-register, the Y-register, and the Z-register, respectively.

<table>
<thead>
<tr>
<th>Display</th>
<th>Functions</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHA DATA</td>
<td>Mathematical</td>
<td>Nonnumeric data was used for a function needing numeric data: the X-register (or Y- or Z-register, if relevant) contains Alpha data.</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended Memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any other function using numeric data</td>
<td></td>
</tr>
<tr>
<td>CHKSUM ERR</td>
<td>GETP</td>
<td>Part of the program file has been lost.</td>
</tr>
<tr>
<td>DATA ERROR</td>
<td>SDEV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(x^y)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T+X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEAN</td>
<td></td>
</tr>
</tbody>
</table>

Mathematical functions:

- Illegal math operation with the given operands (division by zero, square root of a negative number).
- Invalid number in the X-register.
- \(x \leq 0\) and \(y = 0\), or \(x\) is noninteger and \(y < 0\).
- \(x < -9999.595999\) or \(x > 9999.595999\), or MM or SS > 59.
- \(x \geq 10\) or \(x < 0\).
- \(n = 0\).
<table>
<thead>
<tr>
<th>Display</th>
<th>Functions</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA ERROR</td>
<td>OCT</td>
<td>(</td>
</tr>
<tr>
<td>(continued)</td>
<td>DEC</td>
<td>(x) is noninteger, or any digit in (x) is an 8 or a 9.</td>
</tr>
<tr>
<td></td>
<td>FACT</td>
<td>(x &lt; 0) or (x) is noninteger.</td>
</tr>
<tr>
<td></td>
<td>%CH</td>
<td>(y = 0).</td>
</tr>
<tr>
<td></td>
<td>FIX</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>SCI</td>
<td>(x \geq 100).</td>
</tr>
<tr>
<td></td>
<td>ENG</td>
<td>(x &gt; 255).</td>
</tr>
<tr>
<td></td>
<td>GETKEYX</td>
<td>(x &gt; 999).</td>
</tr>
<tr>
<td></td>
<td>AROT</td>
<td>(x = 0). (Attempted to create a file zero registers long.)</td>
</tr>
<tr>
<td></td>
<td>POSA</td>
<td>(x = 0) or (x &gt; 999).</td>
</tr>
<tr>
<td></td>
<td>XTQA</td>
<td>(x) (or (y), if (x) is a range of flags in the form (bb.)(ee)) was not obtained by executing ([RCLFLAG]).</td>
</tr>
<tr>
<td></td>
<td>X&lt;&gt;F</td>
<td>(Y)-register contains Alpha data other than (X), (Y), (Z), (T), or (L), or (y &gt; 999).</td>
</tr>
<tr>
<td></td>
<td>PSIZE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLRGX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEEKPT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEEKPTA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWPT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRFLAS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRFLD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EMDIRX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLALMX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RCLALM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RSZFL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOFLAG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X=NN?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X\neq NN?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X&lt;) (NN?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X\leq ) (NN?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X&gt;) (NN?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(X\geq ) (NN?)</td>
<td></td>
</tr>
<tr>
<td>DATA ERROR X</td>
<td>DDAYS</td>
<td>(x) is an invalid or negative date, or the year portion uses more than four digits.</td>
</tr>
<tr>
<td></td>
<td>XYZALM</td>
<td>(x \geq 24) or is not a valid (HH.MMSS) value.</td>
</tr>
<tr>
<td>DATA ERROR Y</td>
<td>DATE+</td>
<td>(y) is an invalid or negative date, or the year portion uses more than four digits.</td>
</tr>
<tr>
<td></td>
<td>DDAYS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XYZALM</td>
<td></td>
</tr>
<tr>
<td>Display</td>
<td>Functions</td>
<td>Meaning</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>DATA ERROR Z</strong></td>
<td>XYZALM</td>
<td>The $z$-value $\geq 10,000$ hours or is not a valid HHHH.MMSS value.</td>
</tr>
<tr>
<td><strong>DUP FL</strong> <em>(duplicate file)</em></td>
<td>Extended Memory</td>
<td>A file of the same name already exists in extended memory. Text, data, and program files cannot use the same names. (The named file becomes the current file.)</td>
</tr>
<tr>
<td><strong>END OF FL</strong> <em>(end of file)</em></td>
<td>Extended Memory</td>
<td>A nonexistent pointer address was used during an attempt to position the pointer in a file, or read, write, or delete within a file. (With [SAVER] and [SEEKPTA] the named file becomes the current file, although the file and pointers are not changed.)</td>
</tr>
<tr>
<td><strong>END OF REC</strong> <em>(end of record)</em></td>
<td>SEEKPT SEEKPTA</td>
<td>Not enough room to add the character or record.</td>
</tr>
<tr>
<td><strong>ERROR=Dnn</strong>* <em>(delta split error in Rnn)</em></td>
<td>SW</td>
<td>File transfer not completed because the end of the destination file was encountered before the end of the source file. Part of the file was transferred.</td>
</tr>
<tr>
<td><strong>ERROR=Rnn</strong>* <em>(split error in Rnn)</em></td>
<td>SW</td>
<td>The end of the record was encountered during an attempt to position the character pointer.</td>
</tr>
<tr>
<td><strong>FL NOT FOUND</strong> <em>(file not found)</em></td>
<td>Extended Memory</td>
<td>The number stored in $R_{nn}$ or $R_{nn-1}$ is not in HHHH.MMSS format; or the split stored in $R_{nn}$ is smaller than the split stored in $R_{nn-1}$.</td>
</tr>
<tr>
<td><strong>FL SIZE ERR</strong> <em>(file size error)</em></td>
<td>RESZFL</td>
<td>Not enough room to add the character or record.</td>
</tr>
<tr>
<td><strong>FL TYPE ERR</strong> <em>(file type error)</em></td>
<td>Extended Memory</td>
<td>The integer portion in $R_{nn}$ exceeds 99.</td>
</tr>
</tbody>
</table>

* This error message is for information only, and does not have the effect of a true error condition. Refer to section 17.
<table>
<thead>
<tr>
<th>Display</th>
<th>Functions</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEYCODE ERR</td>
<td>[PASN]</td>
<td>The key specified (by keycode) is not assignable.</td>
</tr>
<tr>
<td>(keycode error)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEMORY LOST</td>
<td></td>
<td>Continuous Memory has been cleared and reset.</td>
</tr>
<tr>
<td>NAME ERR</td>
<td>Extended</td>
<td>No file name specified (the Alpha register is empty), or the Alpha register contains seven bytes of decimal value 255 (illegal).</td>
</tr>
<tr>
<td>(file name error)</td>
<td>Memory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[PCLPS]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[SAVEP]</td>
<td>The named program does not exist in main memory.</td>
</tr>
<tr>
<td>NO</td>
<td>Flags</td>
<td>Status message. The result of a flag test or conditional test is false.</td>
</tr>
<tr>
<td></td>
<td>Conditionals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[GETAS]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[SAVEAS]</td>
<td>No HP-IL module is plugged in, or no mass storage device is on the interface loop.</td>
</tr>
<tr>
<td>NO DRIVE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(no drive device present)</td>
<td>[GETP]</td>
<td>One or more registers specified do not exist in data storage.</td>
</tr>
<tr>
<td></td>
<td>[GETAS]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[SAVEAS]</td>
<td></td>
</tr>
<tr>
<td>NONEXISTENT</td>
<td>Storage</td>
<td>The label (of a program) specified or called does not exist. (If the function used requires a global label, then specifying a local one also causes this error.)</td>
</tr>
<tr>
<td></td>
<td>Recall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended</td>
<td>The function called does not exist. For alarms, the function called must be a programmable catalog-2 function. If a catalog-2 function is called, its source device must be attached to the HP-41.</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>One or more flags specified are outside the range 0 to 43.</td>
</tr>
<tr>
<td></td>
<td>Conditionals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[CLRGX]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[SWPT]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ASN]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[GTO]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[XEQ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alarms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ASN]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[XEQ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alarms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[STOFLAG]</td>
<td></td>
</tr>
<tr>
<td>NO ROOM</td>
<td>Extended</td>
<td>There is not enough room in extended memory for the program or file specified.</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>There is not enough room in main memory for the specified program. (When executed as a program instruction.) Not enough room remaining in main memory.</td>
</tr>
<tr>
<td>Display</td>
<td>Functions</td>
<td>Meaning</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>NO ROOM</strong> (continued)</td>
<td><strong>RESZFL</strong></td>
<td>Not enough room in extended memory to increase the file size.</td>
</tr>
<tr>
<td></td>
<td><strong>XYZALM</strong></td>
<td>Not enough room in uncommitted memory to set the alarm; or, the maximum number (253) of registers for alarm storage would be exceeded.</td>
</tr>
<tr>
<td></td>
<td><strong>Text Editor</strong>*</td>
<td>No room left to add more characters or records.</td>
</tr>
<tr>
<td><strong>NO SUCH ALM</strong> <em>(no such alarm)</em></td>
<td><strong>Alarms</strong></td>
<td>The alarm specified does not exist.</td>
</tr>
<tr>
<td><strong>NULL</strong></td>
<td><strong>Any</strong></td>
<td><em>Status message.</em> The function was cancelled by holding its key down.</td>
</tr>
<tr>
<td><strong>OUT OF RANGE</strong></td>
<td><strong>Numeric</strong></td>
<td>A number has exceeded the computational or storage capability of the HP-41. Overflow = ±9.999999999 99.</td>
</tr>
<tr>
<td></td>
<td><strong>DATE+</strong></td>
<td>The resulting date is outside the allowed calendar range.</td>
</tr>
<tr>
<td></td>
<td><strong>T+X</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PACKING</strong></td>
<td><strong>ASN</strong></td>
<td><em>Status message.</em> Packing program memory; repeat the operation just attempted. If <strong>TRY AGAIN</strong> appears again, then there is not enough space in main memory to carry out the operation. Try to resize (<strong>SIZE</strong>).</td>
</tr>
<tr>
<td><strong>TRY AGAIN</strong></td>
<td><strong>PASN</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>XEQ</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>GTO</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>GETP</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>GETSUB</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Program mode</strong></td>
<td>Packing program memory; repeat the operation. If <strong>TRY AGAIN</strong> repeats, then then there is not enough space to resize.</td>
</tr>
<tr>
<td></td>
<td><strong>SIZE</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>PSIZE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PRIVATE</strong></td>
<td><strong>Card Reader</strong></td>
<td>Attempting to view a private program; refer to the owner’s handbook for the HP 82104A Card Reader.</td>
</tr>
<tr>
<td></td>
<td><strong>Custom ROMs</strong></td>
<td></td>
</tr>
<tr>
<td><strong>RAM</strong></td>
<td><strong>COPY</strong></td>
<td>Attempting to copy into RAM a program whose global label (as specified) is already in RAM (main memory).</td>
</tr>
</tbody>
</table>

* This error message is for information only, and does not have the effect of a true error condition. Refer to section 14.
<table>
<thead>
<tr>
<th>Display</th>
<th>Functions</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>REC TOO LONG</td>
<td>Text Editor</td>
<td>Attempted to exceed the maximum record length (254). (Deactivates the Text Editor if it was active.)</td>
</tr>
<tr>
<td></td>
<td>APPCHR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INSCHR</td>
<td></td>
</tr>
<tr>
<td>ROM</td>
<td>Flags</td>
<td>Attempting to alter or access a program that is in ROM (read-only memory, as in an application module).</td>
</tr>
<tr>
<td>YES</td>
<td>Conditionals</td>
<td>Status message. The result of a flag test or conditional test is true.</td>
</tr>
</tbody>
</table>
Appendix B

More About Past-Due Alarms

Contents

- Conditions That Cause Execution of Past-Due Alarms .................. 361
- Off/Clock Condition ................................................. 361
- Alarm Condition ..................................................... 361
- Past-Due Alarm Responses in the Alarm Condition .................... 362
- Mode Changes ....................................................... 362
- Interruption of a Past-Due Alarm by Another Past-Due Alarm ....... 363
- Alarms and Subroutine Levels ...................................... 363
- Example of a Past-Due Alarm Sequence ................................ 363

When an alarm becomes past-due for one of the reasons described in section 16 under “Past-Due Alarms,” it is maintained in memory until it is activated or until you delete it. This operation reminds you of an alarm that has not been allowed to serve its intended purpose. If you allow several past-due alarms to accumulate in memory, sequences of automatic past-due alarm activations can occur. (If any bypassed past-due alarms are in memory, the order in which past-due alarms activate can become complex.) If you plan to use past-due alarms or simultaneous alarms in your applications, the information in this appendix will be helpful. Simultaneous alarms activate in the same sequence as past-due alarms.

If past-due alarms are present, they will automatically begin to activate whenever you turn off the computer or press [ON]. This operation is to remind you that one or more past-due alarms exist. For the same reason, if an alarm comes due while any bypassed past-due alarms exist, all of the bypassed past-due alarms will activate ahead of the alarm that came due.* This appendix describes the rules governing the activation sequences in these two cases. (Refer to section 16 for a description and classification of past-due alarms.)

* A bypassed past-due alarm, as defined in section 16, is an alarm that never went off (never activated) because it was set to the past or because it was bypassed due to a time-change function ([SETIME], [SETDATE], [T+X], or [CORRECT]).
Appendix B: More About Past-Due Alarms

Conditions That Cause Execution of Past-Due Alarms

Turning off the computer or displaying the clock with [ON] initiates the off/clock condition. If any past-due alarms exist when this condition occurs, the computer attempts to activate all of them, beginning with the earliest alarm. If any past-due control or conditional alarm is encountered, the computer turns off momentarily—which aborts the off/clock condition—then turns back on in the alarm condition described under the heading, “Alarm Condition.” The control/conditional alarm is then executed in the alarm condition.

Off/Clock Condition

In the off/clock condition:

- As long as no past-due control/conditional alarms are encountered, any past-due message alarms will go off in chronological order, beginning with the earliest alarm time. Each alarm will finish its activation cycle before the next alarm activates. Such alarms will not interrupt each other.
- If the [ON] key is pressed when a past-due message alarm goes off, the alarm halts without being acknowledged and the computer turns off or displays the clock.
- If no control/conditional alarms are past-due, and [ON] is not pressed during activation, the computer turns off or displays the clock after activating all the past-due alarms.

Alarm Condition

The alarm condition is initiated when:

- A future alarm comes due.
- A past-due control or conditional alarm (from the off/clock condition) starts a program or executes a function.

In the alarm condition, the computer activates only the bypassed past-due alarms in memory, beginning with the earliest alarm and proceeding in chronological order of the alarm times. Other past-due alarms are ignored and remain in memory. When a future alarm comes due while there are bypassed past-due alarms, the computer switches to this alarm condition and the future alarm becomes, in essence, a bypassed past-due alarm. It will be activated in its turn, after all of the earlier bypassed past-due alarms are activated.
Past-Due Alarm Responses in the Alarm Condition

Listed below are terms used in the rest of this appendix to describe modes of the computer that affect alarm response.

### Past-Due Alarm Responses

<table>
<thead>
<tr>
<th>Alarm Type</th>
<th>Off</th>
<th>Clock</th>
<th>Keyboard</th>
<th>Running</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditional</td>
<td>Runs program</td>
<td>Runs program</td>
<td>Tone series and flashing display</td>
<td>Sounds two tones and becomes past-due.</td>
</tr>
<tr>
<td>Control</td>
<td>Runs program</td>
<td></td>
<td></td>
<td>Runs program as a sub-routine of current program.</td>
</tr>
<tr>
<td>Message</td>
<td></td>
<td></td>
<td>Tone series and flashing display.</td>
<td></td>
</tr>
</tbody>
</table>

- Off: the computer is turned off.
- Clock: the clock is displayed.
- Keyboard: the computer is turned on but is not displaying the clock or running a program.
- Running: A program is running.

The above table summarizes the computer’s response when an alarm comes due in each of the modes described above.

When the alarm condition occurs, the computer’s response to the various bypassed past-due alarms is determined by the current mode of the computer and by the alarm type.

### Mode Changes

The program or function specified by an activating control or conditional alarm can change the computer operating mode:

- If any control or conditional alarm starts a program, the computer immediately switches to Running mode. (The mode change occurs before the first program instruction is executed.)

- A function executed by a control/conditional alarm can also change the mode. For example, if the clock is displayed when an alarm that executes the printer function \texttt{PRX} (print X) activates, the computer will change from Clock mode to Keyboard mode. Similarly, if the computer is executing a program when an alarm that executes the \texttt{CLOCK} function activates, the computer will change from Running mode to Clock mode.
Appendix B: More About Past-Due Alarms

Interruption of a Past-Due Alarm by Another Past-Due Alarm

- A program started by any past-due control or conditional alarm will be temporarily suspended by any subsequent bypassed past-due alarms before the first program instruction is executed.
- A message alarm or a function started by a past-due control/conditional alarm cannot be interrupted by a bypassed past-due alarm.

Alarms and Subroutine Levels

Any program alarm that interrupts a previous program alarm will operate as a subroutine. If there are several past-due control alarms that execute programs (which is unlikely, since any past-due control alarm would be a bypassed past-due alarm), then several subroutine levels will be used.

Example of a Past-Due Alarm Sequence

Suppose that the computer is turned off, the current time is 9:59 a.m., and the following four alarms are set:

<table>
<thead>
<tr>
<th>Alpha Register</th>
<th>Time</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>MESSAGE1</td>
<td>4:00 a.m.</td>
<td>Past-Due</td>
</tr>
<tr>
<td>tABC</td>
<td>5:00 a.m.</td>
<td>Bypassed Past-Due</td>
</tr>
<tr>
<td>ttXYZ</td>
<td>6:00 a.m.</td>
<td>Bypassed Past-Due</td>
</tr>
<tr>
<td>MESSAGE2</td>
<td>10:00 a.m.</td>
<td>Set to a Future Time</td>
</tr>
</tbody>
</table>

Note: The situation given in this example is unlikely, since bypassed past-due alarms do not occur in most applications. However, this mix of alarms helps to illustrate additional aspects of alarm response.

When the current time reaches 10:00 a.m. the MESSAGE2 alarm causes the Alarm condition to occur. Because there are bypassed past-due alarms, the following sequence occurs:

1. Alarm tABC (the oldest bypassed past-due alarm) starts program ABC. (This is the first alarm to activate. The earlier MESSAGE1 alarm is not a bypassed past-due alarm and therefore will not be activated.)
2. Alarm ttXYZ immediately suspends program ABC and starts program XYZ as a subroutine.
3. Alarm MESSAGE2 (which is now a bypassed past-due alarm) immediately suspends program XYZ, begins flashing MESSAGE2 in the display, and, if not acknowledged from the keyboard, begins sounding a series of tones.

4. After alarm MESSAGE2 is acknowledged (or finishes its cycle), program XYZ is executed. Control then returns to program ABC (assuming that program XYZ did not stop or turn off the computer or use too many subroutine levels).

5. Program ABC is executed.

If program XYZ turns off the computer (by executing [OFF]), program ABC will not be resumed. Since alarm tABC has already activated, it no longer exists in memory.

If alarm XYZ had been a conditional alarm it would have activated only by sounding a pair of tones and becoming a regular past-due alarm (since alarm tABC would have switched the computer to Running mode). Refer back to the table of “Past-Due Alarm Responses” and to “Mode Changes”. As a general guideline, whenever a past-due control or conditional alarm activates and starts a program, any subsequent past-due conditional alarm(s) will activate only by sounding the pair of tones and becoming past due alarm(s).

If the computer had been in Keyboard mode rather than off, alarm tABC would have activated like a message alarm, displaying tABC. Program XYZ would then have started (but not as a subroutine), have been interrupted by alarm MESSAGE2, and finally have been executed.
Null Characters

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Treatment of Null Characters ............................................................... 366

Null Characters and the Alpha Register

The null character is the — (overbar) and corresponds to character code 0.*† Normally the computer does not generate null characters. However, under certain conditions, you can place null characters in Alpha data strings.

Since the null character is not commonly generated, the HP-41 uses the null character as a special indicator. As a result, nulls in the Alpha register occasionally cause unexpected displays, as described in this appendix.

Treatment of Null Characters

The distinction between the Alpha register and the Alpha display is important when considering the treatment of nulls.

- The Alpha register is always 24 characters long; when it is “empty” it actually contains 24 null characters. As characters enter the Alpha register from the right side, they displace nulls. Any leading nulls (either that you entered or that were already there) remain, but they are ignored by computer operation.
- The Alpha display consists of the characters in the Alpha register after the leading nulls. It starts with the first (leftmost) non-null character and displays all others to the right, including any embedded or trailing nulls.

The HP-41 and its functions always consider that an Alpha string starts at the first non-null character, ignoring leading nulls. Nulls embedded between non-null characters are retained. However, if the Alpha string is rotated until an embedded null becomes a leading null, that null and any immediately following nulls will be lost.

* The null character has nothing to do with the NULL message (which occurs when a function is being cancelled).
† A displayed null is printed as * (which corresponds to character codes 0 and 10) by the HP 82143A and HP 82162A Printers.
Appending Characters. If you append a character to the Alpha register (using \[F\], the append key on the Alpha keyboard), the display will differ from the actual contents of the Alpha register if the last character (before appending) was a null.

If the last character in the Alpha register is a null, then—while you enter characters to append—the HP-41 acts like the register is empty, and displays only the characters that you are appending. (The input cue (_\(\_\)) is present in the display while you append characters.) However, the Alpha register itself properly retains the original string and combines it with the appended string.

You can view the full, appended contents by pressing \[AVIEW\] or \[ALPHA \[ALPHA\]. (Remember that leading nulls are never displayed.)

Deleting Characters While Appending. If you use \[\downarrow\] or \[\[ARCL\]\] and the last character in the Alpha string is a null, using \[\downarrow\] to delete the rightmost character will clear the entire Alpha register. This is because when a null character gets deleted the computer figures that it has encountered the leading nulls that precede a string, and it concludes that the register is empty—so it clears everything.

Alpha Strings in Data or Stack Registers. If you store an Alpha string containing nulls in a data or stack register, none of the nulls will be displayed when you view (or print) the contents of that register (as with \[VIEW\] or \[RCL\]). However, if you recall those contents to the Alpha register and then view them (\[ARCL\]), all the characters in the Alpha data string will be displayed (except, of course, leading nulls).

If you print out the Alpha string contents of a data or stack register, only the characters to the left of the first null (the first null from the left) are printed. Any characters to the right of that first null are not printed.

An embedded null in an Alpha string in the X-register signals the end of the string for which the function \[\text{POSA}\] (position in Alpha) will search to match in the Alpha register. (That is, the computer will match only that portion of the X-register string that is to the left of the first null.)

File Names. Any null embedded in a file name in the Alpha register is ignored by functions using that file name.
Appendix D

Printer Operation

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</thead>
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<td>368</td>
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<tr>
<td>Controlling Program Execution and Display With Flags 21 and 55</td>
<td>368</td>
</tr>
<tr>
<td>The Time and Date on Program Listings</td>
<td>369</td>
</tr>
</tbody>
</table>

Paper Advance

The programmable function `[ADV]` (advance) causes the printer paper to advance one line. If no printer is attached to the HP-41, `[ADV]` has no effect at all. Also has no effect if the printer is attached but off, or if flag 21 (below) is clear during a running program.

Controlling Program Execution and Display With Flags 21 and 55

Flag 21 (printer enable) and flag 55 (printer existence) are set or cleared automatically by the computer each time it is turned on. Normally, then, they are either both cleared or both set: set if a printer is attached, and cleared if no printer is attached.

By using the `[VIEW]` or `[AVIEW]` functions and manipulating flag 21 (which can be changed by the user; 55 cannot), you can control the display of messages and results during program execution; that is, whether execution stops to show the result or merely displays the result and continues.

The status of flags 21 and 55 determine how `[VIEW]` and `[AVIEW]` affect a running program. When their status is the same—the usual, default case—operation is normal:

- If no printer is present, `[VIEW]` or `[AVIEW]` causes the specified register or the Alpha register to be displayed until a later display command places new data in the display. `[VIEW]` and `[AVIEW]` do not halt program execution.
- If a printer is present and turned on, the HP-41 acts as above and, in addition, the displayed data are printed.

There are two reasons to use `[VIEW]` and `[AVIEW]` in a program. 1) A message can tell you what the program is doing—for example, which subroutine is being executed. However, there is no need for a permanent record of these messages. 2) Other messages give you the results of the program, and you probably want a record of these results. If you don’t have a printer, you’ll need to halt program execution when results are displayed so you can write them down.
Note that the normal operations above don’t halt program execution (to write down data) if a printer is not present, and they record all VIEWed data or messages if a printer is present. By clearing or setting flag 21 before executing [VIEW] or [AVIEW], you can control whether the program stops while displaying data and messages regardless of whether a printer is present.

- **Clear flag 21 to display but not record messages.** If flag 21 is clear when [VIEW] or [AVIEW] is executed, and no printer is present or it is off, the messages and results are displayed and program execution is not halted. This is the first type of normal operation above.

  If a printer is present and turned on, the message is displayed but not printed, and program execution is not halted.

- **Set flag 21 to record results**—whether by printer or by hand. If flag 21 is set when [VIEW] or [AVIEW] is executed, and if no printer is present or the printer is off, program execution halts so you can write down the displayed result. Press [R/S] to resume program execution.

  If a printer is present, the result is printed and program execution is not halted. This is the second type of normal operation above.

Therefore, with a printer connected you can still choose whether to print all displays or not. With no printer connected you can choose whether to halt execution or not for displayed results and messages.

**The Time and Date on Program Listings**

If a program is printed on an HP-IL printer (HP 82162A) using the HP 82160A HP-IL Module functions [PRP] or [LIST], the time and date appear in the display and are printed at the head of the program listing. (The time and date in the display are not in the X-register; press [→] to return to the X-register.)
Appendix E

Extended Memory Modules

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Using the Modules

CAUTION

Always turn off the computer before inserting or removing any modules. Otherwise, the computer might be damaged or its operation might be disrupted.

The HP 82181A Extended Memory Module is identified by the legend X MEMORY on the module.

Legal Configurations

If you add only one extended memory module to your computer, the module can be installed in any of the four ports in the computer. Follow the steps for installation that are given below.

If you add a second extended memory module, the modules must be arranged in one of the following configurations. Don’t install one above the other.

Legal Configurations for Two HP 82181A Extended Memory Modules

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>X MEMORY</td>
<td>X MEMORY</td>
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<td></td>
<td></td>
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<td>X MEMORY</td>
<td></td>
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<td>X MEMORY</td>
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<tr>
<td></td>
<td>X MEMORY</td>
</tr>
</tbody>
</table>

370
Installing the Modules

To insert an extended memory module:

1. **Turn off the computer!**
2. Hold the computer with the keyboard facing up.
3. Remove the cover from the port to be used.
4. Hold the module so that “X MEMORY” reads right side up.
5. Gently insert the module straight into the port.

You will feel the module snap into place when it’s properly seated.

Removing the Modules

To remove an extended memory module:

1. **Turn off the computer!**
2. Use your fingernail to gently extend the extractor handle.
3. Grasp the handle and pull the module straight out of the computer.
4. Replace the cover on the open port.

The information in an extended memory module is lost when the module is removed from the computer. You can lose all data in two extended memory modules even if you remove only one of the two modules. To avoid this, observe the following rules when choosing which of two modules to remove.

- If one module was installed and used before the second module was installed, remove the second module rather than the first.
- If both modules were installed at the same time, remove the module in port 2 or port 4 rather than the module in port 1 or port 3. (The numbering of the ports is shown on the bottom of the computer.)
Before removing an extended memory module you can calculate which files will be lost. To save an important file you can purge earlier files until the following procedure shows that your important file will be saved:

1. Check the number of registers in each file using [EMDIR], described on page 206.
2. For each file, add two extra registers for the header.
3. Add the total registers in the second file to the total registers in the first file to calculate the “address” of the end of the second file.
4. Add the total registers in each subsequent file to the previous total, calculating the “address” of the end of each file.

All files that end at an “address” exceeding 364 are lost when you remove one of two extended memory modules; all files that end at an “address” exceeding 126 are lost when you remove both memory modules.

**Map of Extended Memory**

Shown below is a map of extended memory in a computer with two extended memory modules installed. The top block represents the 126 registers of extended memory built into the computer. File 1 is entirely inside the computer, so it is saved even if both extended memory modules are removed.

The middle block represents the 238 registers in the first extended memory module (the module used first or else the module in port 1 or 3). If you remove this module, files 2, 3, and 4 are lost.

The bottom block represents the 238 registers in the second extended memory module (the module used second or else the module in port 2 or 4). If you remove this module, files 3 and 4 are lost.
Map of Extended Memory

Extended Memory
Built Into the Computer

126

File 1. This file is entirely inside the computer.

First Extended Memory Module

364

File 2. This file is lost when the first extended memory module is removed.

File 3. This file is lost when the second extended memory module is removed.

Second Extended Memory Module

Unused Registers Available for New Files
Appendix F

Time Specifications

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The Accuracy Factor

The programmable, time adjustment functions allow you to correct the current time setting and to set and monitor the clock accuracy factor.

Like most timekeeping devices, the accuracy and precision of the HP-41 timer can be affected by variations in power supply, temperature, and manufacturing processes. While the effects of these variations are small, you might want to use the built-in accuracy factor to help compensate for the conditions affecting the time, if these conditions will be fairly constant. The accuracy factor (used with the [CORRECT], [RCLAF], and [SETAF] function) is meant to compensate over the long term for variations from the ideal, and not to compensate for anomalous conditions (such as exposure to freezing temperatures for several days). In the latter case, just reset the time ([T+X]) instead, if necessary.

The clock in the HP-41CX is basically the same as the clock in a quartz crystal watch. The accuracy of the HP-41CX clock, when adjusted with the accuracy factor, is similar to that of a quartz crystal watch. The unadjusted accuracy of the HP-41CX clock is not quite as good as that of a quartz crystal watch, but is better than that of a spring watch.
The accuracy factor is the time interval (in seconds) at which one pulse (of approximately \(9.8 \times 10^{-5}\) second duration) is added to or subtracted from the clock's 10240 Hz time base. The table at the right shows the accuracy factor limits and format.

An accuracy factor of \(-10.5\) would cause one pulse to be subtracted every 10.5 seconds. An accuracy factor of 0.1 would cause one pulse to be added every 0.1 second.

You can determine the appropriate accuracy factor automatically with the \textbf{CORRECT} function or by calculation.

For information concerning timer precision and accuracy, see “Specifications for Time Precision and Accuracy”.

**Correcting the Time With the Accuracy Factor (\textbf{CORRECT})**

The \textbf{CORRECT} (correct the time) function sets the time that you specify and automatically adjusts the accuracy factor. When you place a time value (\textit{HH.MMSShh}) in the X-register and execute \textbf{CORRECT}:

- The clock is set to the specified time in the same way that it is when you execute \textbf{SETIME}.
- The accuracy factor is automatically adjusted using an internal calculation based on drift* and the time span since \textbf{SETIME}, \textbf{SETDATE}, \textbf{SETAFA} (set accuracy factor), or \textbf{CORRECT} was last executed. The timer then begins to alter automatically and continuously the clock time base according to the newly adjusted accuracy factor.

When you execute \textbf{CORRECT} manually, the precision of the timesetting operation will vary with your keystroke execution. Execution takes place when the key that executes \textbf{CORRECT} is released.† The time span between the most recent execution of \textbf{SETIME}, \textbf{SETDATE}, \textbf{SETAFA}, or \textbf{CORRECT} and the subsequent execution of \textbf{CORRECT} must be long enough to render keystroke precision error insignificant. In most cases this time span should be a minimum of 30 hours. Greater increases in the time span between executions of \textbf{CORRECT} increase the probability of a more reliable accuracy factor.‡

* Drift is deviation from the correct time due to variations in power supply, temperature, and material variables. The value that the timer uses for drift is the difference between the current clock time and the new clock time (specified in the X-register) at the moment that you execute \textbf{CORRECT}.

† Approximately \(\pm 0.1\) second is the maximum keystroke precision for most users. You can reduce precision error by executing \textbf{CORRECT} as a function assigned to a key instead of by \textbf{XEQ ALPHA CORRECT ALPHA}. This is because the computer takes less time to internally locate and execute a function assigned to a single key.

‡ The longer you wait to execute \textbf{CORRECT}, the smaller the error due to keystroke variation becomes in proportion to any error resulting from a combination of all error factors. A practical time span for many applications is 1 week.
Note: The \texttt{[CORRECT]} function uses the calculated drift to determine the accuracy factor. For this reason, if you wish to use \texttt{[CORRECT]} to improve the long-term accuracy of the timer, you should not use \texttt{T+X} to remove time errors due to normal drift, because the alteration would not be detected by the \texttt{[CORRECT]} function. For this reason, using \texttt{T+X} to correct errors due to normal drift may result in a less reliable accuracy factor.

The accuracy factor adjustment performed by \texttt{[CORRECT]} depends in part upon the difference between the current time setting and the new time setting at the moment that you execute \texttt{CORRECT}. If the time has not been previously set using \texttt{[SETIME]}, executing \texttt{[CORRECT]} can result in an unfavorable accuracy factor. However, once the time has been initially set using \texttt{[SETIME]}, you can use \texttt{[CORRECT]} as often as is practicable.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure}
\caption{The \texttt{[CORRECT]} Function}
\end{figure}

Remember that increasing the time span between execution of \texttt{[SETIME]} or \texttt{[CORRECT]} and execution of the next \texttt{[CORRECT]} will result in a more precise accuracy factor.

Recalling, Setting, and Clearing the Accuracy Factor

The \texttt{[RCLAF]} (\textit{recall accuracy factor}) function recalls the current accuracy factor to the X-register. The stack is lifted in the same way as when you recall a number from a data storage register.

The \texttt{[SETAF]} (\textit{set accuracy factor}) uses the value \(x\) put in the X-register to set the accuracy factor. The accuracy factor represents a time interval in seconds, as explained at the beginning of this section. The accuracy factor is either rounded to the nearest tenth of a second (\texttt{SS.t}) or set to zero, as follows:

- The accuracy factor will be set to 0.0 if \(x = 0\) or \(x \geq |99.95|\).
- The accuracy factor is set to 0.1 if \(0 < x \leq 0.1\) (\(x \neq 0\)) and is set to \(-0.1\) if \(-0.1 \leq x < 0\).
- If the value \(x\) in the X-register is in the range \(0.1 < x < 99.949\) or \(-99.95 < x < -0.1\), the accuracy factor will be rounded to a \(\pm \text{SS.t}\) format.

When you execute \texttt{[SETAF]}, the timer begins to automatically and continuously alter the clock time base according to the accuracy factor you specified.
To clear the accuracy factor, place 0 in the X-register and execute [SETAF].

If you know that the HP-41 will have an interruption of power (such as removing the batteries), then you might want to recall the accuracy factor, write it down, and then use it to reset the accuracy factor when the power supply is normal again.

**Accuracy Factor Calculation**

The [CORRECT] function provides a convenient means to correct the timer’s time base (through automatic calculation of the average accumulated error). However, if you want to establish an accuracy factor over a relatively short period of time (such as a 36-hour interval), any keystroke error that occurs when you execute [CORRECT] can have a more significant effect than when [CORRECT] is executed after longer intervals. By calculating the accuracy factor yourself, then entering it using [SETAF], you can often implement a more effective accuracy factor over a shorter interval than you could by using [CORRECT]. Also, if you alter the drift by executing [T+X], the accuracy factor that results from subsequently executing [CORRECT] is likely to be wrong. Thus, where drift has been altered by [T+X], the best method of determining an effective accuracy factor would be by performing your own calculation.

You can calculate the accuracy factor using the following formula:

\[
AF = \frac{1}{IAF} - \frac{10240}{86400} \times \text{ERR}_{spd}
\]

Where:

- **IAF** = initial accuracy factor
  (If IAF is zero, substitute “0” for 1/IAF.)
- **ERR_{spd}** = the current error in seconds per day
  (A “slow” clock has a negative error, and a “fast” clock has a positive error.)
- 10240 = clock internal time base pulse rate
- 86400 = the number of seconds in a day

After you calculate an accuracy factor, it should be rounded to one decimal place, then set using the [SETAF] function.

**Specifications for Time Precision and Accuracy**

**Precision**

Timesetting from the keyboard can be performed with a precision of about 0.1 second, but this can be less precise, depending upon human response time. The current clock setting can be adjusted with a precision of up to 0.01 seconds through use of the [T+X] function.


**Accuracy**

A crystal-stabilized time base provides accuracy control for the timer. As with any crystal-based timepiece, actual stability at any time is a function of operating temperature and voltage variations. If the computer is subjected to a consistent daily pattern of environmental conditions, the total inaccuracy can be made negligible through appropriate application and maintenance of the accuracy factor. The overall accuracy of the timer at 25°C is ±3.02 seconds per day (±35 ppm), not to change with age more than an additional ±1.30 seconds per day (±15 ppm).

**Stopwatch**

The precision for stopwatch time and difference between splits is ±0.01 seconds. For maximum accuracy, splits should be taken at intervals of no less than 0.08 seconds; otherwise, an error due to delays in internal processing time could result. Rapidly pressing the keys on the Stopwatch keyboard can cause temporary suppression of all or part of the stopwatch display, but does not affect stopwatch timekeeping ability.
Appendix G

Battery, Warranty, and Service Information

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The Input/Output Ports

Keep the caps on the input/output ports whenever nothing is plugged into them.

CAUTION

Do not insert your fingers or any object other than an HP module or plug-in accessory into an input/output port. Doing so could interrupt Continuous Memory and possibly damage the computer.

Batteries and Power Use

The HP-41 is powered by four batteries. Depending on how it is used, the HP-41 can operate up to six months or more on a set of alkaline batteries. The batteries supplied with the computer are alkaline N cells, but a rechargeable battery pack (nickel cadmium cells) can also be used.

The total number of operating hours supplied by the batteries depends greatly on what kinds of operations you do and how much you use peripheral devices. Without using peripheral devices, a set of four fresh alkaline batteries will provide about 45 to 85 hours of continuous program running (the most power-consuming kind of computer use—refer to “Power Consumption,” below). When only the display is on and no operations are being performed, much less power is consumed.

The actual lifetime of the batteries depends on how often you use the HP-41 and its peripherals, whether you use the HP-41 more for running programs or more for manual calculations, and which functions you use. Next to using peripheral devices, the most power-consuming operations are: running programs, displaying/running the stopwatch, using the catalogs, and displaying the clock. Catalogs 4, 5, and 6 draw as much power as a running program even when they are stopped (which is why they cause a faster time-out than usual).

If the computer remains turned off, a set of fresh batteries will preserve the contents of Continuous Memory for as long as the batteries would last outside of the computer—about 1½ years for alkaline batteries.

Power Consumption

The actual rate of power consumption depends upon how the HP-41 is being used at any given time. There are three basic power consumption modes:

- **Operating:** high current drain (5 to 20 mA). This corresponds to running a program, a catalog, or the Text Editor; displaying the stopwatch; or performing an operation (pressing a key).
• **Idle**: moderate current drain (0.5 to 2.0 mA). This mode corresponds to the display being on, including the display of the clock. If the clock shows only the time ([CLKT]), it consumes more power than if it shows the time and date ([CLKTD]). ([CLKT updates the display more frequently.)

• **Off**: low current drain (0.01 to 0.05 mA). Exists when the computer is off. The timer’s precision oscillator runs continuously to maintain the clock and, if running, the stopwatch.

While the computer is turned on, typical computer use is a mixture of idle time and operating time. Therefore, the actual lifetime of the batteries depends on how much time the computer spends in each of the three modes.

A freshly charged HP 82120A Rechargeable Battery Pack has a capacity of 65 mAH (milliampere-hours). A fresh set of alkaline batteries provides approximately 500 mAH.

**Power Consumption by Peripheral Devices**

When you use peripheral devices that draw power from the HP-41 batteries (such as the card reader or the optical wand), total battery life will be reduced considerably. If you use peripherals frequently, it is recommended that you power the HP-41 with an HP 82120A Rechargeable Battery Pack.

**Effects of Clearing Memory, Power Interruptions, and Low Power**

**Clearing Memory.** Resetting Continuous Memory ([]+/[ON]) does not affect:

- The stopwatch.

Resetting Continuous Memory does:

- Clear all of main and extended memories.
- Clear all alarms.
- Clear all User function assignments.
- Reset all flags to their initial, power-on settings. See the table “Summary of Flag Status” in section 19.
- Reset the allocation of registers in main memory to 100 registers for data storage.

Refer also to “Continuous Memory” in section 1 for information about clearing and resetting memory.
**Temporary Power Interruption.** A power interruption (including taking the batteries out) of sufficient duration can cause a **power reset**, which clears Continuous Memory and affects the time, date, and alarms. If affected, the time and date reset to 12:00 a.m. on January 1, 1900. Various other errors will be introduced into timer operation. For this reason it is recommended that after any power interruption you check the status of the current time and date. If the time and date are correct, then the integrity of the time data has been preserved. If the time and/or date are **not** correct, then do the following:

1. Reset the time and date (**SETIME** and **SETDATE**).
2. Reset the clock display formats, if they are not correct (**CLK12** or **CLK24**, **CLKT** or **CLKTD**).
3. Initialize the stopwatch (set to zero), and stop it if it is running (**0 **SETSW** STOPSW**).

**Low Power.** When battery power is too low to operate the clock display, executing **CLOCK** or **ON** will turn off the computer. (The clock will continue to keep time internally.) In most cases, this will not occur until the **BAT** annunciator is lit.

**Low-Power Indication**

The **BAT** (battery) annunciator appears in the display when the available battery power is running low. If a peripheral is in use, disconnecting it (after turning off both the HP-41 and the peripheral) will significantly extend battery life.

With alkaline batteries installed (and no peripheral attached):

- The computer can be used for about 2 to 7 hours of continuous program running after **BAT** first appears.*
- If the computer remains turned off, the contents of its Continuous Memory will be preserved for about a month after **BAT** first appears.

**Battery Replacement and Installation**

The batteries supplied with the HP-41, as well as the alkaline batteries listed below for replacement, are **not** rechargeable.

---

**WARNING**

Do not attempt to recharge the batteries; do not store batteries near a source of high heat; do not dispose of batteries in fire. Doing so may cause the batteries to leak or explode.

---

* Note that this is the time available for **continuous operation**. If you are using the computer for manual calculations—a mixture of the idle and operating modes—the computer can be used for a much longer time after the **BAT** first appears.
The following batteries are recommended for replacement in your HP-41:

- Eveready E90*
- Mallory MN9100
- VARTA 7245
- National AM5(s)
- Panasonic AM5(s)

The contents of the computer’s Continuous Memory are preserved for a short time while the batteries are out of the computer (provided that you turn off the computer before removing the batteries). This allows you ample time to replace the batteries without losing data or programs. If the batteries are left out of the computer for an extended period, the contents of Continuous Memory may be lost.

To install new batteries, use the following procedure:

1. Be sure the computer is off.
2. Holding the computer as shown, push up on the battery holder until it pops out.
3. Remove the batteries from the battery holder.

**CAUTION**

In the next step, replace all four batteries with fresh ones. If you leave an old battery inside, it may leak. Furthermore, be careful not to insert the batteries backwards. If you do so, the contents of Continuous Memory may be lost.

* Not available in the United Kingdom or Republic of Ireland.
4. Insert the new batteries by matching the position of their polarity marks to those on the battery holder. If any of the batteries are inserted backwards, the computer will not turn on.

5. Insert the battery pack into the computer such that the exposed ends of the batteries are pointing toward the input/output ports.

6. Push the upper edge of the battery pack into the HP-41 until it goes no further. Then snap the lower edge of the holder into place.

7. Turn the computer on. If for any reason memory has been cleared (that is, its contents have been lost), the display will show MEMORY LOST. Pressing any key will clear this message from the display.

**Verifying Proper Operation**

If it appears that the computer will not turn on or otherwise is not operating properly, review the following steps.

1. Be sure that all the batteries are inserted with the correct polarity and that the battery contacts are not dirty.

2. If the computer does not respond to keystrokes, try to reset it as follows: press and hold the [ON] and [ENTER+] keys simultaneously, then release them. Turn the computer on, if necessary, and test for a response to keystrokes.

3. If there is no response, remove and reinsert the battery pack.

   If the computer still does not turn on, install fresh batteries.

   If this does not suffice, remove the battery pack and let the computer discharge overnight. When you reinstall the batteries and turn the computer on, if the display shows MEMORY LOST, then memory and the computer have been cleared and reset.
4. If the computer still does not respond to keystrokes, remove the battery pack and short the end battery terminals inside the HP-41 together. Only momentary contact is required. Replace the batteries. The contents of Continuous Memory will be lost, and you might need to press the ON key more than once to turn the computer back on.

5. If there is still no response, the computer requires service.

**Limited One-Year Warranty**

**What We Will Do**

The HP-41 is warranted by Hewlett-Packard against defects in material and workmanship for one year from the date of original purchase. If you sell your unit or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to a Hewlett-Packard service center.

**What Is Not Covered**

The batteries or damage caused by the batteries are not covered by this warranty. However, certain battery manufacturers may arrange for the repair of the computer if it is damaged by the batteries. Contact the battery manufacturer first if you computer has been damaged by the batteries.

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than an authorized Hewlett-Packard service center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY. Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. IN NO EVENT SHALL HEWLETT-PACKARD COMPANY BE LIABLE FOR CONSEQUENTIAL DAMAGES. Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, province to province, or country to country.

**Warranty for Consumer Transactions in the United Kingdom**

This warranty shall not apply to consumer transactions and shall not affect the statutory rights of a consumer. In relation to such transactions, the rights and obligations of Seller and Buyer shall be determined by statute.
Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of manufacture. Hewlett-Packard shall have no obligation to modify or update products once sold.

Warranty Information

If you have any questions concerning this warranty, please contact:

- In the United States:

  Hewlett-Packard Company
  Portable Computer Division
  1000 N.E. Circle Blvd.
  Corvallis, OR 97330, U.S.A.
  Telephone: (503) 758-1010
  Toll-Free Number: (800) 547-3400 (except in Oregon, Hawaii, and Alaska)

- In Europe:

  Hewlett-Packard S.A.
  150, route du Nant-d’Avril
  P.O. Box
  CH-1217 Meyrin 2
  Geneva
  Switzerland
  Telephone: (022) 83 81 11

  Note: Do not send computers to this address for repair.

- In other countries:

  Hewlett-Packard Intercontinental
  3495 Deer Creek Rd.
  Palo Alto, California 94304
  U.S.A.
  Telephone: (415) 857-1501

  Note: Do not send computers to this address for repair.
Service

Hewlett-Packard maintains service centers in most major countries throughout the world. You may have your unit repaired at a Hewlett-Packard service center any time it needs service, whether the unit is under warranty or not. There is a charge for repairs after the one-year warranty period.

Hewlett-Packard handheld computer products normally are repaired and reshipped within five (5) working days of receipt at any service center. This is an average time and could vary depending upon the time of year and work load at the service center. The total time you are without your unit will depend largely on the shipping time.

Obtaining Repair Service in the United States

The Hewlett-Packard United States Service Center for handheld and portable computer products is located in Corvallis, Oregon:

Hewlett-Packard Company
Service Department
P.O. Box 999
Corvallis, Oregon 97339, U.S.A.

or

1030 N.E. Circle Blvd.
Corvallis, Oregon 97330, U.S.A.

Telephone: (503) 757-2000

Obtaining Repair Service in Europe

Service centers are maintained at the following locations. For countries not listed, contact the dealer where you purchased your computer.

AUSTRIA
HEWLETT-PACKARD Ges.m.b.H.
Kleinrechner-Service
Wagramerstrasse-Lieblgasse 1
A-1220 Wien (Vienna)
Telephone: (0222) 23 65 11

BELGIUM
HEWLETT-PACKARD BELGIUM SA/NV
Woluwedal 100
B-1200 Brussels
Telephone: (02) 762 32 00

DENMARK
HEWLETT-PACKARD A/S
Datavej 52
DK-3460 Birkerød (Copenhagen)
Telephone: (02) 81 66 40

EASTERN EUROPE
Refer to the address listed under Austria.

FINLAND
HEWLETT-PACKARD OY
Reventulentie 7
SF-02100 Espoo 10 (Helsinki)
Telephone: (90) 455 02 11

FRANCE
HEWLETT-PACKARD FRANCE
Division Informatique Personnelle
S.A.V. Calculateurs de Poche
F-91947 Les Ulis Cedex
Telephone: (6) 907 78 25

GERMANY
HEWLETT-PACKARD GmbH
Kleinrechner-Service
Vertriebszentrale
Berner Strasse 117
Postfach 560 140
D-6000 Frankfurt 56
Telephone: (611) 50041

ITALY
HEWLETT-PACKARD ITALIANA S.P.A.
Casella postale 3645 (Milano)
Via G. Di Vittorio, 9
I-20063 Cernusco Sul Naviglio (Milan)
Telephone: (2) 90 36 91
International Service Information

Not all Hewlett-Packard service centers offer service for all models of HP computer products. However, if you bought your product from an authorized Hewlett-Packard dealer, you can be sure that service is available in the country where you bought it.

If you happen to be outside of the country where you bought your unit, you can contact the local Hewlett-Packard service center to see if service is available for it. If service is unavailable, please ship the unit to the address listed above under “Obtaining Repair Service in the United States.” A list of service centers for other countries can be obtained by writing to that address.

All shipping, reimportation arrangements, and customs costs are your responsibility.

Service Repair Charge

There is a standard repair charge for out-of-warranty repairs. The repair charges include all labor and materials. In the United States, the full charge is subject to the customer’s local sales tax. In European countries, the full charge is subject to Value Added Tax (VAT) and similar taxes wherever applicable. All such taxes will appear as separate items on invoiced amounts.

Computer products damaged by accident or misuse are not covered by the fixed repair charges. In these situations, repair charges will be individually determined based on time and material.

Service Warranty

Any out-of-warranty repairs are warranted against defects in materials and workmanship for a period of 90 days from date of service.
Shipping Instructions

Should your unit require service, return it with the following items:

- A completed Service Card, including a description of the problem.
- A sales receipt or other proof of purchase date if the one-year warranty has not expired.

The product, the Service Card, a brief description of the problem, and (if required) the proof of purchase should be packaged in the original shipping case or other adequate protective packaging to prevent in-transit damage. Such damage is not covered by the one-year limited warranty; Hewlett-Packard suggests that you insure the shipment to the service center. The packaged unit should be shipped to the nearest Hewlett-Packard designated collection point or service center. Contact your dealer for assistance. (If you are not in the country where you originally purchased the unit, refer to International Service Information above.)

Whether the unit is under warranty or not, it is your responsibility to pay shipping charges for delivery to the Hewlett-Packard service center.

After warranty repairs are completed, the service center returns the unit with postage prepaid. On out-of-warranty repairs in the United States and some other countries, the unit is returned C.O.D. (covering shipping costs and the service charge).

Further Information

Service contracts are not available. Computer product circuitry and design are proprietary to Hewlett-Packard, and service manuals are not available to customers.

Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard service center.

Technical Assistance

The keystroke procedures in this manual are supplied with the assumption that the user has a working knowledge of the concepts and terminology used. Hewlett-Packard's technical support is limited to explanation of operating procedures used in the manual and verification of answers given in the examples. Should you need further assistance, you may write to:

Hewlett-Packard Company
Portable Computer Division
Customer Support
1000 N.E. Circle Blvd.
Corvallis, OR 97330
Dealer and Product Information

For dealer locations, product information, and prices, please call (800) 547-3400. In Oregon, Alaska, or Hawaii, call (503) 758-1010.

Temperature Specifications

- Operating: 0° to 45°C (32° to 113°F)
- Storage: 0° to 45°C (32° to 113°F).

If the batteries are removed, or if clock accuracy is not a concern, then the storage temperature tolerances for the HP-41 are:*  

−20° to 60°C (−4° to 140°F)

Potential for Radio and Television Interference (For U.S.A. Only)

The HP-41 generates and uses radio frequency energy and, if not installed and used properly, that is, in strict accordance with the manufacturer’s instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If your HP-41 does cause interference to radio or television reception, you are encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna.
- Relocate the computer with respect to the receiver.
- Move the computer away from the receiver.

If necessary, you should consult your dealer or an experienced radio/television technician for additional suggestions. You may find the following booklet prepared by the Federal Communications Commission helpful: How to Identify and Resolve Radio-TV Interference Problems. This booklet is available from the U.S. Government Printing Office, Washington, D.C.20402, Stock No. 004-000-00345-4.

* If the clock’s operation is affected by temporary exposure to extreme temperature, do not reset it using the accuracy factor; use |

T+X |

instead (that is, simply reset the time, and do not adjust the accuracy factor). As explained in appendix F, the accuracy factor compensates for the effects of fairly constant conditions, and should not be used to compensate for conditions that will fluctuate irregularly.
The HP-41 handheld computer becomes a *controller* for a computing system when it is connected to HP peripheral devices and extensions. In addition, the Hewlett-Packard Interface Loop (HP-IL) Module can integrate the HP-41 and up to 30 other devices in a serial communications loop.

Four input/output (I/O) ports are provided on the computer for plugging in system extensions—one device per port. (The HP-IL module uses one port, but each additional HP-IL peripheral does not—it just hooks up by cable to the module or another HP-IL device.)

**HP-41 Peripherals**

**HP 82104A Card Reader**

The card reader can record programs, data registers, and key assignments from the HP-41 onto magnetic cards. In turn, programs, registers, and assignments recorded on magnetic cards can then be loaded into the main memory of an HP-41 by the card reader.
The card reader provides quick storage and loading of information (no keying in instructions!). All programs from the Users’ Library come with magnetic cards. Furthermore, the card reader can also read cards of HP-67 and HP-97 programs, automatically translating them into the internal code used by the HP-41.

**HP 82143A Printer**

The printer prints instructions and programs quietly on 24-character-wide thermal paper. The printer can produce upper- and lower-case alphabetic characters, digits, and double-wide characters. There are several printing modes, so you can determine what kinds of output will be printed. This lets you, for instance, check long calculations or diagnose programming problems.

**HP 82153A Optical Wand**

The wand reads programs encoded in HP bar code, and stores them in the main memory of the HP-41. This is much faster and more accurate than manual key entry; data and individual functions can also be read from bar code into the computer. All Users’ Library programs and HP Solutions Books for the HP-41 come with bar code versions of their programs.

**Extensions**

**HP 82181A Extended Memory Modules**

An extended memory module provides an additional 238 storage registers (1,666 bytes) of extended memory to the HP-41 (the HP-41CX comes with 124 registers of extended memory). You can add one or two extended memory modules. For more information, refer to appendix E, “Extended Memory Modules.”

**Application Pac Modules**

The application pac modules are prewritten ROM (read-only memory) software for solving specific problems in specific fields (like Circuit Analysis and Financial Decisions). You can add up to four application pac modules. The programs and functions contained in the application module are listed by catalog 2.
Hewlett-Packard Interface Loop (HP-IL) and Peripherals

By plugging the HP 82160A HP-IL Module into one of the HP-41 ports, you can create a serial interface loop containing up to 30 other HP-IL-compatible devices. The HP-41 itself acts as the controller for the loop, monitoring and controlling the activity of the other devices. With its timekeeping capabilities, the HP-41CX can conduct timed data collection by HP-IL devices and provide automatic output of results. The HP-IL module contains the functions necessary to manipulate HP-IL printing and mass storage peripherals.

Among the HP-IL peripherals are devices for mass storage, video display, printing, plotting, and measurement. In addition, the HP 82183A Extended I/O Module extends the function set of the HP-IL module for I/O device control, and the HP 82184A Plotter Module provides advanced plotting capabilities (including bar code formulation). Check with your authorized HP dealer for a complete and up-to-date list of current HP-IL products.

XROM Functions and XROM Numbers

Every user-accessible function or program provided by an HP-41 peripheral or extension is considered an “external ROM” (XROM) function. Catalog 2 (below) makes a list of each external device. It can also list every individual function of a source device. Every external ROM function is identified internally by a two-part, XROM number.

Catalog 2: The Catalog of External Functions

Catalog 2 (see also “The Catalogs,” section 9) is a listing of all XROM functions/programs by device.* For the HP-41CX, catalog 2 shows only the names of the source devices (the “ROM headers”) until you stop the catalog and press [ENTER]. This starts a listing of the individual functions and programs supplied by the last device whose name was displayed. To return to the listing of source devices, stop the catalog again and press [ENTER].

[SST] and [BST] work as for other catalogs. [SST] and [BST] will not cross from the header list to the function list (only [ENTER] does this). When a catalog listing of individual functions reaches the end of the list for that device, the listing goes on to the next source header and the functions for that device.

---

* Some internal functions, such as time functions and extended memory functions, are also part of catalog 2. Refer to “Time Functions” and “Extended Memory and Extended Functions” in appendix I.
Programs Versus Functions in External ROM

An operation in ROM in an applications or extension module or in a peripheral is provided either as a program or as a function. A program can be copied into user memory, then listed and altered, etc. A function, on the other hand, cannot be viewed—only used. When you list out catalog 2, the computer differentiates the two with the “raised T” in front of programs:

```
SECUR 1B ← ROM header (device identification)
TBOND
TSTOCK ← program
;
TATP
JDAY ← function
TBEP
;
```

How XROM Functions Are Displayed as Program Instructions

When an external function is written into a program instruction, the display of that instruction depends on whether or not the module containing that function is currently plugged in to the HP-41, and whether that XROM function is presented as a program or a function.

The XROM number identifies an XROM function by its device (ROM identification number) and its location within that device (function number).

If the necessary module is not plugged in, then the HP-41 has no knowledge of any of its XROM functions—unless a function was assigned to a User key, in which case its XROM number is known because it was assigned to that key. Similarly, if a module is removed after one of its functions has been entered in a program, the computer identifies the “missing” function by its XROM number.
Therefore:

- If the computer currently has access to an XROM function, then it will be entered into a program line as either
  
  \[ \text{label} \quad \text{for an external function, or} \]
  
  \[ \text{XROM}^\text{T} \text{label} \quad \text{for an external program.} \]

  This is also the result if a User-defined key is used to enter the program instruction.

- \textbf{XROM number, number} replaces the \text{label} or \text{XROM}^\text{T} \text{label} display of a program instruction \textit{when the relevant module is removed}. The XROM number remains only as long as its module is missing; that is, the original display is restored when the module is reconnected. This is also the result if a User key is used with the relevant module unplugged.*

- If the relevant module is not connected and you do an Alpha execution of an XROM function for a program line, then the program line will read simply
  
  \[ \text{XEQT}^\text{T} \text{label} \]

  just like a call for a program in main memory.

  When the module is subsequently restored, the program line does \textit{not} change, and remains

  \[ \text{XEQT}^\text{T} \text{label} \]

\begin{center}
\textbf{Display of a Program Instruction}
\end{center}

\begin{enumerate}

\item \textbf{A. If the relevant module is plugged in, or a User key is used:}

\begin{itemize}

- \text{XROM}^\text{T} \text{label} \quad \text{(program)}

  \begin{itemize}

  - --- unplug module \hspace{1cm} \rightarrow \hspace{1cm} \text{XROM} \text{ nn,mm}

  - \leftarrow \hspace{1cm} \text{plug module back in} \hspace{1cm} ---

  - \text{label} \quad \text{(function)}

  \end{itemize}

  (This program instruction uses two bytes of memory.)

\item \textbf{B. If the relevant module is not plugged in, and a User key is not used:}

\begin{itemize}

- \text{XEQT}^\text{T} \text{label} \quad \text{plug in module} \hspace{1cm} \rightarrow \hspace{1cm} \text{XEQT}^\text{T} \text{label}

  \begin{itemize}

  - \leftarrow \hspace{1cm} \text{unplug again} \hspace{1cm} ---

  \end{itemize}

  (This program instruction uses two bytes plus one byte per character in the label.)

\end{itemize}

\end{enumerate}

* An external function can only be assigned to a User key when the module containing it is connected to the HP-41. Otherwise, the error message \textbf{NONEXISTENT} results.
Execution Time. Although the instruction \texttt{XEQ label}—entered when the module was out—will work when the module is back in to execute the specified external function/program (case B, above), this instruction is not really equivalent to \texttt{XROM label} or label (case A, above). Case B is less efficient and will take longer to execute, for the following reason: an XROM call (including simply label for an XROM function) goes directly to catalog 2 to search for that particular XROM function. An \texttt{XEQ label} command, on the other hand, first goes to catalog 1, searching through all the user programs. When it doesn’t find the particular label there, it goes on to catalog 2 to continue the search.

Memory Space. An \texttt{XROM label} instruction (case A) requires two bytes of memory, while an \texttt{XEQ label} instruction requires two bytes plus one byte per character in the label.

Duplicate XROM Numbers

All plug-in ROM modules have ROM identification numbers, and some of them are duplicated. Avoid simultaneously using any ROM modules with duplicate ROM identification numbers. Even though they are internal (not plug-in) functions for the HP-41CX, all extended memory functions and extended functions use the XROM identification 25, and all time functions use the XROM identification 26. (None of the other internal functions have XROM numbers.)

\footnote{This brings up the interesting point of what happens if you have a user program in main memory with the same global label as the name of an XROM function or program. Since the search for \texttt{XEQ label} always starts with catalog 1, it will always execute the user program, and not the XROM function. This feature allows you to copy a program from an external ROM module into main memory, modify it, and then execute the modified version rather than the ROM module version even when the module is plugged in.
This appendix defines the differences between the HP-41CX and the HP-41C/CV so that you can quickly learn to use the HP-41CX if you are already familiar with the HP-41C/CV. If you have experience with the HP-41C or HP-41CV, then you already know much about the operation of the HP-41CX.

Programs written for the HP-41C/CV (including plug-in modules) are fully compatible with the HP-41CX. Programs written for the HP-41CX, however, are not necessarily compatible with the HP-41C/CV.

An Overview

The HP-41CX computer is based on the HP-41CV (which is like an HP-41C but with five times as much main memory space). It includes all the functions and memory space from the HP 82182A Time Module and the HP 82180A Extended Functions/Memory Module, plus additional alarm, stopwatch, extended memory, and other functions. The catalogs operate slightly differently compared with the HP-41C/CV, and the initial memory allocation is different: 100 registers for data storage. A point-by-point comparison is given below, including page references to explanations of features in this manual.
Cataloguing the New Functions

The HP-41CX functions are catalogued such that all new functions (functions not in the HP-41C/CV) are listed in catalog 2, the external-functions catalog, leaving catalog 3, the standard-functions catalog, unchanged from the HP-41C/CV. They are categorized in this way for consistency with previous products: the standard function set remains unchanged, and the time functions and extended functions are in catalog 2, as they are when they are supplied by the time module and extended functions/memory module. Therefore, all time and extended memory/extended functions in the HP-41CX use the XROM numbers (external ROM numbers; see appendix H) from the original modules for identification to the computer. The ROM identification number for all extended memory/extended functions is 25; the ROM identification for all time functions is 26. (Do not use a plug-in ROM module if it duplicates one of these identification numbers.)

The Owner’s Manual

The owner’s manual has also been completely rewritten for the HP-41CX. Many explanations in the previous literature (for the HP-41C/CV and for the two modules) have been changed, updated, and clarified. To this aim, some terminology used in this book is new, especially in the areas of programming, memory, and alarms. (See the table “Equivalent Terms” at the end of this section.) The printing conventions for shifted and nonkeyboard functions have also been changed. (See the inside of the front cover.)

Memory Configuration

The allocation of memory in the HP-41 computers is shown below.

<table>
<thead>
<tr>
<th>Device</th>
<th>Main Memory</th>
<th>Total</th>
<th>Extended Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Configuration</td>
<td>Uncommitted*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data Storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HP-41CX</td>
<td>100 (R₀₀–R₉₉)</td>
<td>219</td>
<td>124</td>
</tr>
<tr>
<td>HP-41CV</td>
<td>273 (R₀₀–R₂₇₂)</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>HP-41C</td>
<td>17 (R₀₀–R₁₆)</td>
<td>46</td>
<td>0</td>
</tr>
</tbody>
</table>

* Memory for program instructions, alarms, and User function assignments are all drawn from the uncommitted registers. See section 12 for more information.
Catalog Operation

While an HP-41CX catalog is listing its contents, pressing any key besides $\text{R/S}$ and $\text{ON}$ will speed up the listing. (With the HP-41C/CV, this would slow down the listing.)

All the catalogs are summarized in section 9 under “The Catalogs.”

Catalogs 1, 2, and 3

The display for catalog 1 now shows the number of bytes for each program (page 171). The display for catalog 2 is quite different, being broken up into function groups. (See “Time Functions” and “Extended Memory and Extended Functions” in appendix I.) Catalog 3 remains the same.

New Catalogs: 4, 5, and 6

The HP-41CX has three new catalogs. They all use power at the same rate as a running program, even when stopped, unlike catalogs 1, 2, and 3. They therefore will automatically terminate in 2 minutes (1 minute when the battery power is low) when they are stopped.

The new catalogs blink at the end of the listing when you try to use $\text{SST}$, just as they blink at the beginning of the catalog when you try to use $\text{BST}$. (In the HP-41C/CV, $\text{SST}$ at the end of the listing terminates the catalog function.)

Catalog 4: The Extended Memory Directory (Page 206). A listing of all files in extended memory can be accessed with either $\text{CATALOG 4}$ or $\text{EMDIR}$. $\text{CATALOG 4}$ is not programmable, however, while $\text{EMDIR}$ is. The $\text{EMDIR}$ function is essentially the same function as in the extended functions/memory module, except that now $\text{R/S}$ will start and stop it, $\text{SST}$ and $\text{BST}$ will step through it, and a printer will only print it in Trace mode.

Catalog 5: The Alarm Catalog (Page 255). A listing of all alarms in memory can be accessed with either $\text{CATALOG 5}$ or $\text{ALMCAT}$. $\text{CATALOG 5}$ is not programmable, however, while $\text{ALMCAT}$ is. The $\text{ALMCAT}$ function is essentially the same function as in the time module, except that if there are no alarms in memory, the display shows $\text{CAT EMPTY}$.

Catalog 6: User Key Assignments (Page 168). A listing of all User key assignments for functions and global labels is given in order of keycode. Pressing $\text{C}$ will cancel a particular key assignment.

Time Functions

Part V (“Time Functions in Detail”) contains all of the time functions in the HP-41CX: “Clock and Date Functions” (15), “Alarm Functions” (16), and “Stopwatch Operation” (17). In addition to the set of time functions included in the time module, there are more alarm operations, especially alarm-clearing procedures, and one extra stopwatch function:
Appendix I: A Comparison With the HP-41C/CV

- A repeating message alarm can be cleared from memory by pressing \[\text{C}\] to acknowledge it while the alarm is going off. (Page 255.)

- There are programmable alarm-clearing functions \[\text{CLALMA}\] (clear alarm by Alpha), \[\text{CLALMX}\] (clear alarm by \(X\)), and \[\text{CLRALMS}\] (clear all alarms). (Page 258.)

- The programmable function \[\text{RCLALM}\] (recall alarm) will recall the parameters of an alarm to the stack and Alpha register. (Page 252.)

- The minimum repeat interval for an alarm is 1 second instead of 10 seconds. (Page 250.)

- The stopwatch can be activated and the stopwatch pointers set with the programmable function \[\text{SWPT}\] (stopwatch and pointers). (Page 274.)

Those functions taken from the time module are listed in catalog 2 under \(-\text{TIME 2x}\) (time functions, revision 2x). The new time functions are in catalog 2 under \(-\text{CX TIME}\) (HP-41CX time functions).

Extended Memory and Extended Functions

The HP-41CX includes extended memory, extended memory functions, and extended functions, most of which are from the extended memory/functions module, and some of which are completely new. These capabilities are:

- 124 registers of extended memory for program, data, and text (ASCII) files.
- Functions for creating and operating on files in extended memory (extended memory functions).
- Functions that manipulate flags, data, and Alpha strings (extended functions).
- New conditional tests for branching (extended functions).
- Miscellaneous additional functions (extended functions).

The functions taken from this extended functions/memory module are catalogued in the HP-41CX in catalog 2 under the header \(-\text{EXT FCN 2x}\) (extended functions, revision 2x). The new, HP-41CX extended memory functions and extended functions are listed in catalog 2 under \(-\text{CX EXT FCN}\) (HP-41CX extended functions).

Extended Memory Functions

Section 13 ("Extended Memory") and section 14 ("The Text Editor") cover extended memory and the manipulation of files in extended memory: that is, the extended memory functions. The particular functions listed below are those new to the HP-41CX: the new extended memory functions.

The Text Editor is a major innovation in the HP-41CX. The function \[\text{ED}\] (editor) redefines the keyboard and display so that you can call up a text file and watch the contents of a record as you work on it, instead of having to manipulate text via single operations in the Alpha register. The keyboard for the text editor is reproduced on the backplate of the HP-41CX. This keyboard includes the Alpha character set. (The backplate on the HP-41C/CV shows only the Alpha keyboard.)
The other new extended memory functions are:

- **ASROOM** (ASCII room) and **EMROOM** (extended memory room), to return the amount of memory space left in an ASCII (text) file (page 222) or in extended memory (page 208).
- **EMDIRX** (extended memory directory by X), to recall the name and type of a certain file, and make it the current file (page 207).
- **RESZFL** (resize file), to change the size of a text or data file (page 213).

**Extended Functions**

The extended functions in the HP-41CX fall into the three general categories outlined below. Some of these functions were part of the extended functions/memory module. Those that were not are called the HP-41CX extended functions, as indicated below. They are listed in catalog 2.

**Functions That Manipulate Flags, Data, and Alpha Strings.** The HP-41CX includes functions from the extended functions/memory module to manipulate flags, data, and Alpha strings in and between registers. All functions for manipulating data are in section 12, “Main Memory.” Functions to manipulate flags are in section 19, “Flags.” Functions to manipulate Alpha data are in section 21, “Alpha and Interactive Operations.”

**Conditionals.** The conditionals are new extended functions, allowing you to compare the value in the X-register with the value in any other data register. See section 20, “Branching.”

**Miscellaneous.** The miscellaneous extended functions taken from the extended functions/memory module are:

- **PASN** (programmable assign) and **CLKEYS** (clear key assignments) in section 9, “The Keyboard and Display.”
- **SIZE?** (memory size?) and **PSIZE** (programmable size) in section 12, “Main Memory.”
- **PCLPS** (programmable clear programs) in section 18, “Programming Basics.”
- **GETKEY** in section 21, “Alpha and Interactive Operations.” This function halts program execution until a key is pressed, and that key’s keycode can be used to branch to a particular subroutine.

The new, HP-41CX miscellaneous extended functions are:

- **ΣREG?** (statistics registers?) in section 11, “Numeric Functions.”
- **CLRGX** (clear registers by X) in section 12, “Main Memory.”
- **GETKEYX** (get key by X) in section 21, “Alpha and Interactive Operations.”

**New Terminology Used in This Manual**

Many terms and names used in this manual are not the same as those used in previous literature for the HP-41 and its modules. If you are used to the previous terms, refer to the following list.
### Equivalent Terms

<table>
<thead>
<tr>
<th>HP-41CX</th>
<th>HP-41C/CV, Modules</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha execution</td>
<td>display execution</td>
<td></td>
</tr>
<tr>
<td>Alpha name</td>
<td>display execution name</td>
<td></td>
</tr>
<tr>
<td>bypassed past-due alarm</td>
<td>unactivated past-due alarm</td>
<td></td>
</tr>
<tr>
<td>conditional alarm</td>
<td>noninterrupting control alarm</td>
<td>To emphasize the difference between conditional and control alarms.</td>
</tr>
<tr>
<td>control alarm</td>
<td>interrupting control alarm</td>
<td></td>
</tr>
<tr>
<td>current file</td>
<td>working file</td>
<td></td>
</tr>
<tr>
<td>flags:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user (00–10)</td>
<td>general-purpose user (00–10)</td>
<td>User flags are strictly those defined by the user; control flags are defined by the HP-41. However, you can alter any of the user and control flags (but not the system flags, 30–55).</td>
</tr>
<tr>
<td>control (11–29)</td>
<td>special-purpose user (11–20)</td>
<td></td>
</tr>
<tr>
<td>input cue</td>
<td>prompt</td>
<td>Avoids confusion with the [PROMPT] function.</td>
</tr>
<tr>
<td>keyboards:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm Catalog</td>
<td>modes</td>
<td>These particular conditions are characterized by redefined keyboards.</td>
</tr>
<tr>
<td>Alpha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopwatch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User</td>
<td></td>
<td></td>
</tr>
<tr>
<td>modes:</td>
<td>operations</td>
<td>These conditions define a mode of operation rather than a particular operation or function.</td>
</tr>
<tr>
<td>Regular Split</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta Split</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall (splits)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage (splits)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>registers above R₉₉</td>
<td>extended storage registers</td>
<td>Avoids confusion with registers in extended memory.</td>
</tr>
<tr>
<td>text files</td>
<td>ASCII files</td>
<td></td>
</tr>
<tr>
<td>uncommitted registers</td>
<td>program registers, program memory</td>
<td>This part of memory stores more than just programs.</td>
</tr>
</tbody>
</table>

All shifted functions are gold. See inside front cover.
Appendix J

Bar Code for Programs

Contents

<table>
<thead>
<tr>
<th>Program</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SETALM</td>
<td>404</td>
</tr>
<tr>
<td>ALMREL</td>
<td>404</td>
</tr>
<tr>
<td>SPLITS</td>
<td>405</td>
</tr>
<tr>
<td>TR</td>
<td>406</td>
</tr>
<tr>
<td>SIGMA</td>
<td>409</td>
</tr>
</tbody>
</table>

**SETALM** (from section 16)
Program registers needed: 11

ROW 1 (1 : 3)

ROW 2 (3 : 7)

ROW 3 (7 : 9)

ROW 4 (10 : 12)

ROW 5 (13 : 22)

ROW 6 (23 : 27)

**ALMREL** (from section 16)
Program registers needed: 11

ROW 1 (1 : 3)

(continued)
**ALMREL (continued)**

**ROW 2 (3 : 5)**

**ROW 3 (5 : 9)**

**ROW 4 (9 : 19)**

**ROW 5 (20 : 28)**

**ROW 6 (29 : 34)**

(from section 17)

Program registers needed: **14**

**SPLITS** (from section 17)

Program registers needed: **14**

**ROW 1 (1 : 3)**

**ROW 2 (4 : 6)**

**ROW 3 (6 : 8)**

**ROW 4 (9 : 16)**

**ROW 5 (17 : 23)**

**ROW 6 (24 : 30)**

**ROW 7 (30 : 38)**

**ROW 8 (39 : 40)**
Program registers needed: 70
\( \Sigma \) (from section 22)

Program registers needed: 100

<table>
<thead>
<tr>
<th>Row</th>
<th>(Column Start : Column End)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1 : 7)</td>
</tr>
<tr>
<td>2</td>
<td>(7 : 12)</td>
</tr>
<tr>
<td>3</td>
<td>(13 : 18)</td>
</tr>
<tr>
<td>4</td>
<td>(18 : 25)</td>
</tr>
<tr>
<td>5</td>
<td>(25 : 34)</td>
</tr>
<tr>
<td>6</td>
<td>(34 : 37)</td>
</tr>
<tr>
<td>7</td>
<td>(37 : 44)</td>
</tr>
<tr>
<td>8</td>
<td>(44 : 51)</td>
</tr>
<tr>
<td>9</td>
<td>(51 : 58)</td>
</tr>
<tr>
<td>10</td>
<td>(56 : 64)</td>
</tr>
<tr>
<td>11</td>
<td>(65 : 71)</td>
</tr>
<tr>
<td>12</td>
<td>(72 : 79)</td>
</tr>
<tr>
<td>13</td>
<td>(80 : 88)</td>
</tr>
</tbody>
</table>

(continued)
### Appendix J: Bar Codes for Programs

#### Σ (continued)

<table>
<thead>
<tr>
<th>Row</th>
<th>Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>88:90</td>
</tr>
<tr>
<td>15</td>
<td>90:99</td>
</tr>
<tr>
<td>16</td>
<td>99:109</td>
</tr>
<tr>
<td>17</td>
<td>109:117</td>
</tr>
<tr>
<td>18</td>
<td>118:126</td>
</tr>
<tr>
<td>19</td>
<td>127:130</td>
</tr>
<tr>
<td>20</td>
<td>130:135</td>
</tr>
<tr>
<td>21</td>
<td>135:140</td>
</tr>
<tr>
<td>22</td>
<td>140:145</td>
</tr>
<tr>
<td>23</td>
<td>145:147</td>
</tr>
<tr>
<td>24</td>
<td>147:153</td>
</tr>
<tr>
<td>25</td>
<td>153:162</td>
</tr>
<tr>
<td>26</td>
<td>163:173</td>
</tr>
</tbody>
</table>

(continued)
Σ (continued)

ROW 41 (279:288)

ROW 42 (288:296)

ROW 43 (296:302)

ROW 44 (303:304)

ROW 45 (304:310)

ROW 46 (310:312)

ROW 47 (313:321)

ROW 48 (321:330)

ROW 49 (331:333)

ROW 50 (333:340)

ROW 51 (340:344)

ROW 52 (345:353)

ROW 53 (353:361)

ROW 54 (362:367)
Function Tables
Function Tables

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Introduction

These ten tables describe the functions in the computer. Each table describes functions with common characteristics, and some functions appear in more than one table. Most tables include the information found in “Explanation of Table Entries”; the table for extended memory functions includes special entries described with that table.

Locating a Function

- To find a function that performs a particular operation, look through the function table whose title describes the desired type of operation.
- To find out what a function does when you know only its name, refer to the Function Index inside the back cover. The last page reference listed will direct you to the proper function table.

Explanation of Table Entries

Alpha Name. This is how the function is named in catalog 2 or 3, in a program listing, and when you hold down a key for function preview. This is how you must specify the function to assign it to the User keyboard; if the function has no entry in this column, you can’t assign it to the User keyboard.
**Keyboard Name.** This is how the function is indicated on the Normal or Alpha keyboard. (If the entry is printed in gold, you must press \[XEQ\] before the appropriate key.) If the function has no entry in this column, you must use \[XEQ\] and the Alpha name or else assign the function to the User keyboard.

**IND.** An “I” in this column indicates that you can indirectly specify the parameter for this function. To do so, enter the function and press \[\]^; **IND** will then appear in the display following the function name. Then specify the register holding the *address* of the register to access.

**Stack.** This shows how the function affects the automatic memory stack.

- **L = LAST X.** The previous contents of the X-register are copied into the LAST X register.
- **\(\dagger\) = The stack drops.** The contents of the Z-register are copied into the Y-register and the contents of the T-register are copied into the Z-register.
- **\(\uparrow\) = The stack lifts.** The contents of the X-, Y- and Z-registers are copied into the Y-, Z-, and T-registers respectively; the previous contents of the T-register are lost. (This assumes that stack lift was previously enabled.)
- **E = Stack lift enabled.** If the next function executed shows “\(\uparrow\)” in the “Stack” column or if you key in a number, the stack will lift. (Almost all functions enable stack lift.)
- **D = Stack lift disabled.** If the next function executed shows “\(\uparrow\)” in the “Stack” column or if you key in a number, the new number in the X-register replaces the previous contents and the stack doesn’t lift. (Only \[CLx\], \[ENTER\], \[\Sigma\]+, and \[\Sigma\]- disable stack lift.)
- **N = Neutral.** Stack lift is neither enabled nor disabled; the previous status is maintained.

**Flags.** These are the flags that affect or are affected by the function’s operation.

**Bytes.** This is the number of bytes of program memory required when the function is used in a program. If the function has no entry in this column, it is not programmable.

**Page.** These are references to this volume. For references to volume 1, “Basic HP-41 Operation,” see the Function Index inside the back cover.
System/Format Functions

Most of these functions involve options that remain in effect indefinitely: display formats, angular mode, main memory allocation, User-keyboard assignments, and so on. Included are certain system operations such as the toggle keys and the catalogs.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td></td>
<td>Activates/deactivates Alpha keyboard.</td>
<td>48</td>
<td></td>
<td>155</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AOFF</td>
<td></td>
<td>Deactivates Alpha keyboard.</td>
<td>E</td>
<td>48</td>
<td>1 159</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AON</td>
<td></td>
<td>Activates Alpha keyboard.</td>
<td>E</td>
<td>48</td>
<td>1 159</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASN</td>
<td></td>
<td>Assigns specified function or global label to specified key on User keyboard.</td>
<td>E</td>
<td></td>
<td>166</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT n</td>
<td>CATALOG n</td>
<td>Executes catalog n, 1 ≤ n ≤ 6.</td>
<td>N</td>
<td></td>
<td>170</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Catalogs 1, 2, 3, 6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Catalog 4 ([EMDIR]).</td>
<td>E</td>
<td></td>
<td>206</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Catalog 5 ([ALMCAT]).</td>
<td>E</td>
<td></td>
<td>255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF nn</td>
<td>CF nn</td>
<td>Clears flag nn, 00 ≤ nn ≤ 29.</td>
<td>E</td>
<td>nn</td>
<td>2 288</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects 12-hour clock display.</td>
<td>E</td>
<td></td>
<td>239</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects 24-hour clock display.</td>
<td>E</td>
<td></td>
<td>239</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clears all assignments on User keyboard.</td>
<td>E</td>
<td></td>
<td>168</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects time-only clock display.</td>
<td>E</td>
<td></td>
<td>239</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects time-and-date clock display.</td>
<td>E</td>
<td></td>
<td>239</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects decimal Degrees angular mode.</td>
<td>E</td>
<td>42-43</td>
<td>1 186</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects day-month-year date format.</td>
<td>E</td>
<td>31</td>
<td>2 242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENG n</td>
<td>ENG n</td>
<td>Selects engineering display format with n + 1 digits.</td>
<td>L</td>
<td>E</td>
<td>36-41</td>
<td>161</td>
<td></td>
</tr>
</tbody>
</table>
## System/Format Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIX</strong> <em>n</em></td>
<td><strong>FIX</strong> <em>n</em></td>
<td>Selects fixed-point display format with <em>n</em> decimal places.</td>
<td><strong>I</strong></td>
<td><strong>E</strong></td>
<td>36-41</td>
<td>2</td>
<td>160</td>
</tr>
<tr>
<td><strong>GRAD</strong></td>
<td></td>
<td>Selects Grads angular mode.</td>
<td><strong>E</strong></td>
<td></td>
<td>42-43</td>
<td>1</td>
<td>186</td>
</tr>
<tr>
<td><strong>MDY</strong></td>
<td><strong>ON</strong></td>
<td>Selects month-day-year date format.</td>
<td><strong>E</strong></td>
<td></td>
<td>31</td>
<td>2</td>
<td>242</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turns computer on/off.</td>
<td></td>
<td></td>
<td></td>
<td>11-26, 45-55</td>
<td>155</td>
</tr>
<tr>
<td><strong>ON</strong></td>
<td></td>
<td>Selects continuous on (disables time-out).</td>
<td></td>
<td></td>
<td></td>
<td>44</td>
<td>155</td>
</tr>
<tr>
<td><strong>PASN</strong></td>
<td></td>
<td>Assigns function or label specified in Alpha register to User keyboard by key code specified in X-register.</td>
<td><strong>E</strong></td>
<td></td>
<td></td>
<td>2</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td><strong>PRGM</strong></td>
<td>Enters/exits Program mode.</td>
<td><strong>N</strong></td>
<td></td>
<td></td>
<td></td>
<td>155</td>
</tr>
<tr>
<td><strong>FSIZE</strong></td>
<td></td>
<td>Allocates <em>n</em> main memory registers for data storage, <em>n</em> specified in X-register.</td>
<td><strong>E</strong></td>
<td></td>
<td>42-43</td>
<td>1</td>
<td>199</td>
</tr>
<tr>
<td><strong>RAD</strong></td>
<td></td>
<td>Selects Radians angular mode.</td>
<td><strong>E</strong></td>
<td></td>
<td>42-43</td>
<td>1</td>
<td>186</td>
</tr>
<tr>
<td><strong>RCFLAG</strong></td>
<td></td>
<td>Recalls status of flags 00 through 43.</td>
<td><strong>t, E</strong></td>
<td></td>
<td>2</td>
<td>296</td>
<td></td>
</tr>
<tr>
<td><strong>SCI</strong> <em>n</em></td>
<td><strong>SCI</strong> <em>n</em></td>
<td>Selects scientific display format with <em>n</em> decimal places.</td>
<td><strong>I</strong></td>
<td><strong>E</strong></td>
<td>36-41</td>
<td>2</td>
<td>161</td>
</tr>
<tr>
<td><strong>SF</strong> <em>nn</em></td>
<td><strong>SF</strong> <em>nn</em></td>
<td>Sets flag <em>nn</em>, 00 ≤ <em>nn</em> ≤ 29.</td>
<td><strong>I</strong></td>
<td><strong>E</strong></td>
<td><em>nn</em></td>
<td>2</td>
<td>288</td>
</tr>
<tr>
<td><strong>XREG</strong> <em>nn</em></td>
<td></td>
<td>Assigns statistics registers to ( R_{nn} ) through ( R_{nn+5} ).</td>
<td><strong>I</strong></td>
<td><strong>E</strong></td>
<td></td>
<td>2</td>
<td>190</td>
</tr>
<tr>
<td><strong>ZREG?</strong></td>
<td></td>
<td>Returns address of first currently defined statistics register.</td>
<td><strong>t, E</strong></td>
<td></td>
<td></td>
<td>2</td>
<td>190</td>
</tr>
<tr>
<td><strong>SIZE</strong> <em>nnn</em></td>
<td></td>
<td>Allocates <em>nnn</em> main memory registers for data storage.</td>
<td><strong>E</strong></td>
<td></td>
<td></td>
<td></td>
<td>199</td>
</tr>
</tbody>
</table>
System/Format Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE?</td>
<td></td>
<td>Returns number of main memory registers currently allocated for data storage.</td>
<td>t, E</td>
<td>2</td>
<td></td>
<td>199</td>
<td></td>
</tr>
<tr>
<td>STOFLAG</td>
<td></td>
<td>Restores status of flags 00 through 43 using flag-status data in X-register, or: Restores status of flags bb through ee specified by bb.ee in X-register using flag-status data in Y-register.</td>
<td>E</td>
<td>00-43</td>
<td>2</td>
<td>296</td>
<td></td>
</tr>
<tr>
<td>USER</td>
<td></td>
<td>Activates/deactivates User keyboard.</td>
<td>N</td>
<td>27</td>
<td></td>
<td>155</td>
<td></td>
</tr>
</tbody>
</table>

Clearing Functions

To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td></td>
<td>When input cue (_) is displayed, clears last digit or character entered. When digit or character entry is terminated, clears X-register or Alpha register in Execution mode; deletes displayed program line in Program mode. When message is displayed, clears message. Clears all of computer’s memory except for clock time and date.</td>
<td>*</td>
<td></td>
<td>158</td>
<td></td>
</tr>
<tr>
<td>← down, ON, up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>CLA</td>
<td>Clears Alpha register.</td>
<td>E</td>
<td>1</td>
<td>155</td>
<td>159</td>
</tr>
</tbody>
</table>

* When pressing + clears the X-register, stack lift is disabled. Otherwise, + is neutral.
## Clearing Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLALMA</td>
<td></td>
<td>Clears first alarm whose message matches <strong>target in Alpha register.</strong></td>
<td>E</td>
<td></td>
<td>2</td>
<td>258</td>
</tr>
<tr>
<td>CLALMX</td>
<td></td>
<td>Clears <em>nth</em> alarm listed by <strong>[ALMCAT]</strong>, <em>n specified X-register.</em></td>
<td>E</td>
<td></td>
<td>2</td>
<td>259</td>
</tr>
<tr>
<td>CLD</td>
<td></td>
<td>Clears message from display.</td>
<td>E</td>
<td>50</td>
<td>1</td>
<td>318</td>
</tr>
<tr>
<td>CLFL</td>
<td></td>
<td>Clears file <strong>named in Alpha register.</strong></td>
<td>E</td>
<td></td>
<td>2</td>
<td>213</td>
</tr>
<tr>
<td>CLKEYS</td>
<td></td>
<td>Clears all assignments on User keyboard.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>168</td>
</tr>
<tr>
<td>CLP</td>
<td><em>label</em></td>
<td>Clears the program in main memory containing specified global label.</td>
<td>E</td>
<td></td>
<td></td>
<td>286</td>
</tr>
<tr>
<td>CLRALMS</td>
<td></td>
<td>Clears all alarms.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>258</td>
</tr>
<tr>
<td>CLRG</td>
<td></td>
<td>Clears all data storage registers in main memory.</td>
<td>E</td>
<td></td>
<td>1</td>
<td>202</td>
</tr>
<tr>
<td>CLRGX</td>
<td></td>
<td>Clears every <em>i</em>th register from <em>R</em>&lt;sub&gt;bbb&lt;/sub&gt; through <em>R</em>&lt;sub&gt;eee&lt;/sub&gt; in main memory, <strong>bbb.eeei</strong> specified in X-register.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>202</td>
</tr>
<tr>
<td>CLS</td>
<td><strong>CLX</strong></td>
<td>Clears statistics registers.</td>
<td>E</td>
<td></td>
<td>1</td>
<td>190</td>
</tr>
<tr>
<td>CLST</td>
<td></td>
<td>Clears automatic memory stack.</td>
<td>E</td>
<td></td>
<td>1</td>
<td>183</td>
</tr>
<tr>
<td>CLX</td>
<td><strong>CLX</strong></td>
<td>Clears X-register.</td>
<td>D</td>
<td></td>
<td>1</td>
<td>159</td>
</tr>
<tr>
<td>DEL</td>
<td><em>nnn</em></td>
<td>Deletes <em>nnn</em> program lines, starting with displayed line.</td>
<td>N</td>
<td></td>
<td></td>
<td>286</td>
</tr>
<tr>
<td>DELCHR</td>
<td></td>
<td>Deletes <em>n</em> characters <strong>specified in X-register</strong> from record in current text file, starting at current pointer.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>225</td>
</tr>
<tr>
<td>DELREC</td>
<td></td>
<td>Deletes current record in current text file.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>224</td>
</tr>
<tr>
<td>PCLPS</td>
<td></td>
<td>Clears program in main memory containing global label <strong>specified in Alpha register</strong> and all programs that follow it.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>286</td>
</tr>
<tr>
<td>PURFL</td>
<td></td>
<td>Purges file <strong>named in Alpha register.</strong></td>
<td>E</td>
<td></td>
<td>2</td>
<td>208</td>
</tr>
</tbody>
</table>
Stack/Data Register Functions

These functions manipulate the stack or the data storage registers, or take one of those registers as a parameter. (For functions that transfer data between data files in extended memory and the stack or main memory data registers, refer to “Extended Memory Functions” on page 425.) To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTO nn</td>
<td>ASTO nn</td>
<td>Copies six leftmost characters in Alpha register into $R_{nn}$.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>ARCL nn</td>
<td>ARCL nn</td>
<td>Appends contents of $R_{nn}$ to Alpha register.</td>
<td>I</td>
<td>E</td>
<td>28, 29, 36-41</td>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>CLRG</td>
<td></td>
<td>Clears all data storage registers.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>202</td>
</tr>
<tr>
<td>CLRGX</td>
<td></td>
<td>Clears every $i$th register from $R_{bbb}$ through $R_{eee}$, $bbb.eeeii$ specified in X-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>2</td>
<td>202</td>
</tr>
<tr>
<td>CLΣ</td>
<td>CLΣ</td>
<td>Clears statistics registers</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>190</td>
</tr>
<tr>
<td>CLST</td>
<td></td>
<td>Clears automatic memory stack.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>183</td>
</tr>
<tr>
<td>CLX</td>
<td>CLx</td>
<td>Clears X-register.</td>
<td>D</td>
<td></td>
<td></td>
<td>1</td>
<td>159</td>
</tr>
<tr>
<td>DSE nn</td>
<td></td>
<td>For $iii.fffcc$ in $R_{nn}$, decrements $iii$ by $cc$ and skips next program line if $iii - cc \leq fff$.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>306</td>
</tr>
<tr>
<td>ENTER+</td>
<td>ENTER+</td>
<td>Copies number in X-register into Y-register and lifts stack.</td>
<td>t, D</td>
<td></td>
<td></td>
<td>1</td>
<td>175</td>
</tr>
<tr>
<td>ISG nn</td>
<td>ISG nn</td>
<td>For $iii.fffcc$ in $R_{nn}$, increments $iii$ by $cc$ and skips next program step if $iii + cc &gt; fff$.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>306</td>
</tr>
<tr>
<td>LASTX</td>
<td>LASTx</td>
<td>Recalls number in LAST X register.</td>
<td>t, E</td>
<td></td>
<td></td>
<td>1</td>
<td>179</td>
</tr>
<tr>
<td>PSIZE</td>
<td></td>
<td>Allocates $n$ main memory registers to data storage, $n$ specified in X-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>2</td>
<td>199</td>
</tr>
</tbody>
</table>
### Stack/Data Register Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>R+</td>
<td></td>
<td>Rolls up stack.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>181</td>
</tr>
<tr>
<td>RCL nn</td>
<td>RCL nn</td>
<td>Recalls contents of $R_{nn}$.</td>
<td>I</td>
<td>t, E</td>
<td>*</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>RDN</td>
<td>R+</td>
<td>Rolls down stack.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>181</td>
</tr>
<tr>
<td>REGMOVE</td>
<td></td>
<td>Copies contents of one block of $nn$ registers (starting with $R_{sss}$) to another block of $nn$ registers (starting with $R_{ddd}$). $sss.dddnnn$ specified in X-register.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>REGSWAP</td>
<td></td>
<td>Swaps contents of one block of $nn$ registers (starting with $R_{sss}$) with another block of $nn$ registers (starting with $R_{ddd}$). $sss.dddnnn$ specified in X-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>Σ+</td>
<td>Σ+</td>
<td>Accumulations for statistics.</td>
<td>L,D</td>
<td></td>
<td></td>
<td>1</td>
<td>191</td>
</tr>
<tr>
<td>Σ−</td>
<td>Σ−</td>
<td>Corrects statistics accumulations.</td>
<td>L,D</td>
<td></td>
<td></td>
<td>1</td>
<td>191</td>
</tr>
<tr>
<td>ΣREG nn</td>
<td></td>
<td>Assigns statistics registers to $R_{nn}$ through $R_{nn} + 5$.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>190</td>
</tr>
<tr>
<td>ΣREG?</td>
<td></td>
<td>Returns address of first currently defined statistics register.</td>
<td>t,E</td>
<td></td>
<td></td>
<td>2</td>
<td>190</td>
</tr>
<tr>
<td>SIZE nnn</td>
<td></td>
<td>Allocates $nnn$ main memory registers for data storage.</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td>199</td>
</tr>
<tr>
<td>SIZE?</td>
<td></td>
<td>Returns number of main memory registers currently allocated for data storage.</td>
<td>t, E</td>
<td></td>
<td></td>
<td>2</td>
<td>199</td>
</tr>
<tr>
<td>ST+ nn</td>
<td>STO + nn</td>
<td>Adds number in X-register to number in $R_{nn}$ and places result in $R_{nn}$.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
</tbody>
</table>

* If $00 \leq nn \leq 15$, requires 1 byte; otherwise, requires 2 bytes.
### Stack/Data Register Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST(-) (nn)</td>
<td>STO (-) (nn)</td>
<td>Subtracts number in X-register from number in (R_{nn}) and places result in (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>ST(*) (nn)</td>
<td>STO (\times) (nn)</td>
<td>Multiplies number in X-register by number in (R_{nn}) and places result in (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>ST(/) (nn)</td>
<td>STO (+) (nn)</td>
<td>Divides number in X-register into number in (R_{nn}) and places result in (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>STO (nn)</td>
<td>STO (nn)</td>
<td>Copies contents of X-register into (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td></td>
<td>*</td>
<td>200</td>
</tr>
<tr>
<td>VIEW (nn)</td>
<td>VIEW (nn)</td>
<td>Displays contents of (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td>21,50, 55</td>
<td>2</td>
<td>319</td>
</tr>
<tr>
<td>X(&lt;&gt;) (nn)</td>
<td>X(&lt;&gt;) (nn)</td>
<td>Exchanges contents of X-register with contents of (R_{nn}).</td>
<td>I</td>
<td>E</td>
<td></td>
<td>2</td>
<td>201</td>
</tr>
<tr>
<td>X(&lt;&gt;)F</td>
<td></td>
<td>Exchanges number in X-register with status of flags 00 through 07.</td>
<td>E</td>
<td></td>
<td>00-07</td>
<td>2</td>
<td>295</td>
</tr>
<tr>
<td>X(&lt;&gt;)Y</td>
<td>X(\equiv)Y</td>
<td>Exchanges contents of X-register with contents of Y-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>181</td>
</tr>
</tbody>
</table>

* If 00 \(\leq nn \leq 15\), requires 1 byte; otherwise, requires 2 bytes.
### Numeric Functions

All numeric functions are programmable, requiring one byte of program memory. The operation of trigonometric functions and rectangular/polar coordinate conversions depends on the angular mode (flags 42 and 43). To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Stack</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>$y + x.$</td>
<td>L,E</td>
<td>188</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>$y - x.$</td>
<td>L,I,E</td>
<td>188</td>
</tr>
<tr>
<td>*</td>
<td>$\times$</td>
<td>$y \times x.$</td>
<td>L,I,E</td>
<td>188</td>
</tr>
<tr>
<td>/</td>
<td>$\div$</td>
<td>$y / x.$</td>
<td>L,I,E</td>
<td>188</td>
</tr>
<tr>
<td>1/x</td>
<td>$1/x$</td>
<td>Reciprocal.</td>
<td>L,E</td>
<td>185</td>
</tr>
<tr>
<td>10+X</td>
<td>$10^x$</td>
<td>Common exponential.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>ABS</td>
<td></td>
<td>$</td>
<td>x</td>
<td>$ (Absolute value).</td>
</tr>
<tr>
<td>ACOS</td>
<td>COS$^{-1}$</td>
<td>Arc (inverse) cosine.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>ASIN</td>
<td>SIN$^{-1}$</td>
<td>Arc (inverse) sine.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>ATAN</td>
<td>TAN$^{-1}$</td>
<td>Arc (inverse) tangent.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>CHS</td>
<td>CHS</td>
<td>Change sign.</td>
<td>E</td>
<td>185</td>
</tr>
<tr>
<td>COS</td>
<td>COS</td>
<td>Cosine.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>D–R</td>
<td></td>
<td>Degrees to radians conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>DEC</td>
<td></td>
<td>Octal to decimal conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>E+X</td>
<td>$e^x$</td>
<td>Natural exponential.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>E+X–1</td>
<td></td>
<td>Natural exponential for arguments close to zero.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>FACT</td>
<td></td>
<td>$x!$ (Factorial).</td>
<td>L,E</td>
<td>185</td>
</tr>
<tr>
<td>FRC</td>
<td></td>
<td>Fractional part.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>HMS</td>
<td></td>
<td>Decimal hours to hours-minutes-seconds conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>HMS+</td>
<td></td>
<td>Hours-minutes-seconds add.</td>
<td>L,I,E</td>
<td>188</td>
</tr>
<tr>
<td>HMS–</td>
<td></td>
<td>Hours-minutes-seconds subtract.</td>
<td>L,I,E</td>
<td>188</td>
</tr>
<tr>
<td>HR</td>
<td></td>
<td>Hours-minutes-seconds to decimal hours conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>INT</td>
<td></td>
<td>Integer part.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>LN</td>
<td>LN</td>
<td>Natural logarithm.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>LN1+X</td>
<td></td>
<td>Natural logarithm for arguments close to 1.</td>
<td>L,E</td>
<td>187</td>
</tr>
</tbody>
</table>
### Numeric Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Stack</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG</td>
<td>LOG</td>
<td>Common logarithm.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>MEAN</td>
<td></td>
<td>Means of accumulated x- and y-values.</td>
<td>L,E</td>
<td>192</td>
</tr>
<tr>
<td>MOD</td>
<td></td>
<td>$y \mod x$ (Remainder).</td>
<td>L,↑,E</td>
<td>190</td>
</tr>
<tr>
<td>OCT</td>
<td>P→R</td>
<td>Decimal to octal conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>P→R</td>
<td></td>
<td>Polar to rectangular conversion.</td>
<td>L,E</td>
<td>189</td>
</tr>
<tr>
<td>%</td>
<td>%</td>
<td>$x$ percent of $y$.</td>
<td>L,E</td>
<td>188</td>
</tr>
<tr>
<td>%CH</td>
<td></td>
<td>Percent change from $y$ to $x$.</td>
<td>L,E</td>
<td>188</td>
</tr>
<tr>
<td>PI</td>
<td>π</td>
<td>Pi (3.141592654).</td>
<td>↑,E</td>
<td>159</td>
</tr>
<tr>
<td>R→D</td>
<td></td>
<td>Radians to degrees conversion.</td>
<td>L,E</td>
<td>187</td>
</tr>
<tr>
<td>R→P</td>
<td>R→P</td>
<td>Rectangular to polar conversion.</td>
<td>L,E</td>
<td>189</td>
</tr>
<tr>
<td>RND</td>
<td></td>
<td>Round.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>SDEV</td>
<td>Σ+</td>
<td>Standard deviations of accumulated x- and y-values.</td>
<td>L,E</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>Σ−</td>
<td>Accumulations for statistics.</td>
<td>L,D</td>
<td>191</td>
</tr>
<tr>
<td>SIN</td>
<td>SIN</td>
<td>Sine.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>SIGN</td>
<td></td>
<td>Sign of $x$.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>SQRT</td>
<td>√</td>
<td>Square root.</td>
<td>L,E</td>
<td>185</td>
</tr>
<tr>
<td>TAN</td>
<td>TAN</td>
<td>Tangent.</td>
<td>L,E</td>
<td>186</td>
</tr>
<tr>
<td>X→2</td>
<td>$x^2$</td>
<td>Square.</td>
<td>L,E</td>
<td>185</td>
</tr>
<tr>
<td>Y→X</td>
<td>$y^x$</td>
<td>$y$ raised to the $x$ power.</td>
<td>L,↑,E</td>
<td>189</td>
</tr>
</tbody>
</table>
Extended Memory Functions

All extended memory functions are programmable, requiring two bytes of program memory. To interpret this table, refer to “Explanation of Table Entries” on page 414 and to the following explanation of the special entries for this table.

File Types. Functions with an entry in this column act only on files of the indicated type.

P = Program file.
D = Data file.
A = Text (ASCII) file.

File Name. Functions with an entry in this column act on a file that is specified as indicated.

Yes = You must place the name of the desired file in the Alpha register.
OK = You may place the name of the desired file in the Alpha register, or you may clear the Alpha register to specify the current file.
No = This function acts only on the current file.

Pointer Used. Functions with an entry in this column act according to the current value of the indicated pointer.

RRR = register pointer (for data files).
rrr.ccc = record/character pointer (for text files).
rrr. = record pointer only (for text files).

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>File Types</th>
<th>Description</th>
<th>File Name</th>
<th>Pointer Used</th>
<th>Stack</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPCHR</td>
<td>A</td>
<td>Appends contents of Alpha register to end of current record.</td>
<td>No</td>
<td>rrr.</td>
<td>E</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>APPREC</td>
<td>A</td>
<td>Appends contents of Alpha register to end of current file as new record.</td>
<td>No</td>
<td>rrr.</td>
<td>E</td>
<td>222</td>
<td></td>
</tr>
<tr>
<td>ARCLREC</td>
<td>A</td>
<td>Appends current record (starting at pointer to Alpha register.</td>
<td>No</td>
<td>rrr.ccc</td>
<td>E</td>
<td>17</td>
<td>226</td>
</tr>
<tr>
<td>ASROOM</td>
<td>A</td>
<td>Returns number of bytes available in current file.</td>
<td>No</td>
<td>r, E</td>
<td></td>
<td>222</td>
<td></td>
</tr>
</tbody>
</table>
## Extended Memory Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>File Types</th>
<th>Description</th>
<th>File Name</th>
<th>Pointer Used</th>
<th>Stack</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLFL</td>
<td>A,D</td>
<td>Clears file named in Alpha register.</td>
<td>Yes</td>
<td>E</td>
<td></td>
<td></td>
<td>213</td>
</tr>
<tr>
<td>CRFLAS</td>
<td>A</td>
<td>Creates text file named in Alpha register containing n registers, ( n ) specified in X-register.</td>
<td>Yes</td>
<td>E</td>
<td></td>
<td></td>
<td>212</td>
</tr>
<tr>
<td>CRFLD</td>
<td>D</td>
<td>Creates data file named in Alpha register containing n registers, ( n ) specified in X-register.</td>
<td>Yes</td>
<td>E</td>
<td></td>
<td></td>
<td>211</td>
</tr>
<tr>
<td>DELCHR</td>
<td>A</td>
<td>Deletes ( n ) characters from record (starting at pointer), ( n ) specified in X-register.</td>
<td>No</td>
<td>rrr.ccc</td>
<td>E</td>
<td>June</td>
<td>225</td>
</tr>
<tr>
<td>DELREC</td>
<td>A</td>
<td>Deletes current record.</td>
<td>No</td>
<td>rrr</td>
<td>E</td>
<td></td>
<td>224</td>
</tr>
<tr>
<td>ED</td>
<td>A</td>
<td>Activates Text Editor keyboard and display.</td>
<td>OK</td>
<td>rrr.ccc</td>
<td>E</td>
<td>26,28,48</td>
<td>228</td>
</tr>
<tr>
<td>EMDIR</td>
<td></td>
<td>Lists directory of extended memory. Press ([R/S] ) and then ([\leftarrow]) to terminate the listing and make the displayed file the current file. If allowed to finish, returns the number of available extended memory registers.</td>
<td></td>
<td></td>
<td>E</td>
<td></td>
<td>206</td>
</tr>
<tr>
<td>EMDIRX</td>
<td></td>
<td>Finds the ( n )th file listed by ([\text{EMDIR}]), ( n ) specified in X-register; returns file name to Alpha register and file type to X-register.</td>
<td></td>
<td>L,E</td>
<td></td>
<td></td>
<td>207</td>
</tr>
<tr>
<td>EMROOM</td>
<td></td>
<td>Returns number of registers available for a new file.</td>
<td></td>
<td>t,E</td>
<td></td>
<td></td>
<td>208</td>
</tr>
<tr>
<td>FLSIZE</td>
<td>A,D,P</td>
<td>Returns number of registers in file.</td>
<td>OK</td>
<td>t,E</td>
<td></td>
<td></td>
<td>208</td>
</tr>
<tr>
<td>GETAS</td>
<td>A</td>
<td>Copies mass storage file to extended memory file named in Alpha register.</td>
<td>Yes</td>
<td>E</td>
<td></td>
<td></td>
<td>227</td>
</tr>
</tbody>
</table>
### Extended Memory Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>File Types</th>
<th>Description</th>
<th>File Name</th>
<th>Pointer Used</th>
<th>Stack</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>GETP</td>
<td>P</td>
<td>Replaces last program in program memory with file named in Alpha register.</td>
<td>Yes</td>
<td>E</td>
<td>27</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>GETR</td>
<td>D</td>
<td>Copies corresponding registers from file to main memory.</td>
<td>OK</td>
<td>E</td>
<td>217</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GETREC</td>
<td>A</td>
<td>Copies record (starting at pointer) to Alpha register.</td>
<td>No</td>
<td>rrr.ccc</td>
<td>E</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>GETRX</td>
<td>D</td>
<td>Copies file registers (starting at pointer) to R_{bbb} through R_{eee}, bbb.eee specified in X-register.</td>
<td>No</td>
<td>RRR</td>
<td>E</td>
<td>218</td>
<td></td>
</tr>
<tr>
<td>GETSUB</td>
<td>P</td>
<td>Copies file named in Alpha register to bottom of program memory.</td>
<td>Yes</td>
<td>E</td>
<td>27</td>
<td>209</td>
<td></td>
</tr>
<tr>
<td>GETX</td>
<td>D</td>
<td>Copies current register to X-register.</td>
<td>No</td>
<td>RRR</td>
<td>t,E</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>INSCHR</td>
<td>A</td>
<td>Inserts contents of Alpha register, starting at character pointer.</td>
<td>No</td>
<td>rrr.ccc</td>
<td>E</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>INSREC</td>
<td>A</td>
<td>Inserts contents of Alpha register as new record.</td>
<td>No</td>
<td>rrr</td>
<td>E</td>
<td>222</td>
<td></td>
</tr>
<tr>
<td>POSFL</td>
<td>A</td>
<td>Searches file for target specified in Alpha register and returns pointer value for match (−1 if no match).</td>
<td>No</td>
<td>rrr.ccc</td>
<td>t,E</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>PURFL</td>
<td>A,D,P</td>
<td>Purges file named in Alpha register.</td>
<td>Yes</td>
<td>E</td>
<td>208</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCLPT</td>
<td>A,D</td>
<td>Returns pointer value for current file.</td>
<td>No</td>
<td>rrr.ccc</td>
<td>t,E</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>Returns number of bytes in current program file.</td>
<td>No</td>
<td>t,E</td>
<td>211</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Extended Memory Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>File Types</th>
<th>Description</th>
<th>File Name Used</th>
<th>Pointer</th>
<th>Stack</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCLPTA</td>
<td>A,D</td>
<td>Returns pointer value.</td>
<td>OK</td>
<td>rrrcccRRR</td>
<td>t,E</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>RESZFL</td>
<td>A,D</td>
<td>Resizes current file to n registers, \textit{n specified in X-register}.</td>
<td>No</td>
<td>E</td>
<td>213</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAVEAS</td>
<td>A</td>
<td>Copies extended memory file \textit{named in Alpha register} to mass storage file \textit{named in Alpha register}.</td>
<td>Yes</td>
<td>E</td>
<td>227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAVEP</td>
<td>P</td>
<td>Copies program \textit{named in Alpha register} to file \textit{named in Alpha register}.</td>
<td>Yes</td>
<td>E</td>
<td>208</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAVER</td>
<td>D</td>
<td>Copies all main memory registers to file.</td>
<td>OK</td>
<td>E</td>
<td>217</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAVERX</td>
<td>D</td>
<td>Copies contents of (R_{bbb}) through (R_{eee}) in main memory to file (starting with current file register), \textit{bbb.eee specified in X-register}.</td>
<td>No</td>
<td>RRR</td>
<td>E</td>
<td>218</td>
<td></td>
</tr>
<tr>
<td>SAVEX</td>
<td>D</td>
<td>Copies number in X-register to current file register.</td>
<td>No</td>
<td>RRR</td>
<td>E</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>SEEKPT</td>
<td>A,D</td>
<td>Sets pointer for current file to number in X-register.</td>
<td>No</td>
<td>E</td>
<td>215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEEKPTA</td>
<td>A,D</td>
<td>Sets pointer to number in X-register.</td>
<td>OK</td>
<td>E</td>
<td>215</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Time Functions

To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Description</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADATE</strong></td>
<td>Appends number in X-register to Alpha register in current date format.</td>
<td>E 31, 36-39</td>
<td>2</td>
<td>243</td>
<td></td>
</tr>
<tr>
<td><strong>ALMCAT</strong></td>
<td>Lists alarms in chronological order. Can be executed manually as [CATALOG] 5.</td>
<td>E 31</td>
<td>2</td>
<td>255</td>
<td></td>
</tr>
<tr>
<td><strong>ALMNOW</strong></td>
<td>Activates the oldest past-due control or conditional alarm.</td>
<td>E 2</td>
<td>2</td>
<td>261</td>
<td></td>
</tr>
<tr>
<td><strong>ATIME</strong></td>
<td>Appends number in X-register to Alpha register in current time format.</td>
<td>E 36-39</td>
<td>2</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td><strong>ATIME24</strong></td>
<td>Appends number in X-register to Alpha register in format.</td>
<td>E 36-39</td>
<td>2</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td><strong>CLALMA</strong></td>
<td>Clears first alarm whose message matches contents of Alpha register.</td>
<td>E 2</td>
<td>2</td>
<td>258</td>
<td></td>
</tr>
<tr>
<td><strong>CLALMX</strong></td>
<td>Clears nth alarm listed by [ALMCAT], n specified in X-register.</td>
<td>E 2</td>
<td>2</td>
<td>259</td>
<td></td>
</tr>
<tr>
<td><strong>CLK12</strong></td>
<td>Selects 12-hour time display format.</td>
<td>E 2</td>
<td>2</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td><strong>CLK24</strong></td>
<td>Selects 24-hour time display format.</td>
<td>E 2</td>
<td>2</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td><strong>CLKT</strong></td>
<td>Selects time-only display for clock.</td>
<td>E 2</td>
<td>2</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td><strong>CLKTD</strong></td>
<td>Selects time-and-date display for clock.</td>
<td>E 2</td>
<td>2</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td><strong>CLOCK</strong></td>
<td>Displays clock.</td>
<td>E 31</td>
<td>2</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td><strong>CLEARMS</strong></td>
<td>Clears all alarms.</td>
<td>E 2</td>
<td>2</td>
<td>258</td>
<td></td>
</tr>
<tr>
<td><strong>CORRECT</strong></td>
<td>Sets time and adjusts accuracy factor.</td>
<td>E 2</td>
<td>2</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td><strong>DATE</strong></td>
<td>Returns number for current date.</td>
<td>t,E 31</td>
<td>2</td>
<td>242</td>
<td></td>
</tr>
<tr>
<td><strong>DATE+</strong></td>
<td>Calculates new date from date in Y-register and number of days n in X-register. New date is later if n is positive, earlier if n is negative.</td>
<td>L,+,E 31</td>
<td>2</td>
<td>244</td>
<td></td>
</tr>
</tbody>
</table>
### Time Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Description</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDAYS</td>
<td>Calculates the difference in days between dates in X- and Y-registers. Difference is positive if date in Y-register is earlier, negative if date in Y-register is later.</td>
<td>L, t, E</td>
<td>31</td>
<td>2</td>
<td>244</td>
</tr>
<tr>
<td>DMY</td>
<td>Selects day-month-year date format.</td>
<td>E</td>
<td>31</td>
<td>2</td>
<td>242</td>
</tr>
<tr>
<td>DOW</td>
<td>Returns day-of-week number (0 = Sunday, 6 = Saturday) for date number in X-register.</td>
<td>L, E</td>
<td>31</td>
<td>2</td>
<td>244</td>
</tr>
<tr>
<td>HMS</td>
<td>Converts number in X-register from decimal hours format to hours-minutes-seconds format.</td>
<td>L, E</td>
<td></td>
<td>1</td>
<td>187</td>
</tr>
<tr>
<td>HMS+</td>
<td>Adds number in X-register to number in Y-register in hours-minutes-seconds format.</td>
<td>L, t, E</td>
<td>1</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>HMS−</td>
<td>Subtracts number in X-register from number in Y-register in hours-minutes-seconds format.</td>
<td>L, t, E</td>
<td>1</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>Converts number in X-register from hours-minutes-seconds format to decimal hours format.</td>
<td>L, E</td>
<td></td>
<td>1</td>
<td>187</td>
</tr>
<tr>
<td>MDY</td>
<td>Selects month-day-year date format.</td>
<td>E</td>
<td>31</td>
<td>2</td>
<td>242</td>
</tr>
<tr>
<td>RCLAF</td>
<td>Recalls clock accuracy factor.</td>
<td>t, E</td>
<td></td>
<td>2</td>
<td>376</td>
</tr>
<tr>
<td>RCLALM</td>
<td>Recalls XYZALM</td>
<td>-type parameters for nth alarm listed by ALMCAT, n specified in X-register.</td>
<td>L, t, E</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>RCLSW</td>
<td>Returns stopwatch time.</td>
<td>t, E</td>
<td></td>
<td>2</td>
<td>273</td>
</tr>
<tr>
<td>RUNSW</td>
<td>Runs stopwatch.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>273</td>
</tr>
<tr>
<td>SETAF</td>
<td>Sets clock accuracy factor.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>376</td>
</tr>
<tr>
<td>SETDATE</td>
<td>Sets clock to date specified in X-register.</td>
<td>E</td>
<td>31</td>
<td>2</td>
<td>242</td>
</tr>
<tr>
<td>SETIME</td>
<td>Sets clock to time specified in X-register.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>237</td>
</tr>
<tr>
<td>SETSW</td>
<td>Sets stopwatch to starting time specified in X-register.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>273</td>
</tr>
<tr>
<td>STOPSW</td>
<td>Stops running stopwatch.</td>
<td>E</td>
<td></td>
<td>2</td>
<td>273</td>
</tr>
<tr>
<td>SW</td>
<td>Activates Stopwatch keyboard and display.</td>
<td>E</td>
<td>26</td>
<td>2</td>
<td>266</td>
</tr>
</tbody>
</table>

* Copies the contents of the Y-register into the T-register, regardless of whether stick lift is enabled.
Time Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Description</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWPT</td>
<td>Sets the stopwatch store and recall pointers by <strong>sss.rrr in X-register</strong>, and activates Stopwatch keyboard and display; returns current pointer values when Stopwatch keyboard is deactivated.</td>
<td>L,E</td>
<td>26</td>
<td>2</td>
<td>274</td>
</tr>
<tr>
<td>T+X</td>
<td>Adjusts clock time by <strong>increment in X-register</strong>.</td>
<td>E</td>
<td>2</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>Returns number for current time.</td>
<td>t,E</td>
<td>2</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>XYZALM</td>
<td>Sets alarm for <strong>time in X-register, date in Y-register, repeat interval in Z-register</strong>, and message or global label in Alpha register.</td>
<td>E</td>
<td>31</td>
<td>2</td>
<td>250</td>
</tr>
</tbody>
</table>

Editing Functions

These are non-programmable functions that are executed in Program mode. They help you write or edit your programs. Like the toggle keys **[ON]**, **[USER]**, and **[ALPHA]**, these functions don’t require you to return to Execution mode for execution. To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASN</td>
<td>ASN</td>
<td>Assigns specified function or global label to specified key on User keyboard.</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td>BST</td>
<td>BST</td>
<td>Displays preceding program line.</td>
<td>284</td>
<td></td>
</tr>
<tr>
<td>CAT n</td>
<td>CATALOG n</td>
<td>Executes catalog n, 1 ≤ n ≤ 6.</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>CLP label</td>
<td></td>
<td>Clears program in main memory containing specified global label.</td>
<td>286</td>
<td></td>
</tr>
<tr>
<td>COPY label</td>
<td></td>
<td>Copies ROM program containing specified global label to program memory.</td>
<td>281</td>
<td></td>
</tr>
</tbody>
</table>
Editing Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>Flags</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEL nnn</td>
<td></td>
<td>Deletes nnn program lines, starting with displayed line.</td>
<td></td>
<td>286</td>
</tr>
<tr>
<td></td>
<td>GTO</td>
<td>Goes to specified line number or global label.</td>
<td></td>
<td>283</td>
</tr>
<tr>
<td></td>
<td>GTO</td>
<td>Goes to bottom of program memory; packs program memory and creates null program.</td>
<td></td>
<td>281</td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td>Selects continuous on (disables time-out).</td>
<td>44</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>PACK</td>
<td>Packs program memory.</td>
<td></td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>SIZE nnn</td>
<td>Allocates nnn main memory registers for data storage.</td>
<td></td>
<td>199</td>
</tr>
<tr>
<td></td>
<td>SST</td>
<td>Displays next program line.</td>
<td></td>
<td>284</td>
</tr>
</tbody>
</table>

Functions That Direct Program Execution

These are functions that can halt program execution or cause program lines to be executed other than sequentially. To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIEW</td>
<td>AVIEW</td>
<td>Displays contents of Alpha register; if flag 21 is set and flag 55 is clear, stops program execution.</td>
<td>E</td>
<td>21,50, 55</td>
<td>1</td>
<td>318</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLOCK</td>
<td></td>
<td>Stops program execution and displays the clock.</td>
<td>E</td>
<td>31</td>
<td>2</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>DSE nn</td>
<td></td>
<td>For iiiii.fffcc in Rnn, decrements iiiii by cc and skips next program line if iiiii − cc ≤ fff.</td>
<td>I</td>
<td>E</td>
<td>2</td>
<td>306</td>
<td></td>
</tr>
<tr>
<td>END</td>
<td></td>
<td>Marks end of program.</td>
<td>E</td>
<td>3</td>
<td></td>
<td>301</td>
<td></td>
</tr>
<tr>
<td>FC? nn</td>
<td></td>
<td>Tests flag nn (00 ≤ nn ≤ 55) and skips next program line unless flag nn is clear.</td>
<td>I</td>
<td>E</td>
<td>nn</td>
<td>2</td>
<td>304</td>
</tr>
</tbody>
</table>
## Functions That Direct Program Execution (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC?C nn</td>
<td></td>
<td>Tests flag $nn$ ($00 \leq nn \leq 29$), clears flag $nn$, and then skips next program line unless flag $nn$ was clear.</td>
<td>I</td>
<td>E</td>
<td>$nn$</td>
<td>2</td>
<td>304</td>
</tr>
<tr>
<td>FS? nn</td>
<td>FS? nn</td>
<td>Tests flag $nn$ ($00 \leq nn \leq 55$) and skips next program line unless flag $nn$ is set.</td>
<td>I</td>
<td>E</td>
<td>$nn$</td>
<td>2</td>
<td>304</td>
</tr>
<tr>
<td>FS?C nn</td>
<td></td>
<td>Tests flag $nn$ ($00 \leq nn \leq 29$), clears flag $nn$, and then skips next program line unless flag $nn$ was set.</td>
<td>I</td>
<td>E</td>
<td>$nn$</td>
<td>2</td>
<td>304</td>
</tr>
<tr>
<td>GETP</td>
<td></td>
<td>Replaces last program in memory with program file named in Alpha register. If last program calls new program (and is replaced), execution transfers to first line of new program.</td>
<td></td>
<td>E</td>
<td>27</td>
<td>2</td>
<td>209</td>
</tr>
<tr>
<td>GTO label</td>
<td>GTO label</td>
<td>Transfers execution to specified global, numeric, or local Alpha label.</td>
<td>I</td>
<td>E</td>
<td></td>
<td>*</td>
<td>300</td>
</tr>
<tr>
<td>ISG nn</td>
<td>ISG nn</td>
<td>For $iii.fffcc$ in $R_{nn}$, increments $iii$ by $cc$ and skips next program step if $iii+cc&gt;fff$.</td>
<td>I</td>
<td>E</td>
<td>2</td>
<td>306</td>
<td></td>
</tr>
<tr>
<td>LBL</td>
<td>LBL</td>
<td>Global, numeric, or local Alpha label.</td>
<td>E</td>
<td></td>
<td></td>
<td>†</td>
<td>299</td>
</tr>
<tr>
<td>OFF</td>
<td></td>
<td>Turns off the computer.</td>
<td>N</td>
<td>11-26</td>
<td>44-55</td>
<td>1</td>
<td>292</td>
</tr>
<tr>
<td>PROMPT</td>
<td></td>
<td>Displays contents of the Alpha register and stops execution.</td>
<td>E</td>
<td></td>
<td></td>
<td>50</td>
<td>314</td>
</tr>
</tbody>
</table>

*If $00 \leq nn \leq 14$ or parameter is indirectly specified, requires 2 bytes; if parameter is global label of $m$ characters, requires $2 + m$ bytes; otherwise, requires 3 bytes.*

†If $00 \leq nn \leq 14$, requires 1 byte; if parameter is global label of $m$ characters, requires $4 + m$ bytes; otherwise, requires 2 bytes.
### Functions That Direct Program Execution (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTN</td>
<td>RTN</td>
<td>Returns execution to line following [XEQ] instruction that called this subroutine.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>301</td>
</tr>
<tr>
<td>STOP</td>
<td>R/S</td>
<td>Stops execution.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>302</td>
</tr>
<tr>
<td>VIEW (nn)</td>
<td>VIEW (nn)</td>
<td>Displays contents of (R_{nn}) and, if flag 21 is set and flag 55 is clear, stops execution.</td>
<td>I</td>
<td>E</td>
<td>21, 50, 55</td>
<td>2</td>
<td>319</td>
</tr>
<tr>
<td>X = 0?</td>
<td>x = 0?</td>
<td>Skips next instruction unless number in X-register = 0.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X ≠ 0?</td>
<td></td>
<td>Skips next instruction unless number in X-register ≠ 0.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X &lt; 0?</td>
<td></td>
<td>Skips next instruction unless number in X-register &lt; 0.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X ≤ 0?</td>
<td></td>
<td>Skips next instruction unless number in X-register ≤ 0.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X &gt; 0?</td>
<td></td>
<td>Skips next instruction unless number in X-register &gt; 0.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X &lt; Y?</td>
<td></td>
<td>Skips next instruction unless number in X-register &lt; number in Y-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X ≤ Y?</td>
<td>x ≤ y?</td>
<td>Skips next instruction unless number in X-register ≤ number in Y-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
<tr>
<td>X &gt; Y?</td>
<td>x &gt; y?</td>
<td>Skips next instruction unless number in X-register &gt; number in Y-register.</td>
<td>E</td>
<td></td>
<td></td>
<td>1</td>
<td>304</td>
</tr>
</tbody>
</table>
Functions That Direct Program Execution (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register = contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>X ≠ NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register ( \neq ) contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>X &lt; NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register &lt; contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>X &lt;= NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register ( \leq ) contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>X &gt; NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register &gt; contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>X &gt;= NN?</td>
<td></td>
<td>Skips next instruction unless contents of X-register ( \geq ) contents of ( R_{nn} ), ( nn ) specified in Y-register.</td>
<td>E</td>
<td>2</td>
<td></td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>XEQ ( label )</td>
<td>XEQ ( label )</td>
<td>Calls specified global, numeric, or local Alpha label as subroutine. (If you specify a function, refer to the table entry for that function.)</td>
<td>I</td>
<td>E</td>
<td></td>
<td>301</td>
<td></td>
</tr>
</tbody>
</table>

* If label is specified indirectly, requires 2 bytes; if local label is specified, requires 3 bytes; if global label of \( m \) characters is specified, requires \( 2 + m \) bytes.
## Alpha Functions

These functions involve moving data into and out of the Alpha register, and manipulating the data in the Alpha register. Not included are functions that use the Alpha register for a file name. To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Description</th>
<th>Ind</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appends subsequent characters to Alpha register.</td>
<td>N</td>
<td>E 31, 36-39</td>
<td>2</td>
<td>243</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appends number in X-register to Alpha register in current date format.</td>
<td>E</td>
<td>313</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returns number of characters in Alpha register.</td>
<td>t,E</td>
<td>2</td>
<td>313</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returns first digit string in Alpha register.</td>
<td>t,E</td>
<td>22,28,29</td>
<td>2</td>
<td>311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deactivates Alpha keyboard.</td>
<td>E</td>
<td>48</td>
<td>1</td>
<td>159</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activates Alpha keyboard.</td>
<td>E</td>
<td>48</td>
<td>1</td>
<td>159</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appends contents of R to Alpha register.</td>
<td>I</td>
<td>E 28,29,36-41</td>
<td>2</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appends record (starting at pointer) to Alpha register.</td>
<td>E</td>
<td>17</td>
<td>2</td>
<td>226</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotates contents of Alpha register by ( n ) places, ( n ) specified in X-register. Rotates left for positive ( n ), right for negative ( n ).</td>
<td>E</td>
<td>313</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shifts six leftmost characters out of the Alpha register.</td>
<td>E</td>
<td>1</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copies six leftmost characters in Alpha register into ( R_{nn} ).</td>
<td>I</td>
<td>E</td>
<td>2</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appends number in X-register to Alpha register in current time format.</td>
<td>E</td>
<td>36-39</td>
<td>2</td>
<td>240</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Alpha Functions (continued)

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATIME24</td>
<td></td>
<td>Appends number in X-register to Alpha register in format.</td>
<td>E</td>
<td>36-39</td>
<td>2</td>
<td>2</td>
<td>241</td>
</tr>
<tr>
<td>ATOX</td>
<td></td>
<td>Shifts leftmost byte out of Alpha register and returns its decimal value to X-register.</td>
<td>t, E</td>
<td></td>
<td>2</td>
<td>311</td>
<td></td>
</tr>
<tr>
<td>AVIEW</td>
<td>AVIEW</td>
<td>Displays contents of Alpha register.</td>
<td>E</td>
<td>21,50,55</td>
<td>1</td>
<td>318</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>CLA</td>
<td>Clears Alpha register.</td>
<td>E</td>
<td>1</td>
<td>159</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GETREC</td>
<td></td>
<td>Copies record (starting at pointer) to Alpha register.</td>
<td>E</td>
<td>17</td>
<td>2</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>POSA</td>
<td></td>
<td>Searches Alpha register for target in X-register and returns position of match (−1 if no match).</td>
<td>L, E</td>
<td></td>
<td>2</td>
<td>312</td>
<td></td>
</tr>
<tr>
<td>PROMPT</td>
<td></td>
<td>Displays contents of Alpha register and stops program execution.</td>
<td>E</td>
<td>21,50,55</td>
<td>1</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>XTOA</td>
<td></td>
<td>Converts number in X-register to equivalent byte and appends it to Alpha register.</td>
<td>E</td>
<td>2</td>
<td>309</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Interactive Functions

To interpret this table, refer to “Explanation of Table Entries” on page 414.

<table>
<thead>
<tr>
<th>Alpha Name</th>
<th>Keyboard Name</th>
<th>Description</th>
<th>IND</th>
<th>Stack</th>
<th>Flags</th>
<th>Bytes</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADV</td>
<td></td>
<td>Advances paper (if printer is present).</td>
<td>E</td>
<td>21,55</td>
<td>1</td>
<td>368</td>
<td></td>
</tr>
<tr>
<td>BEEP</td>
<td>BEEP</td>
<td>Sounds four tones.</td>
<td>E</td>
<td>26</td>
<td>1</td>
<td>319</td>
<td></td>
</tr>
<tr>
<td>GETKEY</td>
<td></td>
<td>Waits up to 10 seconds for a key to be pressed; returns key code (0 if no key is pressed).</td>
<td>t,E</td>
<td></td>
<td>2</td>
<td>317</td>
<td></td>
</tr>
<tr>
<td>GETKEYX</td>
<td></td>
<td>Waits up to SS.ss seconds for a key to be pressed, SS.ss specified in X-register; returns keycode to Y-register and character code to X-register.</td>
<td>L,t,E</td>
<td>28,48</td>
<td>2</td>
<td>317</td>
<td></td>
</tr>
<tr>
<td>PROMPT</td>
<td></td>
<td>Displays contents of Alpha register and stops execution.</td>
<td>E</td>
<td>50</td>
<td>1</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>PSE</td>
<td></td>
<td>Delays execution for about one second.</td>
<td>E</td>
<td></td>
<td>1</td>
<td>315</td>
<td></td>
</tr>
<tr>
<td>TONE n</td>
<td></td>
<td>Sounds tone n. 0 ≤ n ≤ 9.</td>
<td>I</td>
<td>E</td>
<td>26</td>
<td>2</td>
<td>319</td>
</tr>
</tbody>
</table>

* Copies the contents of Y- and Z-registers into the Z- and T-registers respectively, regardless of whether stack lift is enabled.
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Page numbers in **bold** type indicate primary references; page numbers in regular type indicate secondary references. Also, page numbers in *italic* type are in volume 1, while page numbers *not* in italic type are in volume 2.

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Each function has up to three page references. The first one, in italics, is for volume 1. The second one is for volume 2. The third one, in boldface, is for the Function Tables, a summary in volume 2 of all functions.

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