

# TABLE OF CONTENTS

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<b>25. Input/Output Functions</b>	25.1
<b>25.1. Specifying Streams for Input/Output Functions</b>	25.1
<b>25.2. Input Functions</b>	25.2
<b>25.3. Output Functions</b>	25.7
<b>25.3.1. PRINTLEVEL</b>	25.11
<b>25.3.2. Printing numbers</b>	25.13
<b>25.3.3. User Defined Printing</b>	25.16
<b>25.3.4. Printing Unusual Data Structures</b>	25.17
<b>25.4. Random Access File Operations</b>	25.18
<b>25.5. Input/Output Operations with Characters and Bytes</b>	25.22
<b>25.6. PRINTOUT</b>	25.23
<b>25.6.1. Horizontal Spacing Commands</b>	25.25
<b>25.6.2. Vertical Spacing Commands</b>	25.26
<b>25.6.3. Special Formatting Controls</b>	25.27
<b>25.6.4. Printing Specifications</b>	25.27
<b>25.6.4.1. Paragraph Format</b>	25.28
<b>25.6.4.2. Right-Flushning</b>	25.29
<b>25.6.4.3. Centering</b>	25.29
<b>25.6.4.4. Numbering</b>	25.29
<b>25.6.5. Escaping to Lisp</b>	25.30
<b>25.6.6. User-Defined Commands</b>	25.31
<b>25.6.7. Special Printing Functions</b>	25.32
<b>25.7. READFILE and WRITEFILE</b>	25.33
<b>25.8. Read Tables</b>	25.33
<b>25.8.1. Read Table Functions</b>	25.34
<b>25.8.2. Syntax Classes</b>	25.35
<b>25.8.3. Read Macros</b>	25.39

This chapter describes the standard I/O functions used for reading and printing characters and Interlisp expressions on files and other streams. First, the primitive input functions are presented, then the output functions, then functions for random-access operations (such as searching a file for a given stream, or changing the "next-character" pointer to a position in a file). Next, the **PRINTOUT** statement is documented (page 25.23), which provides an easy way to write complex output operations. Finally, read tables, used to parse characters as Interlisp expressions, are documented.

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## 25.1 Specifying Streams for Input/Output Functions

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Most of the input/output functions in Interlisp-D have an argument named **STREAM** or **FILE**, specifying on which open stream the function's action should occur (the name **FILE** is used in older functions that predate the concept of stream; the two should, however, be treated synonymously). The value of this argument should be one of the following:

**a stream** An object of type **STREAM**, as returned by **OPENSTREAM** (page 24.2) or other stream-producing functions, is always the most precise and efficient way to designate a stream argument.

**T**

The litatom **T** designates the terminal input or output stream of the currently running process, controlling input from the keyboard and output to the display screen. For functions where the direction (input or output) is ambiguous, **T** is taken to designate the terminal output stream. The **T** streams are always open; they cannot be closed.

The terminal output stream can be set to a given window or display stream by using **TTYDISPLAYSTREAM** (page 28.29). The terminal input stream cannot be changed. For more information on terminal I/O, see page 30.1.

**NIL**

The litatom **NIL** designates the "primary" input or output stream. These streams are initially the same as the terminal

input/output streams, but they can be changed by using the functions **INPUT** (page 25.3) and **OUTPUT** (page 25.8).

For functions where the direction (input or output) is ambiguous, e.g., **GETFILEPTR**, the argument **NIL** is taken to mean the primary input stream, if that stream is not identical to the terminal input stream, else the primary output stream.

- |             |   |
|-------------|---|
| a window    | Uses the display stream of the window (page 28.34). Valid for output only.  |
| a file name | As of this writing, the name of an open file (as a litatom) can be used as a stream argument. However, there are inefficiencies and possible future incompatibilities associated with doing so. See page 24.13 for details. |

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**(GETSTREAM FILE ACCESS)****[Function]**

Coerces the argument *FILE* to a stream by the above rules. If *ACCESS* is **INPUT**, **OUTPUT**, or **BOTH**, produces the stream designated by *FILE* that is open for *ACCESS*. If *ACCESS*=**NIL**, returns a stream for *FILE* open for any kind of input/output (see the list above for the ambiguous cases). If *FILE* does not designate a stream open in the specified mode, causes an error, **FILE NOT OPEN**.

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**(STREAMP X)****[Function]**

Returns *X* if *X* is a **STREAM**, otherwise **NIL**.

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## 25.2 Input Functions

While the functions described below can take input from any stream, some special actions occur when the input is from the terminal (the **T** input stream, see page 25.1). When reading from the terminal, the input is buffered a line at a time, unless buffering has been inhibited by **CONTROL** (page 30.10) or the input is being read by **READC** or **PEEKC** (page 25.5). Using specified editing characters, the user can erase a character at a time, a word at a time, or the whole line. The keys that perform these editing functions are assignable via **SETSYNTAX** (page 25.37), with the initial settings chosen to be those most natural for the given operating system. In Interlisp-D, the initial settings are as follows: characters are deleted one at a time by Backspace; words are erased by control-W; the whole line is erased by control-Q.

On the Interlisp-D display, deleting a character or a line causes the characters to be physically erased from the screen. In

Interlisp-10, the deleting action can be modified for various types of display terminals by using **DELETECONTROL** (page 30.8).

Unless otherwise indicated, when the end of file is encountered while reading from a file, all input functions generate an error, **END OF FILE**. Note that this does not close the input file. The **ENDOFSTREAMOP** stream attribute (page 24.19) is useful for changing the behavior at end of file.

Most input functions have a *RDTBL* argument, which specifies the read table to be used for input (see page 25.33). Unless otherwise specified, if *RDTBL* is **NIL**, the primary read table is used.

If the *FILE* or *STREAM* argument to an input function is **NIL**, the primary input stream is used (see page 25.1).

(INPUT FILE)	[Function]
	Sets <i>FILE</i> as the primary input stream; returns the old primary input stream. <i>FILE</i> must be open for input.
(INPUT)	(INPUT) returns the current primary input stream, which is not changed.
	Note: If the primary input stream is set to a file, the file's full name, rather than the stream itself, is returned. See discussion on page 24.13.

(READ FILE RDTBL FLG)	[Function]
	Reads one expression from <i>FILE</i> . Atoms are delimited by the break and separator characters as defined in <i>RDTBL</i> . To include a break or separator character in an atom, the character must be preceded by the character %, e.g., <b>AB%(C</b> is the atom <b>AB(C</b> , %% is the atom %, %control-K is the atom control-K. For input from the terminal, an atom containing an interrupt character can be input by typing instead the corresponding alphabetic character preceded by control-V, e.g., ↑VD for control-D.
	Strings are delimited by double quotes. To input a string containing a double quote or a %, precede it by %, e.g., "AB%"C" is the string AB"C. Note that % can always be typed even if next character is not "special", e.g., %A%B%C is read as ABC.
	If an atom is interpretable as a number, READ creates a number, e.g., <b>1E3</b> reads as a floating point number, <b>1D3</b> as a literal atom, <b>1.0</b> as a number, <b>1,0</b> as a literal atom, etc. An integer can be input in a non-decimal radix by using syntax such as <b>123Q</b> , <b> b10101</b> , <b> 5r1234</b> (see page 7.4). The function <b>RADIX</b> (page 25.13), sets the radix used to print integers.

When reading from the terminal, all input is line-buffered to enable the action of the backspacing control characters, unless inhibited by **CONTROL** (page 30.10). Thus no characters are

actually seen by the program until a carriage-return (actually the character with terminal syntax class **EOL**, see page 30.6), is typed. However, for reading by **READ**, when a matching right parenthesis is encountered, the effect is the same as though a carriage-return were typed, i.e., the characters are transmitted. To indicate this, Interlisp also prints a carriage-return line-feed on the terminal. The line buffer is also transmitted to **READ** whenever an **IMMEDIATE** read macro character is typed (page 25.41).

*FLG = T* suppresses the carriage-return normally typed by **READ** following a matching right parenthesis. (However, the characters are still given to **READ**; i.e., the user does not have to type the carriage-return.)

**(RATOM FILE RDTBL)**

[Function]

Reads in one atom from *FILE*. Separation of atoms is defined by *RDTBL*. % is also defined for **RATOM**, and the remarks concerning line-buffering and editing control characters also apply.

If the characters comprising the atom would normally be interpreted as a number by **READ**, that number is returned by **RATOM**. Note however that **RATOM** takes no special action for "whether or not it is a break character, i.e., **RATOM** never makes a string.

**(RSTRING FILE RDTBL)**

[Function]

Reads characters from *FILE* up to, but not including, the next break or separator character, and returns them as a string. Backspace, control-W, control-Q, control-V, and % have the same effect as with **READ**.

Note that the break or separator character that terminates a call to **RATOM** or **RSTRING** is *not* read by that call, but remains in the buffer to become the first character seen by the next reading function that is called. If that function is **RSTRING**, it will return the null string. This is a common source of program bugs.

**(RATOMS A FILE RDTBL)**

[Function]

Calls **RATOM** repeatedly until the atom *A* is read. Returns a list of the atoms read, not including *A*.

**(RATEST FLG)**

[Function]

If *FLG = T*, **RATEST** returns *T* if a separator was encountered immediately prior to the atom returned by the last **RATOM** or **READ**, **NIL** otherwise.

If *FLG* = NIL, RATEST returns T if last atom read by RATOM or READ was a break character, NIL otherwise.

If *FLG* = 1, RATEST returns T if last atom read (by READ or RATOM) contained a % used to quote the next character (as in %[ or %A%B%C), NIL otherwise.

**(READC FILE RDTBL)**

[Function]

Reads and returns the next character, including %, ", etc, i.e., is not affected by break or separator characters. The action of READC is subject to line-buffering, i.e., READC does not return a value until the line has been terminated even if a character has been typed. Thus, the editing control characters have their usual effect. RDTBL does not directly affect the value returned, but is used as usual in line-buffering, e.g., determining when input has been terminated. If (CONTROL T) has been executed (page 30.10), defeating line-buffering, the RDTBL argument is irrelevant, and READC returns a value as soon as a character is typed (even if the character typed is one of the editing characters, which ordinarily would never be seen in the input buffer).

**(PEEKC FILE —)**

[Function]

Returns the next character, but does not actually read it and remove it from the buffer. If reading from the terminal, the character is echoed as soon as PEEKC reads it, even though it is then "put back" into the system buffer, where backspace, control-W, etc. could change it. Thus it is possible for the value returned by PEEKC to "disagree" in the first character with a subsequent READ.

**(LASTC FILE)**

[Function]

Returns the last character read from FILE.

**(READCCODE FILE RDTBL)**

[Function]

Returns the next character code from STREAM; thus, this operation is equivalent to, but more efficient than, (CHCON1 (READC FILE RDTBL)).

**(PEEKCCODE FILE —)**

[Function]

Returns, without consuming, the next character code from STREAM; thus, this operation is equivalent to, but more efficient than, (CHCON1 (PEEKC FILE)).

**(BIN STREAM)**

[Function]

Returns the next byte from STREAM. This operation is useful for reading streams of binary, rather than character, data.

Note: **BIN** is similar to **READCCODE**, except that **BIN** always reads a single byte, whereas **READCCODE** reads a "character" that can consist of more than one byte, depending on the character and its encoding (see page 25.22).

**READ**, **RATOM**, **RATOMS**, **PEEKC**, **READC** all wait for input if there is none. The only way to test whether or not there is input is to use **READP**:

( <b>READP FILE FLG</b> )	[Function]
	<p>Returns <b>T</b> if there is anything in the input buffer of <i>FILE</i>, <b>NIL</b> otherwise. This operation is only interesting for streams whose source of data is dynamic, e.g., the terminal or a byte stream over a network; for other streams, such as to files, (<b>READP FILE</b>) is equivalent to (<b>NOT (EOFP FILE)</b>).</p> <p>Note that because of line-buffering, <b>READP</b> may return <b>T</b>, indicating there is input in the buffer, but <b>READ</b> may still have to wait.</p> <p>Frequently, the terminal's input buffer contains a single <b>EOL</b> character left over from a previous input. For most applications, this situation wants to be treated as though the buffer were empty, and so <b>READP</b> returns <b>NIL</b> in this case. However, if <i>FLG=T</i>, <b>READP</b> returns <b>T</b> if there is <i>any</i> character in the input buffer, including a single <b>EOL</b>. <i>FLG</i> is ignored for streams other than the terminal.</p>
( <b>EOFP FILE</b> )	[Function]

( <b>EOFP FILE</b> )	[Function]
	<p>Returns true if <i>FILE</i> is at "end of file", i.e., the next call to an input function would cause an <b>END OF FILE</b> error; <b>NIL</b> otherwise. For randomly accessible files (page 25.18), this can also be thought of as the file pointer pointing beyond the last byte of the file. <i>FILE</i> must be open for (at least) input, or an error is generated, <b>FILE NOT OPEN</b>.</p> <p>Note that <b>EOFP</b> can return <b>NIL</b> and yet the next call to <b>READ</b> might still cause an <b>END OF FILE</b> error, because the only characters remaining in the input were separators or otherwise constituted an incomplete expression. The function <b>SKIPSEPRS</b> (page 25.7) is sometimes more useful as a way of detecting end of file when it is known that all the expressions in the file are well formed.</p>

( <b>WAITFORINPUT FILE</b> )	[Function]
	<p>Waits until input is available from <i>FILE</i> or from the terminal, i.e. from <b>T</b>. <b>WAITFORINPUT</b> is functionally equivalent to (until (<b>OR (READP T) (READP FILE)</b>) do <b>NIL</b>), except that it does not use up machine cycles while waiting. Returns the device for which input is now available, i.e. <i>FILE</i> or <b>T</b>.</p>

*FILE* can also be an integer, in which case **WAITFORINPUT** waits until there is input available from the terminal, or until *FILE* milliseconds have elapsed. Value is **T** if input is now available, **NIL** in the case that **WAITFORINPUT** timed out.

**(SKREAD FILE REREADSTRING RDTBL)**

[Function]

"Skip Read". **SKREAD** consumes characters from *FILE* as if one call to **READ** had been performed, without paying the storage and compute cost to really read in the structure. **REREADSTRING** is for the case where the caller has already performed some **READC**'s and **RATOM**'s before deciding to skip this expression. In this case, **REREADSTRING** should be the material already read (as a string), and **SKREAD** operates as though it had seen that material first, thus setting up its parenthesis count, double-quote count, etc.

The read table *RDTBL* is used for reading from *FILE*. If *RDTBL* is **NIL**, it defaults to the value of **FILERDTBL**. **SKREAD** may have difficulties if unusual read macros (page 25.39) are defined in *RDTBL*. **SKREAD** does not recognize read macro characters in **REREADSTRING**, nor **SPLICE** or **INFIX** read macros. This is only a problem if the read macros are defined to parse subsequent input in the stream that does not follow the normal parenthesis and string-quote conventions.

**SKREAD** returns **%)** if the read terminated on an unbalanced closing parenthesis; **%]** if the read terminated on an unbalanced **%]**, i.e., one which also would have closed any extant open left parentheses; otherwise **NIL**.

**(SKIPSEPRS FILE RDTBL)**

[Function]

Consumes characters from *FILE* until it encounters a non-separator character (as defined by *RDTBL*). **SKIPSEPRS** returns, but does not consume, the terminating character, so that the next call to **READC** would return the same character. If no non-separator character is found before the end of file is reached, **SKIPSEPRS** returns **NIL** and leaves the stream at end of file. This function is useful for skipping over "white space" when scanning a stream character by character, or for detecting end of file when reading expressions from a stream with no pre-arranged terminating expression.

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## 25.3 Output Functions

Unless otherwise specified by **DEFPRINT** (page 25.16), pointers other than lists, strings, atoms, or numbers, are printed in the form {**DATATYPE**} followed by the octal representation of the

address of the pointer (regardless of radix). For example, an array pointer might print as {ARRAYP}#43,2760. This printed representation is for compactness of display on the user's terminal, and will *not* read back in correctly; if the form above is read, it will produce the litatom {ARRAYP}#43,2760.

Note: the term "end-of-line" appearing in the description of an output function means the character or characters used to terminate a line in the file system being used by the given implementation of Interlisp. For example, in Interlisp-D end-of-line is indicated by the character carriage-return.

Some of the functions described below have a *RDTBL* argument, which specifies the read table to be used for output (see page 25.33). If *RDTBL* is NIL, the primary read table is used.

Most of the functions described below have an argument *FILE*, which specifies the stream on which the operation is to take place. If *FILE* is NIL, the primary output stream is used (see page 25.1).

(OUTPUT FILE)	[Function]
---------------	------------

Sets *FILE* as the primary output stream; returns the old primary output stream. *FILE* must be open for output.

(OUTPUT) returns the current primary output stream, which is not changed.

Note: If the primary output stream is set to a file, the file's full name, rather than the stream itself, is returned. See discussion on page 24.13.

(PRIN1 X FILE)	[Function]
----------------	------------

Prints *X* on *FILE*.

(PRIN2 X FILE RDTBL)	[Function]
----------------------	------------

Prints *X* on *FILE* with %'s and "'s inserted where required for it to read back in properly by READ, using *RDTBL*.

Both PRIN1 and PRIN2 print any kind of Lisp expression, including lists, atoms, numbers, and strings. PRIN1 is generally used for printing expressions where human readability, rather than machine readability, is important, e.g., when printing text rather than program fragments. PRIN1 does not print double quotes around strings, or % in front of special characters. PRIN2 is used for printing Interlisp expressions which can then be read back into Interlisp with READ; i.e., break and separator characters in atoms will be preceded by %'s. For example, the atom "()" is printed as %()% by PRIN2. If the integer output radix (as set by RADIX, page 25.13) is not 10, PRIN2 prints the integer using the

input syntax for non-decimal integers (see page 7.4) but PRIN1 does not (but both print the integer in the output radix).

**(PRIN3 X FILE)**

[Function]

**(PRIN4 X FILE RDTBL)**

[Function]

PRIN3 and PRIN4 are the same as PRIN1 and PRIN2 respectively, except that they do not increment the horizontal position counter nor perform any linelength checks. They are useful primarily for printing control characters.

**(PRINT X FILE RDTBL)**

[Function]

Prints the expression X using PRIN2 followed by an end-of-line. Returns X.

**(PRINTCCODE CHARCODE FILE)**

[Function]

Outputs a single character whose code is CHARCODE to FILE. This is similar to (PRIN1 (CHARACTER CHARCODE)), except that numeric characters are guaranteed to print "correctly"; e.g., (PRINTCCODE (CHARCODE 9)) always prints "9", independent of the setting of RADIX.

Note that PRINTCCODE may actually print more than one byte on FILE, due to character encoding and end of line conventions; thus, no assumptions should be made about the relative motion of the file pointer (see GETFILEPTR, page 25.19) during this operation.

**(BOUT STREAM BYTE)**

[Function]

Outputs a single 8-bit byte to STREAM. This is similar to PRINTCCODE, but for binary streams the character position in STREAM is not updated (as with PRIN3), and end of line conventions are ignored.

Note: BOUT is similar to PRINTCCODE, except that BOUT always writes a single byte, whereas PRINTCCODE writes a "character" that can consist of more than one byte, depending on the character and its encoding (see page 25.22).

**(SPACES N FILE)**

[Function]

Prints N spaces. Returns NIL.

**(TERPRI FILE)**

[Function]

Prints an end-of-line character. Returns NIL.

(FRESHLINE STREAM)	[Function]
Equivalent to TERPRI, except it does nothing if it is already at the beginning of the line. Returns T if it prints an end-of-line, NIL otherwise.	

(TAB POS MINSPACES FILE)	[Function]
Prints the appropriate number of spaces to move to position POS. MINSPACES indicates how many spaces must be printed (if NIL, 1 is used). If the current position plus MINSPACES is greater than POS, TAB does a TERPRI and then (SPACES POS). If MINSPACES is T, and the current position is greater than POS, then TAB does nothing.	

Note: A sequence of PRINT, PRIN2, SPACES, and TERPRI expressions can often be more conveniently coded with a single PRINTOUT statement (page 25.23).

(SHOWPRIN2 X FILE RDTBL)	[Function]
Like PRIN2 except if SYSPRETTYFLG = T, prettyprints X instead. Returns X.	

(SHOWPRINT X FILE RDTBL)	[Function]
Like PRINT except if SYSPRETTYFLG = T, prettyprints X instead, followed by an end-of-line. Returns X.	

SHOWPRINT and SHOWPRIN2 are used by the programmer's assistant (page 13.1) for printing the values of expressions and for printing the history list, by various commands of the break package (page 14.1), e.g. ?= and BT commands, and various other system packages. The idea is that by simply setting or binding SYSPRETTYFLG to T (initially NIL), the user instructs the system when interacting with the user to PRETTYPRINT expressions (page 26.40) instead of printing them.

(PRINTBELLS —)	[Function]
Used by DWIM (page 20.1) to print a sequence of bells to alert the user to stop typing. Can be advised or redefined for special applications, e.g., to flash the screen on a display terminal.	

(FORCEOUTPUT STREAM WAITFORFINISH)	[Function]
Forces any buffered output data in STREAM to be transmitted. If WAITFORFINISH is non-NIL, this doesn't return until the data has been forced out.	

(POSITION FILE N)	[Function]
	Returns the column number at which the next character will be read or printed. After a end of line, the column number is 0. If <i>N</i> is non- <b>NIL</b> , resets the column number to be <i>N</i> .  Note that resetting <b>POSITION</b> only changes Lisp's belief about the current column number; it does not cause any horizontal motion. Also note that ( <b>POSITION FILE</b> ) is <i>not</i> the same as ( <b>GETFILEPTR FILE</b> ) which gives the position in the <i>file</i> , not on the <i>line</i> .
(LINELENGTH N FILE)	[Function]
	Sets the length of the print line for the output file <i>FILE</i> to <i>N</i> ; returns the former setting of the line length. <i>FILE</i> defaults to the primary output stream. ( <b>LINELENGTH NIL FILE</b> ) returns the current setting for <i>FILE</i> . When a file is first opened, its line length is set to the value of the variable <b>FILELINELENGTH</b> .  Whenever printing an atom or string would increase a file's position <i>beyond</i> the line length of the file, an end of line is automatically inserted first. This action can be defeated by using <b>PRIN3</b> and <b>PRIN4</b> (page 25.9).
(SETLINELENGTH N)	[Function]
	Sets the line length for the terminal by doing ( <b>LINELENGTH N T</b> ). If <i>N</i> is <b>NIL</b> , it determines <i>N</i> by consulting the operating system's belief about the terminal's characteristics. In Interlisp-D, this is a no-op.

### 25.3.1 PRINTLEVEL

When using Interlisp one often has to handle large, complicated lists, which are difficult to understand when printed out. **PRINTLEVEL** allows the user to specify in how much detail lists should be printed. The print functions **PRINT**, **PRIN1**, and **PRIN2** are all affected by level parameters set by:

(PRINTLEVEL CARVAL CDRVAL)	[Function]
	Sets the <b>CAR</b> print level to <i>CARVAL</i> , and the <b>CDR</b> print level to <i>CDRVAL</i> . Returns a list cell whose <b>CAR</b> and <b>CDR</b> are the old settings. <b>PRINTLEVEL</b> is initialized with the value (1000 .-1).  In order that <b>PRINTLEVEL</b> can be used with <b>RESETFORM</b> or <b>RESETSAVE</b> , if <i>CARVAL</i> is a list cell it is equivalent to ( <b>PRINTLEVEL (CAR CARVAL) (CDR CARVAL)</b> ).
(PRINTLEVEL N NIL)	changes the <b>CAR</b> printlevel without affecting the <b>CDR</b> printlevel. ( <b>PRINTLEVEL NIL N</b> ) changes the <b>CDR</b>

printlevel with affecting the **CAR** printlevel. (**PRINTLEVEL**) gives the current setting without changing either.

Note: control-P (page 30.2) can be used to change the **PRINTLEVEL** setting dynamically, even while Interlisp is printing.

---

The **CAR** printlevel specifies how "deep" to print a list. Specifically, it is the number of unpaired left parentheses which will be printed. Below that level, all lists will be printed as &. If the **CAR** printlevel is *negative*, the action is similar except that an end-of-line is inserted after each right parentheses that would be immediately followed by a left parenthesis.

The **CDR** printlevel specifies how "long" to print a list. It is the number of top level list elements that will be printed before the printing is terminated with --. For example, if **CDRVAL** = 2, (A B C D E) will print as (A B --). For sublists, the number of list elements printed is also affected by the depth of printing in the **CAR** direction: Whenever the *sum* of the depth of the sublist (i.e. the number of unmatched left parentheses) and the number of elements is greater than the **CDR** printlevel, -- is printed. This gives a "triangular" effect in that less is printed the farther one goes in either **CAR** or **CDR** direction. If the **CDR** printlevel is negative, then it is the same as if the **CDR** printlevel were infinite.

Examples:

After:	(A (B C (D (E F) G) H) K L) prints as:
(PRINTLEVEL 3 -1)	(A (B C (D & G) H) K L)
(PRINTLEVEL 2 -1)	(A (B C & H) K L)
(PRINTLEVEL 1 -1)	(A & K L)
(PRINTLEVEL 0 -1)	&
(PRINTLEVEL 1000 2)	(A (B --) --)
(PRINTLEVEL 1000 3)	(A (B C --) K --)
(PRINTLEVEL 1 3)	(A & K --)

---

**PLVLFILEFLG**

[Variable]

Normally, **PRINTLEVEL** only affects terminal output. Output to all other files acts as though the print level is infinite. However, if **PLVLFILEFLG** is T (initially NIL), then **PRINTLEVEL** affects output to files as well.

---

The following three functions are useful for printing isolated expressions at a specified print level without going to the overhead of resetting the global print level.

---

(LVLPRINT X FILE CARLVL CDRLVL TAIL)	[Function]
--------------------------------------	------------

Performs **PRINT** of *X* to *FILE*, using as **CAR** and **CDR** print levels the values **CARLVL** and **CDRLVL**, respectively. Uses the **T** read table. If *TAIL* is specified, and *X* is a tail of it, then begins its printing with "...", rather than on open parenthesis.

---

(LVLPRIN2 X FILE CARLVL CDRLVL TAIL)	[Function]
--------------------------------------	------------

Similar to **LVLPRIN2**, but performs a **PRIN2**.

---

(LVLPRIN1 X FILE CARLVL CDRLVL TAIL)	[Function]
--------------------------------------	------------

Similar to **LVLPRIN1**, but performs a **PRIN1**.

---

### 25.3.2 Printing numbers

How the ordinary printing functions (**PRIN1**, **PRIN2**, etc.) print numbers can be affected in several ways. **RADIX** influences the printing of integers, and **FLTFMT** influences the printing of floating point numbers. The setting of the variable **PRXFLG** determines how the symbol-manipulation functions handle numbers. The **PRINTNUM** package permits greater controls on the printed appearance of numbers, allowing such things as left-justification, suppression of trailing decimals, etc.

---

(RADIX <i>N</i> )	[Function]
-------------------	------------

Resets the output radix for integers to the absolute value of *N*. The value of **RADIX** is its previous setting. **(RADIX)** gives the current setting without changing it. The initial setting is 10.

Note that **RADIX** affects output *only*. There is no input radix; on input, numbers are interpreted as decimal unless they are entered in a non-decimal radix with syntax such as **123Q**, **|b10101**, **|5r1234** (see page 7.4). **RADIX** does not affect the behavior of **UNPACK**, etc., unless the value of **PRXFLG** (below) is **T**. For example, if **PRXFLG** is **NIL** and the radix is set to 8 with **(RADIX 8)**, the value of **(UNPACK 9)** is **(9)**, not **(1 1)**.

Using **PRINTNUM** (page 25.15) or the **PRINTOUT** command **.I** (page 25.30) is often a more convenient and appropriate way to print a single number in a specified radix than to globally change **RADIX**.

---

(FLTFMT FORMAT)	[Function]
-----------------	------------

Resets the output format for floating point numbers to the **FLOAT** format *FORMAT* (see **PRINTNUM** below for a description of **FLOAT** formats). **FORMAT=T** specifies the default "free" formatting: some number of significant digits (a function of the implementation) are printed, with trailing zeros suppressed;

numbers with sufficiently large or small exponents are instead printed in exponent notation.

**FLTFMT** returns its current setting. (**FLTFMT**) returns the current setting without changing it. The initial setting is **T**.

Note: In Interlisp-D, **FLTFMT** ignores the **WIDTH** and **PAD** fields of the format (they are implemented only by **PRINTNUM**).

---

Whether print name manipulation functions (**UNPACK**, **NCHARS**, etc.) use the values of **RADIX** and **FLTFMT** is determined by the variable **PRXFLG**:

---

**PRXFLG**

[Variable]

If **PRXFLG = NIL** (the initial setting), then the "PRIN1" name used by **PACK**, **UNPACK**, **MKSTRING**, etc., is computed using base 10 for integers and the system default floating format for floating point numbers, independent of the current setting of **RADIX** or **FLTFMT**. If **PRXFLG = T**, then **RADIX** and **FLTFMT** do dictate the "PRIN1" name of numbers. Note that in this case, **PACK** and **UNPACK** are *not* inverses.

Examples with (**RADIX 8**), (**FLTFMT '(FLOAT 4 2)**):

With **PRXFLG = NIL**,

(**UNPACK 13**) => (1 3)

(**PACK '(A 9)**) => A9

(**UNPACK 1.2345**) => (1 %. 2 3 4 5)

With **PRXFLG = T**,

(**UNPACK 13**) => (1 5)

(**PACK '(A 9)**) => A11

(**UNPACK 1.2345**) => (1 %. 2 3)

Note that **PRXFLG** does not effect the radix of "PRIN2" names, so with (**RADIX 8**), (**NCHARS 9 T**), which uses PRIN2 names, would return 3, (since 9 would print as 11Q) for either setting of **PRXFLG**.

Warning: Some system functions will not work correctly if **PRXFLG** is not **NIL**. Therefore, resetting the global value of **PRXFLG** is not recommended. It is much better to rebind **PRXFLG** as a **SPECVAR** for that part of a program where it needs to be non-**NIL**.

---

The basic function for printing numbers under format control is **PRINTNUM**. Its utility is considerably enhanced when used in conjunction with the **PRINTOUT** package (page 25.23), which implements a compact language for specifying complicated

sequences of elementary printing operations, and makes fancy output formats easy to design and simple to program.

**(PRINNUM FORMAT NUMBER FILE)**

[Function]

Prints *NUMBER* on *FILE* according to the format *FORMAT*. *FORMAT* is a list structure with one of the forms described below.

If *FORMAT* is a list of the form (**FIX** *WIDTH RADIX PADO LEFTFLUSH*), this specifies a **FIX** format. *NUMBER* is rounded to the nearest integer, and then printed in a field *WIDTH* characters long with radix set to *RADIX* (or 10 if *RADIX* = **NIL**; note that the setting from the function **RADIX** is *not* used as the default). If *PADO* and *LEFTFLUSH* are both **NIL**, the number is right-justified in the field, and the padding characters to the left of the leading digit are spaces. If *PADO* is **T**, the character "0" is used for padding. If *LEFTFLUSH* is **T**, then the number is left-justified in the field, with trailing spaces to fill out *WIDTH* characters.

The following examples illustrate the effects of the **FIX** format options on the number 9 (the vertical bars indicate the field width):

*FORMAT:* (**PRINNUM FORMAT** 9) prints:

(**FIX** 2) | 9|

(**FIX** 2 **NIL** **T**) |09|

(**FIX** 12 8 **T**) |000000000011|

(**FIX** 5 **NIL** **NIL** **T**) |9 |

If *FORMAT* is a list of the form (**FLOAT** *WIDTH DECPART EXPPART PADO ROUND*), this specifies a **FLOAT** format. *NUMBER* is printed as a decimal number in a field *WIDTH* characters wide, with *DECPART* digits to the right of the decimal point. If *EXPPART* is not 0 (or **NIL**), the number is printed in exponent notation, with the exponent occupying *EXPPART* characters in the field. *EXPPART* should allow for the character **E** and an optional sign to be printed before the exponent digits. As with **FIX** format, padding on the left is with spaces, unless *PADO* is **T**. If *ROUND* is given, it indicates the digit position at which rounding is to take place, counting from the leading digit of the number.

Interlisp-D interprets *WIDTH* = **NIL** to mean no padding, i.e., to use however much space the number needs, and interprets *DECPART* = **NIL** to mean as many decimal places as needed.

The following examples illustrate the effects of the **FLOAT** format options on the number 27.689 (the vertical bars indicate the field width):

*FORMAT:* (**PRINNUM FORMAT** 27.689) prints:

(**FLOAT** 7 2) | 27.69|

(FLOAT 7 2 NIL T)	0027.69
(FLOAT 7 2 2)	2.77E1
(FLOAT 11 2 4)	2.77E + 01
(FLOAT 7 2 NIL NIL 1)	30.00
(FLOAT 7 2 NIL NIL 2)	28.00

---

**NILNUMPRINTFLG**

[Variable]

If PRINTNUM's *NUMBER* argument is not a number and not NIL, a **NON-NUMERIC ARG** error is generated. If *NUMBER* is NIL, the effect depends on the setting of the variable **NILNUMPRINTFLG**. If **NILNUMPRINTFLG** is NIL, then the error occurs as usual. If it is non-NIL, then no error occurs, and the value of **NILNUMPRINTFLG** is printed right-justified in the field described by *FORMAT*. This option facilitates the printing of numbers in aggregates with missing values coded as NIL.

---

### **25.3.3 User Defined Printing**

---

Initially, Interlisp only knows how to print in an interesting way objects of type litatom, number, string, list and stackp. All other types of objects are printed in the form {datatype} followed by the octal representation of the address of the pointer, a format that cannot be read back in to produce an equivalent object. When defining user data types (using the **DATATYPE** record type, page 8.9), it is often desirable to specify as well how objects of that type should be printed, so as to make their contents readable, or at least more informative to the viewer. The function **DEFPRINT** is used to specify the printing format of a data type.

---

**(DEFPRINT TYPE FN)**

[Function]

*TYPE* is a type name. Whenever a printing function (**PRINT**, **PRIN1**, **PRIN2**, etc.) or a function requiring a print name (**CHCON**, **NCHARS**, etc.) encounters an object of the indicated type, *FN* is called with two arguments: the item to be printed and the name of the stream, if any, to which the object is to be printed. The second argument is NIL on calls that request the print name of an object without actually printing it.

If *FN* returns a list of the form (*ITEM1 . ITEM2*), *ITEM1* is printed using **PRIN1** (unless it is NIL), and then *ITEM2* is printed using **PRIN2** (unless it is NIL). No spaces are printed between the two items. Typically, *ITEM1* is a read macro character.

If *FN* returns NIL, the datum is printed in the system default manner.

If *FN* returns T, nothing further is printed; *FN* is assumed to have printed the object to the stream itself. Note that this case is permitted only when the second argument passed to *FN* is non-NIL; otherwise, there is no destination for *FN* to do its printing, so it must return as in one of the other two cases.

#### 25.3.4 Printing Unusual Data Structures

**HPRINT** (for "Horrible Print") and **HREAD** provide a mechanism for printing and reading back in general data structures that cannot normally be dumped and loaded easily, such as (possibly re-entrant or circular) structures containing user datatypes, arrays, hash tables, as well as list structures. **HPRINT** will correctly print and read back in any structure containing any or all of the above, chasing all pointers down to the level of literal atoms, numbers or strings. **HPRINT** currently cannot handle compiled code arrays, stack positions, or arbitrary unboxed numbers.

**HPRINT** operates by simulating the Interlisp **PRINT** routine for normal list structures. When it encounters a user datatype (see page 8.20), or an array or hash array, it prints the data contained therein, surrounded by special characters defined as read macro characters (see page 25.39). While chasing the pointers of a structure, it also keeps a hash table of those items it encounters, and if any item is encountered a second time, another read macro character is inserted before the first occurrence (by resetting the file pointer with **SETFILEPTR**) and all subsequent occurrences are printed as a back reference using an appropriate macro character. Thus the inverse function, **HREAD** merely calls the Interlisp **READ** routine with the appropriate read table.

##### (**HPRINT EXPR FILE UNCIRCULAR DATATYPESEEN**)

[Function]

Prints *EXPR* on *FILE*. If *UNCIRCULAR* is non-NIL, **HPRINT** does no checking for any circularities in *EXPR* (but is still useful for dumping arbitrary structures of arrays, hash arrays, lists, user data types, etc., that do not contain circularities). Specifying *UNCIRCULAR* as non-NIL results in a large speed and internal-storage advantage.

Normally, when **HPRINT** encounters a user data type for the first time, it outputs a summary of the data type's declaration. When this is read in, the data type is redeclared. If *DATATYPESEEN* is non-NIL, **HPRINT** assumes that the same data type declarations will be in force at read time as were at **HPRINT** time, and not output declarations.

**HPRINT** is intended primarily for output to random access files, since the algorithm depends on being able to reset the file pointer. If *FILE* is not a random access file (and *UNCIRCULAR* = NIL), a temporary file, **HPRINT.SCRATCH**, is opened, *EXPR* is

HPRINTed on it, and then that file is copied to the final output file and the temporary file is deleted.

---

(HREAD FILE)	[Function]
Reads and returns an HPRINT-ed expression from FILE.	

(HCOPYALL X)	[Function]
Copies data structure X. X may contain circular pointers as well as arbitrary structures.	

Note: HORRIBLEVARS and UGLYVARS (page 17.36) are two file package commands for dumping and reloading circular and re-entrant data structures. They provide a convenient interface to HPRINT and HREAD.

When HPRINT is dumping a data structure that contains an instance of an Interlisp datatype, the datatype declaration is also printed onto the file. Reading such a data structure with HREAD can cause problems if it redefines a system datatype. Redefining a system datatype will almost definitely cause serious errors. The Interlisp system datatypes do not change very often, but there is always a possibility when loading in old files created under an old Interlisp release.

To prevent accidental system crashes, HREAD will not redefine datatypes. Instead, it will cause an error "attempt to read DATATYPE with different field specification than currently defined". Continuing from this error will redefine the datatype.

---

## 25.4 Random Access File Operations

---

For most applications, files are read starting at their beginning and proceeding sequentially, i.e., the next character read is the one immediately following the last character read. Similarly, files are written sequentially. However, for files on some devices, it is also possible to read/write characters at arbitrary positions in a file, essentially treating the file as a large block of auxiliary storage. For example, one application might involve writing an expression at the *beginning* of the file, and then reading an expression from a specified point in its *middle*. This particular example requires the file be open for *both* input and output. However, random file input or output can also be performed on files that have been opened for only input or only output.

Associated with each file is a "file pointer" that points to the location where the next character is to be read from or written to. The file position of a byte is the number of bytes that precede

it in the file, i.e., 0 is the position of the beginning of the file. The file pointer to a file is automatically advanced after each input or output operation. This section describes functions which can be used to *reposition* the file pointer on those files that can be randomly accessed. A file used in this fashion is much like an array in that it has a certain number of addressable locations that characters can be put into or taken from. However, unlike arrays, files can be enlarged. For example, if the file pointer is positioned at the end of a file and anything is written, the file "grows." It is also possible to position the file pointer *beyond* the end of file and then to write. (If the program attempts to *read* beyond the end of file, an **END OF FILE** error occurs.) In this case, the file is enlarged, and a "hole" is created, which can later be written into. Note that this enlargement only takes place at the *end* of a file; it is not possible to make more room in the middle of a file. In other words, if expression **A** begins at position 1000, and expression **B** at 1100, and the program attempts to overwrite **A** with expression **C**, whose printed representation is 200 bytes long, part of **B** will be altered.

**Warning:** File positions are always in terms of bytes, not characters. The user should thus be very careful about computing the space needed for an expression. In particular, NS characters may take multiple bytes (see page 25.22). Also, the end-of-line character (see page 24.19) may be represented by a different number of characters in different implementations. Output functions may also introduce end-of-line's as a result of **LINELENGTH** considerations. Therefore **NCHARS** (page 2.9) does *not* specify how many bytes an expression takes to print, even ignoring line length considerations.

( <b>GETFILEPTR</b> <i>FILE</i> )	[Function]
	Returns the current position of the file pointer for <i>FILE</i> , i.e., the byte address at which the next input/output operation will commence.
( <b>SETFILEPTR</b> <i>FILE</i> <i>ADR</i> )	[Function]
	Sets the file pointer for <i>FILE</i> to the position <i>ADR</i> ; returns <i>ADR</i> . The special value <i>ADR</i> = -1 is interpreted to mean the address of the end of file.  Note: If a file is opened for output only, the end of file is initially zero, even if an old file by the same name had existed (see <b>OPENSTREAM</b> , page 24.2). If a file is opened for both input and output, the initial file pointer is the beginning of the file, but ( <b>SETFILEPTR</b> <i>FILE</i> -1) sets it to the end of the file. If the file had been opened in append mode by ( <b>OPENSTREAM</b> <i>FILE</i> 'APPEND'), the file pointer right after opening would be set to the end of the existing file, in which case a <b>SETFILEPTR</b> to position the file at the end would be unnecessary.

**(GETEOFPTR FILE)** [Function]

Returns the byte address of the end of file, i.e., the number of bytes in the file. Equivalent to performing (SETFILEPTR FILE -1) and returning (GETFILEPTR FILE) except that it does not change the current file pointer.

**(RANDACCESSP FILE)** [Function]

Returns FILE if FILE is randomly accessible, NIL otherwise. The file T is not randomly accessible, nor are certain network file connections in Interlisp-D. FILE must be open or an error is generated, FILE NOT OPEN.

**(COPYBYTES SRCFIL DSTFIL START END)** [Function]

Copies bytes from SRCFIL to DSTFIL, starting from position START and up to but not including position END. Both SRCFIL and DSTFIL must be open. Returns T.

If END = NIL, START is interpreted as the number of bytes to copy (starting at the current position). If START is also NIL, bytes are copied until the end of the file is reached.

**Warning:** COPYBYTES does not take any account of multi-byte NS characters (page 2.12). COPYCHARS (below) should be used whenever copying information that might include NS characters.

**(COPYCHARS SRCFIL DSTFIL START END)** [Function]

Like COPYBYTES except that it copies NS characters (page 2.12), and performs the proper conversion if the end-of-line conventions of SRCFIL and DSTFIL are not the same (see page 24.19). START and END are interpreted the same as with COPYBYTES, i.e., as byte (not character) specifications in SRCFIL. The number of bytes actually output to DSTFIL might be more or less than the number of bytes specified by START and END, depending on what the end-of-line conventions are. In the case where the end-of-line conventions happen to be the same, COPYCHARS simply calls COPYBYTES.

**(FILEPOS PATTERN FILE START END SKIP TAIL CASEARRAY)** [Function]

Analogous to STRPOS (page 4.5), but searches a file rather than a string. FILEPOS searches FILE for the string PATTERN. Search begins at START (or the current position of the file pointer, if START = NIL), and goes to END (or the end of FILE, if END = NIL). Returns the address of the start of the match, or NIL if not found.

SKIP can be used to specify a character which matches any character in the file. If TAIL is T, and the search is successful, the value is the address of the first character after the sequence of characters corresponding to PATTERN, instead of the starting address of the sequence. In either case, the file is left so that the

next i/o operation begins at the address returned as the value of FILEPOS.

CASEARRAY should be a "case array" that specifies that certain characters should be transformed to other characters before matching. Case arrays are returned by CASEARRAY or SEPRCASE below. CASEARRAY=NIL means no transformation will be performed.

A case array is an implementation-dependent object that is logically an array of character codes with one entry for each possible character. FILEPOS maps each character in the file "through" CASEARRAY in the sense that each character code is transformed into the corresponding character code from CASEARRAY before matching. Thus if two characters map into the same value, they are treated as equivalent by FILEPOS. CASEARRAY and SETCASEARRAY provide an implementation-independent interface to case arrays.

For example, to search without regard to upper and lower case differences, CASEARRAY would be a case array where all characters map to themselves, except for lower case characters, whose corresponding elements would be the upper case characters. To search for a delimited atom, one could use "ATOM" as the pattern, and specify a case array in which all of the break and separator characters mapped into the same code as space.

---

For applications calling for extensive file searches, the function FFILEPOS is often faster than FILEPOS.

**(FFILEPOS PATTERN FILE START END SKIP TAIL CASEARRAY)**

[Function]

Like FILEPOS, except much faster in most applications. FFILEPOS is an implementation of the Boyer-Moore fast string searching algorithm. This algorithm preprocesses the string being searched for and then scans through the file in steps usually equal to the length of the string. Thus, FFILEPOS speeds up roughly in proportion to the length of the string, e.g., a string of length 10 will be found twice as fast as a string of length 5 in the same position.

---

Because of certain fixed overheads, it is generally better to use FILEPOS for short searches or short strings.

**(CASEARRAY OLDARRAY)**

[Function]

---

Creates and returns a new case array, with all elements set to themselves, to indicate the identity mapping. If OLDARRAY is given, it is reused.

**(SETCASEARRAY CASEARRAY FROMCODE TOCODE)** [Function]

Modifies the case array *CASEARRAY* so that character code *FROMCODE* is mapped to character code *TOCODE*.

**(GETCASEARRAY CASEARRAY FROMCODE)** [Function]

Returns the character code that *FROMCODE* is mapped to in *CASEARRAY*.

**(SEPRCASE CLFLG)** [Function]

Returns a new case array suitable for use by **FILEPOS** or **FFILEPOS** in which all of the break/separators of **FILERDTBL** are mapped into character code zero. If *CLFLG* is non-NIL, then all CLISP characters are mapped into this character as well. This is useful for finding a delimited atom in a file. For example, if *PATTERN* is "FOO", and (SEPRCASE T) is used for *CASEARRAY*, then **FILEPOS** will find "(FOO←".

**UPPERCASEARRAY** [Variable]

*Value* is a case array in which every lowercase character is mapped into the corresponding uppercase character. Useful for searching text files.

---

## 25.5 Input/Output Operations with Characters and Bytes

---

Interlisp-D supports the 16-bit NS character set (see page 2.12). All of the standard string and print name functions accept litatoms and strings containing NS characters. In almost all cases, a program does not have to distinguish between NS characters or 8-bit characters. The exception to this rule is the handling of input/output operations.

Interlisp-D uses two ways of writing 16-bit NS characters on files. One way is to write the full 16-bits (two bytes) every time a character is output. The other way is to use "run-encoding." Each 16 NS character can be decoded into a character set (an integer from 0 to 254 inclusive) and a character number (also an integer from 0 to 254 inclusive). In run-encoding, the byte 255 (illegal as either a character set number or a character number) is used to signal a change to a given character set, and the following bytes are all assumed to come from the same character set (until the next change-character set sequence). Run-encoding can reduce the number of bytes required to encode a string of NS characters, as long as there are long sequences of characters from the same character set (usually the case).

Note that characters are not the same as bytes. A single character can take anywhere from one to four bytes bytes, depending on whether it is in the same character set as the preceding character, and whether run-encoding is enabled. Programs which assume that characters are equal to bytes must be changed to work with NS characters.

The functions **BIN** (page 25.5) and **BOUT** (page 25.9) should only be used to read and write single eight-bit bytes. The functions **READCCODE** (page 25.5) and **PRINTCCODE** (page 25.9) should be used to read and write single character codes, interpreting run-encoded NS characters. **COPYBYTES** (page 25.20) should only be used to copy blocks of 8-bit data; **COPYCHARS** should be used to copy characters. Most I/O functions (**READC**, **PRIN1**, etc.) read or write 16-bit NS characters.

The use of NS characters has serious consequences for any program that uses file pointers to access a file in a random access manner. At any point when a file is being read or written, it has a "current character set." If the file pointer is changed with **SETFILEPTR** (page 25.19) to a part of the file with a different character set, any characters read or written may have the wrong character set. The current character set can be accessed with the following function:

(CHARSET STREAM CHARACTERSET)	[Function]
	Returns the current character set of the stream <i>STREAM</i> . If <i>CHARACTERSET</i> is non-NIL, the current character set for <i>STREAM</i> is set. Note that for output streams this may cause bytes to be written to the stream.  If <i>CHARACTERSET</i> is T, run encoding for <i>STREAM</i> is disabled: both the character set and the character number (two bytes total) will be written to the stream for each character printed.

---

## 25.6 PRINTOUT

---

Interlisp provides many facilities for controlling the format of printed output. By executing various sequences of **PRIN1**, **PRIN2**, **TAB**, **TERPRI**, **SPACES**, **PRINTNUM**, and **PRINTDEF**, almost any effect can be achieved. **PRINTOUT** implements a compact language for specifying complicated sequences of these elementary printing functions. It makes fancy output formats easy to design and simple to program.

**PRINTOUT** is a CLISP word (like **FOR** and **IF**) for interpreting a special printing language in which the user can describe the kinds of printing desired. The description is translated by **DWIMIFY** to the appropriate sequence of **PRIN1**, **TAB**, etc.,

before it is evaluated or compiled. **PRINTOUT** printing descriptions have the following general form:

(**PRINTOUT** *STREAM* *PRINTCOM*<sub>1</sub> ... *PRINTCOM*<sub>*N*</sub>)

*STREAM* is evaluated to obtain the stream to which the output from this specification is directed. The **PRINTOUT** commands are strung together, one after the other without punctuation, after *STREAM*. Some commands occupy a single position in this list, but many commands expect to find arguments following the command name in the list. The commands fall into several logical groups: one set deals with horizontal and vertical spacing, another group provides controls for certain formatting capabilities (font changes and subscripting), while a third set is concerned with various ways of actually printing items. Finally, there is a command that permits escaping to a simple Lisp evaluation in the middle of a **PRINTOUT** form. The various commands are described below. The following examples give a general flavor of how **PRINTOUT** is used:

Example 1: Suppose the user wanted to print out on the terminal the values of three variables, X, Y, and Z, separated by spaces and followed by a carriage return. This could be done by:

```
(PRIN1 X T)  
(SPACES 1 T)  
(PRIN1 Y T)  
(SPACES 1 T)  
(PRIN1 Z T)  
(TERPRI T)
```

or by the more concise **PRINTOUT** form:

```
(PRINTOUT T X , Y , Z T)
```

Here the first T specifies output to the terminal, the commas cause single spaces to be printed, and the final T specifies a TERPRI. The variable names are not recognized as special **PRINTOUT** commands, so they are printed using PRIN1 by default.

Example 2: Suppose the values of X and Y are to be pretty-printed lined up at position 10, preceded by identifying strings. If the output is to go to the primary output stream, the user could write either:

```
(PRIN1 "X = ")  
(PRINTDEF X 10 T)  
(TERPRI )  
(PRIN1 "Y = ")  
(PRINTDEF Y 10 T)  
(TERPRI )
```

or the equivalent:

```
(PRINTOUT NIL "X = " 10 .PPV X T)
```

"Y = " 10 .PPV Y T)

Since strings are not recognized as special commands, "X =" is also printed with PRIN1 by default. The positive integer means TAB to position 10, where the .PPV command causes the value of X to be prettyprinted as a variable. By convention, special atoms used as PRINTOUT commands are prefixed with a period. The T causes a carriage return, so the Y information is printed on the next line.

Example 3. As a final example, suppose that the value of X is an integer and the value of Y is a floating-point number. X is to be printed rightFlushed in a field of width 5 beginning at position 15, and Y is to be printed in a field of width 10 also starting at position 15 with 2 places to the right of the decimal point. Furthermore, suppose that the variable names are to appear in the font class named BOLDFONT and the values in font class SMALLFONT. The program in ordinary Interlisp that would accomplish these effects is too complicated to include here. With PRINTOUT, one could write:

```
(PRINTOUT NIL
  .FONT BOLDFONT "X = " 15
  .FONT SMALLFONT .15 X T
  .FONT BOLDFONT "Y = " 15
  .FONT SMALLFONT .F10.2 Y T
  .FONT BOLDFONT)
```

The .FONT commands do whatever is necessary to change the font on a multi-font output device. The .15 command sets up a FIX format for a call to the function PRINTNUM (page 25.15) to print X in the desired format. The .F10.2 specifies a FLOAT format for PRINTNUM.

### 25.6.1 Horizontal Spacing Commands

The horizontal spacing commands provide convenient ways of calling TAB and SPACES. In the following descriptions, N stands for a literal positive integer (*not* for a variable or expression whose value is an integer).

#### N (N a number)

[PRINTOUT command]

Used for absolute spacing. It results in a TAB to position N (literally, a (TAB N)). If the line is currently at position N or beyond, the file will be positioned at position N on the next line.

#### .TAB POS

[PRINTOUT command]

Specifies TAB to position (the value of) POS. This is one of several commands whose effect could be achieved by simply escaping to Lisp, and executing the corresponding form. It is provided as a

---

separate command so that the **PRINTOUT** form is more concise and is prettyprinted more compactly. Note that **.TAB N** and **N**, where **N** is an integer, are equivalent.

---

**.TAB0 POS**

[PRINTOUT command]

---

Like **.TAB** except that it can result in zero spaces (i.e. the call to **TAB** specifies **MINSPACES = 0**).

---

**-N (N a number)**

[PRINTOUT command]

---

Negative integers indicate relative (as opposed to absolute) spacing. Translates as (**SPACES |N|**).

---

**,**

[PRINTOUT command]

**"**

[PRINTOUT command]

**...**

[PRINTOUT command]

---

(1, 2 or 3 commas) Provides a short-hand way of specifying 1, 2 or 3 spaces, i.e., these commands are equivalent to **-1**, **-2**, and **-3**, respectively.

---

**.SP DISTANCE**

[PRINTOUT command]

---

Translates as (**SPACES DISTANCE**). Note that **.SP N** and **-N**, where **N** is an integer, are equivalent.

---

**25.6.2 Vertical Spacing Commands**


---

Vertical spacing is obtained by calling **TERPRI** or printing form-feeds. The relevant commands are:

**T**

[PRINTOUT command]

---

Translates as (**TERPRI**), i.e., move to position 0 (the first column) of the next line. To print the letter **T**, use the string "**T**".

---

**.SKIP LINES**

[PRINTOUT command]

---

Equivalent to a sequence of **LINES (TERPRI)**'s. The **.SKIP** command allows for skipping large constant distances and for computing the distance to be skipped.

---

**.PAGE**

[PRINTOUT command]

---

Puts a form-feed (control-L) out on the file. Care is taken to make sure that Interlisp's view of the current line position is correctly updated.

---

### 25.6.3 Special Formatting Controls

There are a small number of commands for invoking some of the formatting capabilities of multi-font output devices. The available commands are:

#### .FONT FONTSPEC

[PRINTOUT command]

Changes printing to the font *FONTSPEC*, which can be a font descriptor, a "font list" such as '(MODERN 10), an image stream (coerced to its current font), or a windows (coerced to the current font of its display stream). See fonts (page 27.25) for more information.

*FONTSPEC* may also be a positive integer *N*, which is taken as an abbreviated reference to the font class named **FONT*N*** (e.g. 1 => **FONT1**).

#### .SUP

[PRINTOUT command]

Specifies superscripting. All subsequent characters are printed above the base of the current line. Note that this is absolute, not relative: a .SUP following a .SUP is a no-op.

#### .SUB

[PRINTOUT command]

Specifies subscripting. Subsequent printing is below the base of the current line. As with superscripting, the effect is absolute.

#### .BASE

[PRINTOUT command]

Moves printing back to the base of the current line. Un-does a previous .SUP or .SUB; a no-op, if printing is currently at the base.

### 25.6.4 Printing Specifications

The value of any expression in a PRINTOUT form that is not recognized as a command itself or as a command argument is printed using PRIN1 by default. For example, title strings can be printed by simply including the string as a separate PRINTOUT command, and the values of variables and forms can be printed in much the same way. Note that a literal integer, say 51, cannot be printed by including it as a command, since it would be interpreted as a TAB; the desired effect can be obtained by using instead the string specification "51", or the form (QUOTE 51).

For those instances when PRIN1 is not appropriate, e.g., PRIN2 is required, or a list structures must be prettyprinted, the following commands are available:

<b>.P2 THING</b>	[PRINTOUT command]
Causes <i>THING</i> to be printed using PRIN2; translates as (PRIN2 <i>THING</i> ). <hr/>	
<b>.PPF THING</b>	[PRINTOUT command]
Causes <i>THING</i> to be prettyprinted at the current line position via PRINTDEF (page 26.42). The call to PRINTDEF specifies that <i>THING</i> is to be printed as if it were part of a function definition. That is, SELECTQ, PROG, etc., receive special treatment. <hr/>	
<b>.PPV THING</b>	[PRINTOUT command]
Prettyprints <i>THING</i> as a variable; no special interpretation is given to SELECTQ, PROG, etc. <hr/>	
<b>.PPFTL THING</b>	[PRINTOUT command]
Like .PPF, but prettyprints <i>THING</i> as a <i>tail</i> , that is, without the initial and final parentheses if it is a list. Useful for prettyprinting sub-lists of a list whose other elements are formatted with other commands. <hr/>	
<b>.PPVTL THING</b>	[PRINTOUT command]
Like .PPV, but prettyprints <i>THING</i> as a tail. <hr/>	

---

#### 25.6.4.1 Paragraph Format

Interlisp's prettyprint routines are designed to display the structure of expressions, but they are not really suitable for formatting unstructured text. If a list is to be printed as a textual paragraph, its internal structure is less important than controlling its left and right margins, and the indentation of its first line. The .PARA and .PARA2 commands allow these parameters to be conveniently specified.

<b>.PARA LMARG RMARG LIST</b>	[PRINTOUT command]
Prints <i>LIST</i> in paragraph format, using PRIN1. Translates as (PRINTPARA LMARG RMARG <i>LIST</i> ) (see page 25.32).	
Example: (PRINTOUT T 10 .PARA 5 -5 LST) will print the elements of <i>LST</i> as a paragraph with left margin at 5, right margin at (LINELENGTH)-5, and the first line indented to 10. <hr/>	
<b>.PARA2 LMARG RMARG LIST</b>	[PRINTOUT command]
Print as paragraph using PRIN2 instead of PRIN1. Translates as (PRINTPARA LMARG RMARG <i>LIST</i> T).	

---

#### 25.6.4.2 Right-Flushing

Two commands are provided for printing simple expressions flushed-right against a specified line position, using the function **FLUSHRIGHT** (page 25.32). They take into account the current position, the number of characters in the print-name of the expression, and the position the expression is to be flush against, and then print the appropriate number of spaces to achieve the desired effect. Note that this might entail going to a new line before printing. Note also that right-flushing of expressions longer than a line (e.g. a large list) makes little sense, and the appearance of the output is not guaranteed.

---

##### .FR POS EXPR

[PRINTOUT command]

Flush-right using **PRIN1**. The value of *POS* determines the position that the right end of *EXPR* will line up at. As with the horizontal spacing commands, a negative position number means  $|POS|$  columns from the current position, a positive number specifies the position absolutely. *POS* = 0 specifies the right-margin, i.e. is interpreted as (**LINELENGTH**).

---

##### .FR2 POS EXPR

[PRINTOUT command]

Flush-right using **PRIN2** instead of **PRIN1**.

---



---

#### 25.6.4.3 Centering

Commands for centering simple expressions between the current line position and another specified position are also available. As with right flushing, centering of large expressions is not guaranteed.

---

##### .CENTER POS EXPR

[PRINTOUT command]

Centers *EXPR* between the current line position and the position specified by the value of *POS*. A positive *POS* is an absolute position number, a negative *POS* specifies a position relative to the current position, and 0 indicates the right-margin. Uses **PRIN1** for printing.

---

##### .CENTER2 POS EXPR

[PRINTOUT command]

Centers using **PRIN2** instead of **PRIN1**.

---



---

#### 25.6.4.4 Numbering

The following commands provide FORTRAN-like formatting capabilities for integer and floating-point numbers. Each command specifies a printing format and a number to be

printed. The format specification translates into a format-list for the function **PRINTNUM** (see page 25.15).

<b>.IFORMAT NUMBER</b>	[PRINTOUT command]
	Specifies integer printing. Translates as a call to the function <b>PRINTNUM</b> with a <b>FIX</b> format-list constructed from <b>FORMAT</b> . The atomic format is broken apart at internal periods to form the format-list. For example, <b>.15.8.T</b> yields the format-list ( <b>FIX 5 8 T</b> ), and the command sequence ( <b>PRINTOUT T .15.8.T FOO</b> ) translates as ( <b>PRINTNUM '(FIX 5 8 T) FOO</b> ). This expression causes the value of <b>FOO</b> to be printed in radix 8 rightFlushed in a field of width 5, with 0's used for padding on the left. Internal <b>NIL</b> 's in the format specification may be omitted, e.g., the commands <b>.15..T</b> and <b>.15.NIL.T</b> are equivalent.

The format specification **.1I** is often useful for forcing a number to be printed in radix 10 (but not otherwise specially formatted), independent of the current setting of **RADIX**.

---

<b>.FFORMAT NUMBER</b>	[PRINTOUT command]
	Specifies floating-number printing. Like the <b>.I</b> format command, except translates with a <b>FLOAT</b> format-list.

---

<b>.N FORMAT NUMBER</b>	[PRINTOUT command]
	The <b>.I</b> and <b>.F</b> commands specify calls to <b>PRINTNUM</b> with quoted format specifications. The <b>.N</b> command translates as ( <b>PRINTNUM FORMAT NUMBER</b> ), i.e., it permits the format to be the value of some expression. Note that, unlike the <b>.I</b> and <b>.F</b> commands, <b>FORMAT</b> is a separate element in the command list, not part of an atom beginning with <b>.N</b> .

---

## 25.6.5 Escaping to Lisp

---

There are many reasons for taking control away from **PRINTOUT** in the middle of a long printing expression. Common situations involve temporary changes to system printing parameters (e.g. **LINELENGTH**), conditional printing (e.g. **print FOO** only if **FILE** is **T**), or lower-level iterative printing within a higher-level print specification.

<b># FORM</b>	[PRINTOUT command]
	The escape command. <b>FORM</b> is an arbitrary Lisp expression that is evaluated within the context established by the <b>PRINTOUT</b> form, i.e., <b>FORM</b> can assume that the primary output stream has been set to be the <b>FILE</b> argument to <b>PRINTOUT</b> . Note that nothing is done with the <i>value of FORM</i> ; any printing desired is accomplished by <b>FORM</b> itself, and the value is discarded.

---

Note: Although **PRINTOUT** logically encloses its translation in a **RESETFORM** (page 14.26) to change the primary output file to the *FILE* argument (if non-**NIL**), in most cases it can actually pass *FILE* (or a locally bound variable if *FILE* is a non-trivial expression) to each printing function. Thus, the **RESETFORM** is only generated when the # command is used, or user-defined commands (below) are used. If many such occur in repeated **PRINTOUT** forms, it may be more efficient to embed them all in a single **RESETFORM** which changes the primary output file, and then specify *FILE* = **NIL** in the **PRINTOUT** expressions themselves.

### **25.6.6 User-Defined Commands**

The collection of commands and options outlined above is aimed at fulfilling all common printing needs. However, certain applications might have other, more specialized printing idioms, so a facility is provided whereby the user can define new commands. This is done by adding entries to the global list **PRINTOUTMACROS** to define how the new commands are to be translated.

<b>PRINTOUTMACROS</b>	[Variable]
-----------------------	------------

**PRINTOUTMACROS** is an association-list whose elements are of the form (**COMM FN**). Whenever **COMM** appears in command position in the sequence of **PRINTOUT** commands (as opposed to an argument position of another command), **FN** is applied to the tail of the command-list (including the command).

After inspecting as much of the tail as necessary, the function must return a list whose **CAR** is the translation of the user-defined command and its arguments, and whose **CDR** is the list of commands still remaining to be translated in the normal way.

For example, suppose the user wanted to define a command "?", which will cause its single argument to be printed with **PRIN1** only if it is not **NIL**. This can be done by entering (? ?TRAN) on **PRINTOUTMACROS**, and defining the function ?TRAN as follows:

```
(DEFNEQ (?TRAN (COMS)
  (CONS
    (SUBST (CADR COMS) 'ARG
      '(PROG ((TEMP ARG))
        (COND (TEMP (PRIN1 TEMP))))))
    (CDDR COMS)))
```

Note that ?TRAN does not do any printing itself; it returns a form which, when evaluated in the proper context, will perform the

desired action. This form should direct all printing to the primary output file.

### 25.6.7 Special Printing Functions

---

The paragraph printing commands are translated into calls on the function **PRINTPARA**, which may also be called directly:

( <b>PRINTPARA</b> <i>LMARG RMARG LIST P2FLAG PARENFLAG FILE</i> )	[Function]
	Prints <i>LIST</i> on <i>FILE</i> in line-filled paragraph format with its first element beginning at the current line position and ending at or before <i>RMARG</i> , and with subsequent lines appearing between <i>LMARG</i> and <i>RMARG</i> . If <i>P2FLAG</i> is non-NIL, prints elements using <b>PRIN2</b> , otherwise <b>PRIN1</b> . If <i>PARENFLAG</i> is non-NIL, then parentheses will be printed around the elements of <i>LIST</i> .
	If <i>LMARG</i> is zero or positive, it is interpreted as an absolute column position. If it is negative, then the left margin will be at $ LMARG  + (\text{POSITION})$ . If <i>LMARG</i> = NIL, the left margin will be at <i>(POSITION)</i> , and the paragraph will appear in block format.
	If <i>RMARG</i> is positive, it also is an absolute column position (which may be greater than the current ( <b>LINELENGTH</b> )). Otherwise, it is interpreted as relative to ( <b>LINELENGTH</b> ), i.e., the right margin will be at $(\text{LINELENGTH}) +  RMARG $ . Example: ( <b>TAB 10</b> ) ( <b>PRINTPARA 5 -5 LST T</b> ) will <b>PRIN2</b> the elements of <i>LST</i> in a paragraph with the first line beginning at column 10, subsequent lines beginning at column 5, and all lines ending at or before ( <b>LINELENGTH</b> )-5.
	The current ( <b>LINELENGTH</b> ) is unaffected by <b>PRINTPARA</b> , and upon completion, <i>FILE</i> will be positioned immediately after the last character of the last item of <i>LIST</i> . <b>PRINTPARA</b> is a no-op if <i>LIST</i> is not a list.

The right-flushing and centering commands translate as calls to the function **FLUSHRIGHT**:

( <b>FLUSHRIGHT</b> <i>POS X MIN P2FLAG CENTERFLAG FILE</i> )	[Function]
	If <i>CENTERFLAG</i> = NIL, prints <i>X</i> rightFlushed against position <i>POS</i> on <i>FILE</i> ; otherwise, centers <i>X</i> between the current line position and <i>POS</i> . Makes sure that it spaces over at least <i>MIN</i> spaces before printing by doing a <b>TERPRI</b> if necessary; <i>MIN</i> = NIL is equivalent to <i>MIN</i> = 1. A positive <i>POS</i> indicates an absolute position, while a negative <i>POS</i> signifies the position which is $ POS $ to the right of the current line position. <i>POS</i> = 0 is interpreted as ( <b>LINELENGTH</b> ), the right margin.

---

## 25.7 READFILE and WRITEFILE

---

For those applications where the user simply wants to simply read all of the expressions on a file, and not evaluate them, the function **READFILE** is available:

<b>(READFILE FILE RDTBL ENDTOKEN)</b>	[NoSpread Function]
Reads successive expressions from file using <b>READ</b> (with read table <i>RDTBL</i> ) until the single litatom <i>ENDTOKEN</i> is read, or an end of file encountered. Returns a list of these expressions.	
If <i>RDTBL</i> is not specified, it defaults to <b>FILERDTBL</b> . If <i>ENDTOKEN</i> is not specified, it defaults to the litatom <b>STOP</b> .	
<b>(WRITEFILE X FILE)</b>	[Function]
Writes a date expression onto <i>FILE</i> , followed by successive expressions from <i>X</i> , using <b>FILERDTBL</b> as a read table. If <i>X</i> is atomic, its value is used. If <i>FILE</i> is not open, it is opened. If <i>FILE</i> is a list, <b>(CAR FILE)</b> is used and the file is left opened. Otherwise, when <i>X</i> is finished, the litatom <b>STOP</b> is printed on <i>FILE</i> and it is closed. Returns <i>FILE</i> .	
<b>(ENDFILE FILE)</b>	[Function]
Prints <b>STOP</b> on <i>FILE</i> and closes it.	

---



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## 25.8 Read Tables

---

Many Interlisp input functions treat certain characters in special ways. For example, **READ** recognizes that the right and left parenthesis characters are used to specify list structures, and that the quote character is used to delimit text strings. The Interlisp input and (to a certain extent) output routines are table driven by read tables. Read tables are objects that specify the syntactic properties of characters for input routines. Since the input routines parse character sequences into objects, the read table in use determines which sequences are recognized as literal atoms, strings, list structures, etc.

Most Interlisp input functions take an optional read table argument, which specifies the read table to use when reading an expression. If **NIL** is given as the read table, the "primary read table" is used. If **T** is specified, the system terminal read table is used. Some functions will also accept the atom **ORIG** (not the value of **ORIG**) as indicating the "original" system read table. Some output functions also take a read table argument. For

example, **PRIN2** prints an expression so that it would be read in correctly using a given read table.

The Interlisp-D system uses the following read tables: **T** for input/output from terminals, the value of **FILERDTBL** for input/output from files, the value of **EDITRDTBL** for input from terminals while in the tty-based editor, the value of **DEDITRDTBL** for input from terminals while in the display-based editor, and the value of **CODERDTBL** for input/output from compiled files. These five read tables are initially copies of the **ORIG** read table, with changes made to some of them to provide read macros (page 25.39) that are specific to terminal input or file input. Using the functions described below, the user may further change, reset, or copy these tables. However, in the case of **FILERDTBL** and **CODERDTBL**, the user is cautioned that changing these tables may prevent the system from being able to read files made with the original tables, or prevent users possessing only the standard tables from reading files made using the modified tables.

The user can also create new read tables, and either explicitly pass them to input/output functions as arguments, or install them as the primary read table, via **SETREADTABLE**, and then not specify a *RDTBL* argument, i.e., use **NIL**.

### **25.8.1 Read Table Functions**

---

<b>(READTABLEP RDTBL)</b>	[Function]
Returns <i>RDTBL</i> if <i>RDTBL</i> is a real read table ( <i>not T or ORIG</i> ), otherwise <b>NIL</b> .	
<b>(GETREADTABLE RDTBL)</b>	[Function]
If <i>RDTBL</i> = <b>NIL</b> , returns the primary read table. If <i>RDTBL</i> = <b>T</b> , returns the system terminal read table. If <i>RDTBL</i> is a real read table, returns <i>RDTBL</i> . Otherwise, generates an <b>ILLEGAL READTABLE</b> error.	
<b>(SETREADTABLE RDTBL FLG)</b>	[Function]
Sets the primary read table to <i>RDTBL</i> . If <i>FLG</i> = <b>T</b> , <b>SETREADTABLE</b> sets the system terminal read table, <b>T</b> . Note that the user can reset the other system read tables with <b>SETQ</b> , e.g., <b>(SETQ FILERDTBL (GETREADTABLE))</b> .	
Generates an <b>ILLEGAL READTABLE</b> error if <i>RDTBL</i> is not <b>NIL</b> , <b>T</b> , or a real read table. Returns the previous setting of the primary read table, so <b>SETREADTABLE</b> is suitable for use with <b>RESETFORM</b> (page 14.26).	

**(COPYREADTABLE RDTBL)**

[Function]

Returns a copy of *RDTBL*. *RDTBL* can be a real read table, NIL, T, or ORIG (in which case **COPYREADTABLE** returns a copy of the *original* system read table), otherwise **COPYREADTABLE** generates an **ILLEGAL READTABLE** error.

Note that **COPYREADTABLE** is the only function that creates a read table.

**(RESETREADTABLE RDTBL FROM)**

[Function]

Copies (smashes) *FROM* into *RDTBL*. *FROM* and *RDTBL* can be NIL, T, or a real read table. In addition, *FROM* can be ORIG, meaning use the system's original read table.

**25.8.2 Syntax Classes**

A read table is an object that contains information about the "syntax class" of each character. There are nine basic syntax classes: **LEFTPAREN**, **RIGHTPAREN**, **LEFTBRACKET**, **RIGHTBRACKET**, **STRINGDELIM**, **ESCAPE**, **BREAKCHAR**, **SEPRCHAR**, and **OTHER**, each associated with a primitive syntactic property. In addition, there is an unlimited assortment of user-defined syntax classes, known as "read macros". The basic syntax classes are interpreted as follows:

<b>LEFTPAREN</b>	(normally left parenthesis) Begins list structure.
<b>RIGHTPAREN</b>	(normally right parenthesis) Ends list structure.
<b>LEFTBRACKET</b>	(normally left bracket) Begins list structure. Also matches <b>RIGHTBRACKET</b> characters.
<b>RIGHTBRACKET</b>	(normally left bracket) Ends list structure. Can close an arbitrary numbers of <b>LEFTPAREN</b> lists, back to the last <b>LEFTBRACKET</b> .
<b>STRINGDELIM</b>	(normally double quote) Begins and ends text strings. Within the string, all characters except for the one(s) with class <b>ESCAPE</b> are treated as ordinary, i.e., interpreted as if they were of syntax class <b>OTHER</b> . To include the string delimiter inside a string, prefix it with the <b>ESCAPE</b> character.
<b>ESCAPE</b>	(normally percent sign) Inhibits any special interpretation of the next character, i.e., the next character is interpreted to be of class <b>OTHER</b> , independent of its normal syntax class.
<b>BREAKCHAR</b>	(None initially) Is a break character, i.e., delimits atoms, but is otherwise an ordinary character.
<b>SEPRCHAR</b>	(space, carriage return, etc.) Delimits atoms, and is otherwise ignored.
<b>OTHER</b>	Characters that are not otherwise special belong to the class <b>OTHER</b> .

Characters of syntax class **LEFTPAREN**, **RIGHTPAREN**, **LEFTBRACKET**, **RIGHTBRACKET**, and **STRINGDELIM** are all *break* characters. That is, in addition to their interpretation as delimiting list or string structures, they also terminate the reading of an atom. Characters of class **BREAKCHAR** serve *only* to terminate atoms, with no other special meaning. In addition, if a break character is the first non-separator encountered by **RATOM**, it is read as a one-character atom. In order for a break character to be included in an atom, it must be preceded by the **ESCAPE** character.

Characters of class **SEPRCHAR** also terminate atoms, but are otherwise completely ignored; they can be thought of as logically spaces. As with break characters, they must be preceded by the **ESCAPE** character in order to appear in an atom.

For example, if \$ were a break character and \* a separator character, the input stream ABC\*\*DEF\$GH\*\$ would be read by 6 calls to **RATOM** returning respectively ABC, DEF, \$, GH, \$, \$.

Although normally there is only one character in a read table having each of the list- and string-delimiting syntax classes (such as **LEFTPAREN**), it is perfectly acceptable for any character to have any syntax class, and for more than one to have the same class.

Note that a "syntax class" is an abstraction: there is no object referencing a collection of characters called a *syntax class*. Instead, a read table provides the *association* between a character and its syntax class, and the input/output routines enforce the abstraction by using read tables to drive the parsing.

The functions below are used to obtain and set the syntax class of a character in a read table. *CH* can either be a character code (a integer), or a character (a single-character atom). Single-digit integers are interpreted as character codes, rather than as characters. For example, 1 indicates control-A, and 49 indicates the *character* 1. Note that *CH* can be a full sixteen-bit NS character (see page 2.12).

Note: Terminal tables, described on page 30.4, also associate characters with syntax classes, and they can also be manipulated with the functions below. The set of read table and terminal table syntax classes are disjoint, so there is never any ambiguity about which type of table is being referred to.

---

**(GETSYNTAX CH TABLE)****[Function]**

Returns the syntax class of *CH*, a character or a character code, with respect to *TABLE*. *TABLE* can be **NIL**, **T**, **ORIG**, or a real read table or terminal table.

*CH* can also be a syntax class, in which case **GETSYNTAX** returns a list of the character codes in *TABLE* that have that syntax class.

(SETSYNTAX CHAR CLASS TABLE)	[Function]
	<p>Sets the syntax class of <i>CHAR</i>, a character or character code, in <i>TABLE</i>. <i>TABLE</i> can be either NIL, T, or a real read table or terminal table. SETSYNTAX returns the previous syntax class of <i>CHAR</i>. <i>CLASS</i> can be any one of the following:</p> <ul style="list-style-type: none"> <li>• The name of one of the basic syntax classes.</li> <li>• A list, which is interpreted as a read macro (see page 25.39).</li> <li>• NIL, T, ORIG, or a real read table or terminal table, which means to give <i>CHAR</i> the syntax class it has in the table indicated by <i>CLASS</i>. For example, (SETSYNTAX '%( 'ORIG TABLE) gives the left parenthesis character in <i>TABLE</i> the same syntax class that it has in the original system read table.</li> <li>• A character code or character, which means to give <i>CHAR</i> the same syntax class as the character <i>CHAR</i> in <i>TABLE</i>. For example, (SETSYNTAX '{ '%[ TABLE) gives the left brace character the same syntax class as the left bracket.</li> </ul>

(SYNTAXP CODE CLASS TABLE)	[Function]
	<p><i>CODE</i> is a character code; <i>TABLE</i> is NIL, T, or a real read table or terminal table. Returns T if <i>CODE</i> has the syntax class <i>CLASS</i> in <i>TABLE</i>; NIL otherwise.</p> <p><i>CLASS</i> can also be a read macro type (MACRO, SPLICE, INFIX), or a read macro option (FIRST, IMMEDIATE, etc.), in which case SYNTAXP returns T if the syntax class is a read macro with the specified property.</p> <p>Note: SYNTAXP will not accept a character as an argument, only a character code.</p>

For convenience in use with SYNTAXP, the atom BREAK may be used to refer to *all* break characters, i.e., it is the union of LEFTPAREN, RIGTHPAREN, LEFTBRACKET, RIGHTBRACKET, STRINGDELIM, and BREAKCHAR. For purely symmetrical reasons, the atom SEPR corresponds to all separator characters. However, since the only separator characters are those that also appear in SEPRCHAR, SEPR and SEPRCHAR are equivalent.

Note that GETSYNTAX never returns BREAK or SEPR as a value although SETSYNTAX and SYNTAXP accept them as arguments. Instead, GETSYNTAX returns one of the disjoint basic syntax classes that comprise BREAK. BREAK as an argument to SETSYNTAX is interpreted to mean BREAKCHAR if the character is not already of one of the BREAK classes. Thus, if %( is of class LEFTPAREN, then (SETSYNTAX '%( 'BREAK) doesn't do anything, since %( is already a break character, but (SETSYNTAX '%( 'BREAKCHAR) means make %( be just a break character, and therefore disables the LEFTPAREN function of %. Similarly, if one of the format characters is disabled completely, e.g., by

(**SETSYNTAX** '%( 'OTHER), then (**SETSYNTAX** '%( 'BREAK) would make %( be *only* a break character; it would *not* restore %( as **LEFTPAREN**.

The following functions provide a way of collectively accessing and setting the separator and break characters in a read table:

<b>(GETSEPR RDTBL)</b>	[Function]
	Returns a list of separator character codes in <i>RDTBL</i> . Equivalent to ( <b>GETSYNTAX</b> 'SEPR <i>RDTBL</i> ).
<b>(GETBRK RDTBL)</b>	[Function]
	Returns a list of break character codes in <i>RDTBL</i> . Equivalent to ( <b>GETSYNTAX</b> 'BREAK <i>RDTBL</i> ).
<b>(SETSEPR LST FLG RDTBL)</b>	[Function]
	Sets or removes the separator characters for <i>RDTBL</i> . <i>LST</i> is a list of characters or character codes. <i>FLG</i> determines the action of <b>SETSEPR</b> as follows: If <i>FLG</i> = NIL, makes <i>RDTBL</i> have exactly the elements of <i>LST</i> as separators, discarding from <i>RDTBL</i> any old separator characters not in <i>LST</i> . If <i>FLG</i> = 0, removes from <i>RDTBL</i> as separator characters all elements of <i>LST</i> . This provides an "UNSETSEPR". If <i>FLG</i> = 1, makes each of the characters in <i>LST</i> be a separator in <i>RDTBL</i> .  If <i>LST</i> = T, the separator characters are reset to be those in the system's read table for terminals, regardless of the value of <i>FLG</i> , i.e., ( <b>SETSEPR</b> T) is equivalent to ( <b>SETSEPR</b> ( <b>GETSEPR</b> T)). If <i>RDTBL</i> is T, then the characters are reset to those in the original system table.  Returns NIL.
<b>(SETBRK LST FLG RDTBL)</b>	[Function]
	Sets the break characters for <i>RDTBL</i> . Similar to <b>SETSEPR</b> .  As with <b>SETSYNTAX</b> to the <b>BREAK</b> class, if any of the list- or string-delimiting break characters are disabled by an appropriate <b>SETBRK</b> (or by making it be a separator character), its special action for <b>READ</b> will <i>not</i> be restored by simply making it be a break character again with <b>SETBRK</b> . However, making these characters be break characters when they already are will have no effect.  The action of the <b>ESCAPE</b> character (normally %) is not affected by <b>SETSEPR</b> or <b>SETBRK</b> . It can be disabled by setting its syntax to the class <b>OTHER</b> , and other characters can be used for escape on input by assigning them the class <b>ESCAPE</b> . As of this writing, however, there is no way to change the output escape character; it is "hardwired" as %. That is, on output, characters of special

syntax that need to be preceded by the **ESCAPE** character will always be preceded by %, independent of the syntax of % or which, if any characters, have syntax **ESCAPE**.

The following function can be used for defeating the action of the **ESCAPE** character or characters:

( <b>ESCAPE FLG RDTBL</b> )	[Function]
	If <b>FLG=NIL</b> , makes characters of class <b>ESCAPE</b> behave like characters of class <b>OTHER</b> on input. Normal setting is ( <b>ESCAPE T</b> ). <b>ESCAPE</b> returns the previous setting.

### 25.8.3 Read Macros

Read macros are user-defined syntax classes that can cause complex operations when certain characters are read. Read macro characters are defined by specifying as a syntax class an expression of the form:

(**TYPE OPTION<sub>1</sub> ... OPTION<sub>N</sub> FN**)

where **TYPE** is one of **MACRO**, **SPLIC**, or **INFIX**, and **FN** is the name of a function or a lambda expression. Whenever **READ** encounters a read macro character, it calls the associated function, giving it as arguments the input stream and read table being used for that call to **READ**. The interpretation of the value returned depends on the type of read macro:

- MACRO** This is the simplest type of read macro. The result returned from the macro is treated as the expression to be read, instead of the read macro character. Often the macro reads more input itself. For example, in order to cause **~EXPR** to be read as (**NOT EXPR**), one could define **~** as the read macro:

[**MACRO (LAMBDA (FL RDTBL)**  
    (**LIST 'NOT (READ FL RDTBL)**)]

- SPLIC** The result (which should be a list or **NIL**) is spliced into the input using **NCONC**. For example, if **\$** is defined by the read macro:

(**SPLIC (LAMBDA NIL (APPEND FOO))**)

and the value of **FOO** is (**A B C**), then when the user inputs (**X \$ Y**), the result will be (**X A B C Y**).

- INFIX** The associated function is called with a third argument, which is a list, in **TCONC** format (page 3.6), of what has been read at the current level of list nesting. The function's value is taken as a new **TCONC** list which replaces the old one. For example, the infix operator **+** could be defined by the read macro:

(**INFIX (LAMBDA (FL RDTBL Z)**  
    (**RPLACA (CDR Z)**)  
    (**LIST (QUOTE IPLUS)**)]

(CADR Z)  
(READ FL RDTBL))  
Z))

If an **INFIX** read macro character is encountered *not* in a list, the third argument to its associated function is **NIL**. If the function returns **NIL**, the read macro character is essentially ignored and reading continues. Otherwise, if the function returns a **TCONC** list of one element, that element is the value of the **READ**. If it returns a **TCONC** list of more than one element, the list is the value of the **READ**.

The specification for a read macro character can be augmented to specify various options  $OPTION_1 \dots OPTION_N$ , e.g., (MACRO **FIRST IMMEDIATE FN**). The following three disjoint options specify when the read macro character is to be effective:

<b>ALWAYS</b>	The default. The read macro character is always effective (except when preceded by the % character), and is a break character, i.e., a member of ( <b>GETSYNTAX 'BREAK RDTBL</b> ).
<b>FIRST</b>	The character is interpreted as a read macro character <i>only</i> when it is the first character seen after a break or separator character; in all other situations, the character is treated as having class <b>OTHER</b> . The read macro character is <i>not</i> a break character. For example, the quote character is a <b>FIRST</b> read macro character, so that <b>DON'T</b> is read as the single atom <b>DON'T</b> , rather than as <b>DON</b> followed by ( <b>QUOTE T</b> ).
<b>ALONE</b>	The read macro character is <i>not</i> a break character, and is interpreted as a read macro character <i>only</i> when the character would have been read as a separate atom if it were not a read macro character, i.e., when its immediate neighbors are both break or separator characters.
	Making a <b>FIRST</b> or <b>ALONE</b> read macro character be a break character (with <b>SETBRK</b> ) disables the read macro interpretation, i.e., converts it to syntax class <b>BREAKCHAR</b> . Making an <b>ALWAYS</b> read macro character be a break character is a no-op.
	The following two disjoint options control whether the read macro character is to be protected by the <b>ESCAPE</b> character on output when a litatom containing the character is printed:
<b>ESCQUOTE or ESC</b>	The default. When printed with <b>PRIN2</b> , the read macro character will be preceded by the output escape character (%) as needed to permit the atom containing it to be read correctly. Note that for <b>FIRST</b> macros, this means that the character need be quoted only when it is the first character of the atom.
<b>NOESCQUOTE or NOESC</b>	The read macro character will always be printed without an escape. For example, the ? read macro in the T read table is a <b>NOESCQUOTE</b> character. Unless you are very careful what you are doing, read macro characters in <b>FILERDTBL</b> should never be

**NOESCQUOTE**, since symbols that happen to contain the read macro character will not read back in correctly.

The following two disjoint options control when the macro's function is actually executed:

#### IMMEDIATE or IMMED

The read macro character is immediately activated, i.e., the current line is terminated, as if an **EOL** had been typed, a carriage-return line-feed is printed, and the entire line (including the macro character) is passed to the input function.

**IMMEDIATE** read macro characters enable the user to specify a character that will take effect immediately, as soon as it is encountered in the input, rather than waiting for the line to be terminated. Note that this is not necessarily as soon as the character is *typed*. Characters that cause action as soon as they are typed are interrupt characters (see page 30.1).

Note that since an **IMMEDIATE** macro causes any input before it to be sent to the reader, characters typed before an **IMMEDIATE** read macro character cannot be erased by control-A or control-Q once the **IMMEDIATE** character has been typed, since they have already passed through the line buffer. However, an **INFIX** read macro can still alter some of what has been typed earlier, via its third argument.

#### NONIMMEDIATE or NONIMMED

The default. The read macro character is a normal character with respect to the line buffering, and so will not be activated until a carriage-return or matching right parenthesis or bracket is seen.

Making a read macro character be both **ALONE** and **IMMEDIATE** is a contradiction, since **ALONE** requires that the next character be input in order to see if it is a break or separator character. Thus, **ALONE** read macros are always **NONIMMEDIATE**, regardless of whether or not **IMMEDIATE** is specified.

Read macro characters can be "nested". For example, if **=** is defined by

```
(MACRO (LAMBDA (FL RDTBL)
    (EVAL (READ FL RDTBL))))
```

and **!** is defined by

```
(SPLICE (LAMBDA (FL RDTBL)
    (READ FL RDTBL)))
```

then if the value of **FOO** is **(A B C)**, and **(X = FOO Y)** is input, **(X (A B C) Y)** will be returned. If **(X != FOO Y)** is input, **(X A B C Y)** will be returned.

Note: If a read macro's function calls **READ**, and the **READ** returns **NIL**, the function cannot distinguish the case where a **RIGHTPAREN** or **RIGHTBRACKET** followed the read macro character, (e.g. **"(A B ')"**), from the case where the atom **NIL** (or **"()"**) actually appeared. In Interlisp-D, a **READ** inside of a read macro when the next input character is a **RIGHTPAREN** or

**RIGHTBRACKET** reads the character and returns **NIL**, just as if the **READ** had not occurred inside a read macro.

If a call to **READ** from within a read macro encounters an unmatched **RIGHTBRACKET** *within* a list, the bracket is simply put back into the buffer to be read (again) at the higher level. Thus, inputting an expression such as **(A B 'C D)** works correctly.

<b>(INREADMACROP)</b>	[Function]
	Returns <b>NIL</b> if currently <i>not</i> under a read macro function, otherwise the number of unmatched left parentheses or brackets.

<b>(READMACROS FLG RDTBL)</b>	[Function]
	If <b>FLG = NIL</b> , turns off action of read macros in read table <b>RDTBL</b> . If <b>FLG = T</b> , turns them on. Returns previous setting.

The following read macros are standardly defined in Interlisp in the **T** and **EDITRDTBL** read tables:

**'** (single-quote) Returns the next expression, wrapped in a call to **QUOTE**; e.g., '**FOO** reads as **(QUOTE FOO)**. The macro is defined as a **FIRST** read macro, so that the quote character has no effect in the middle of a symbol. The macro is also ignored if the quote character is immediately followed by a separator character.

**control-Y** Defined in **T** and **EDITRDTBL**. Returns the result of evaluating the next expression. For example, if the value of **FOO** is **(A B)**, then **(LIST 1 control-YFOO 2)** is read as **(LIST 1 (A B) 2)**. Note that no structure is copied; the third element of that input expression is still **EQ** to the value of **FOO**. Control-Y can thus be used to read structures that ordinarily have no read syntax. For example, the value returned from reading **(KEY1 control-Y(ARRAY 10))** has an array as its second element. Control-Y can be thought of as an "un-quote" character. The choice of character to perform this function is changeable with **SETTERMCHARS** (page 16.75).

**'** (backquote) Backquote makes it easier to write programs to construct complex data structures. Backquote is like quote, except that within the backquoted expression, forms can be evaluated. The general idea is that the backquoted expression is a "template" containing some constant parts (as with a quoted form) and some parts to be filled in by evaluating something. Unlike with control-Y, however, the evaluation occurs not at the time the form is read, but at the time the backquoted expression is evaluated. That is, the backquote macro returns an expression which, when evaluated, produces the desired structure.

Within the backquoted expression, the character **,** (comma) introduces a form to be evaluated. The value of a form preceded by **,@** is to be spliced in, using **APPEND**. If it is permissible to

destroy the list being spliced in (i.e., **NCONC** may be used in the translation), then "," can be used instead of ",@".

For example, if the value of **FOO** is (1 2 3 4), then the form

```
'(A ,(CAR FOO) ,@(CDDR FOO) D E)
```

evaluates to (A 1 3 4 D E); it is logically equivalent to writing

```
(CONS 'A  
(CONS (CAR FOO)  
(APPEND (CDDR FOO) '(D E))))
```

Backquote is particularly useful for writing macros. For example, the body of a macro that refers to **X** as the macro's argument list might be

```
'(COND  
((FIXP ,(CAR X))  
,(CADR X))  
(T ,(CDDR X)))
```

which is equivalent to writing

```
(LIST 'COND  
(LIST (LIST 'FIXP (CAR X))  
(CADR X))  
(CONS 'T (CDDR X)))
```

Note that comma does *not* have any special meaning outside of a backquote context.

For users without a backquote character on their keyboards, backquote can also be written as '| (vertical-bar, quote).

- ? Implements the ?= command for on-line help regarding the function currently being "called" in the typein (see page 26.33).

| (vertical bar)

When followed by an end of line, tab or space, | is ignored, i.e., treated as a separator character, enabling the editor's **CHANGECHAR** feature (page 26.49). Otherwise it is a "dispatching" read macro whose meaning depends on the character(s) following it. The following are currently defined:

' (quote) -- A synonym for backquote.

. (period) -- Returns the evaluation of the next expression, i.e., this is a synonym for control-Y.

, (comma) -- Returns the evaluation of the next expression at *load time*, i.e., the following expression is quoted in such a manner that the compiler treats it as a literal whose value is not determined until the compiled expression is loaded.

O or o (the letter O) -- Treats the next number as octal, i.e., reads it in radix 8. For example, |o12 = 10 (decimal).

B or b -- Treats the next number as binary, i.e., reads it in radix 2. For example, |b101 = 5 (decimal).