

Quick Reference

cl

Common

lisp

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Typographic Conventions

name ;	<i>f</i> name ;	<i>g</i> name ;	<i>m</i> name ;	<i>s</i> name ;	<i>v</i> *name* ;	<i>c</i> name
▷ Symbol defined in Common Lisp; esp. function, generic function, macro, special operator, variable, constant.						
<i>them</i>	▷ Placeholder for actual code.					
me	▷ Literal text.					
[<i>foo</i> bar]	▷ Either one <i>foo</i> or nothing; defaults to bar .					
<i>foo</i> *; { <i>foo</i> }*	▷ Zero or more <i>foos</i> .					
<i>foo</i> ⁺ ; { <i>foo</i> } ⁺	▷ One or more <i>foos</i> .					
<i>foos</i>	▷ English plural denotes a list argument.					
{ <i>foo</i> <i>bar</i> <i>baz</i> };	$\begin{cases} foo \\ bar \\ baz \end{cases}$	▷ Either <i>foo</i> , or <i>bar</i> , or <i>baz</i> .				
$\begin{cases} foo \\ bar \\ baz \end{cases}$	▷ Anything from none to each of <i>foo</i> , <i>bar</i> , and <i>baz</i> .					
\widehat{foo}	▷ Argument <i>foo</i> is not evaluated.					
\widetilde{bar}	▷ Argument <i>bar</i> is possibly modified.					
<i>foo</i> ^{P*}	▷ <i>foo</i> * is evaluated as in sprogn ; see page 20.					
$\underline{foo}; \underline{bar}; \underline{baz}$	▷ Primary, secondary, and <i>n</i> th return value.					
T ; NIL	▷ t , or truth in general; and nil or () .					

1 Numbers

1.1 Predicates

- (*f* = *number*⁺)
 (*f* /= *number*⁺)
 ▷ T if all *numbers*, or none, respectively, are equal in value.
- (*f* > *number*⁺)
 (*f* >= *number*⁺)
 (*f* < *number*⁺)
 (*f* <= *number*⁺)
 ▷ Return T if *numbers* are monotonically decreasing, monotonically non-increasing, monotonically increasing, or monotonically non-decreasing, respectively.
- (*f* minusp *a*)
 (*f* zerop *a*)
 (*f* plusp *a*)
 ▷ T if *a* < 0, *a* = 0, or *a* > 0, respectively.
- (*f* evenp *int*)
 (*f* oddp *int*)
 ▷ T if *int* is even or odd, respectively.
- (*f* numberp *foo*)
 (*f* realp *foo*)
 (*f* rationalp *foo*)
 (*f* floatp *foo*)
 (*f* integerp *foo*)
 (*f* complexp *foo*)
 (*f* random-state-p *foo*)
 ▷ T if *foo* is of indicated type.

1.2 Numeric Functions

- (*f* + *a*_□^{*})
 (*f* * *a*_□^{*})
 ▷ Return $\sum a$ or $\prod a$, respectively.
- (*f* - *a* *b*^{*})
 (*f* / *a* *b*^{*})
 ▷ Return $\underline{a} - \sum b$ or $\underline{a} / \prod b$, respectively. Without any *bs*, return $\underline{-a}$ or $\underline{1/a}$, respectively.
- (*f* 1+ *a*)
 (*f* 1- *a*)
 ▷ Return $\underline{a + 1}$ or $\underline{a - 1}$, respectively.
- ($\left\{ \begin{matrix} m \\ m \end{matrix} \right\}$ incf) \widetilde{place} [*delta*_□]
 ($\left\{ \begin{matrix} m \\ m \end{matrix} \right\}$ decf) \widetilde{place} [*delta*_□]
 ▷ Increment or decrement the value of *place* by *delta*. Return new value.
- (*f* exp *p*)
 (*f* expt *b* *p*)
 ▷ Return $\underline{e^p}$ or $\underline{b^p}$, respectively.
- (*f* log *a* [*b*_□])
 ▷ Return $\underline{\log_b a}$ or, without *b*, $\underline{\ln a}$.
- (*f* sqrt *n*)
 (*f* isqrt *n*)
 ▷ $\underline{\sqrt{n}}$ in complex numbers/natural numbers.
- (*f* lcm *integer*_□^{*})
 (*f* gcd *integer*^{*})
 ▷ Least common multiple or greatest common denominator, respectively, of *integers*. (**gcd**) returns 0.
- pi**
 ▷ **long-float** approximation of π , Ludolph's number.
- (*f* sin *a*)
 (*f* cos *a*)
 (*f* tan *a*)
 ▷ $\underline{\sin a}$, $\underline{\cos a}$, or $\underline{\tan a}$, respectively. (*a* in radians.)
- (*f* asin *a*)
 (*f* acos *a*)
 ▷ $\underline{\arcsin a}$ or $\underline{\arccos a}$, respectively, in radians.
- (*f* atan *a* [*b*_□])
 ▷ $\underline{\arctan \frac{a}{b}}$ in radians.
- (*f* sinh *a*)
 (*f* cosh *a*)
 (*f* tanh *a*)
 ▷ $\underline{\sinh a}$, $\underline{\cosh a}$, or $\underline{\tanh a}$, respectively.

- (*f* **asinh** *a*)
(*f* **acosh** *a*) ▷ asinh *a*, acosh *a*, or atanh *a*, respectively.
(*f* **atanh** *a*)
- (*f* **cis** *a*) ▷ Return $e^{i a} = \cos a + i \sin a$.
- (*f* **conjugate** *a*) ▷ Return complex conjugate of *a*.
- (*f* **max** *num*⁺)
(*f* **min** *num*⁺) ▷ Greatest or least, respectively, of *nums*.
- $\left(\begin{array}{l} \{ \textit{fround} | \textit{fround} \} \\ \{ \textit{ffloor} | \textit{ffloor} \} \\ \{ \textit{fceil} | \textit{fceil} \} \\ \{ \textit{ftruncate} | \textit{ftruncate} \} \end{array} \right) n [d_{\square}]$
▷ Return as **integer** or **float**, respectively, n/d rounded, or rounded towards $-\infty$, $+\infty$, or 0, respectively; and remainder.
- $\left(\begin{array}{l} \{ \textit{fmod} \} \\ \{ \textit{frem} \} \end{array} \right) n d$
▷ Same as *f***floor** or *f***truncate**, respectively, but return remainder only.
- (*f* **random** *limit* [*state* *v**random-state*])
▷ Return non-negative random number less than *limit*, and of the same type.
- (*f* **make-random-state** [*state* [NIL|T]_[NIL]])
▷ Copy of **random-state** object *state* or of the current random state; or a randomly initialized fresh random state.
- v****random-state*** ▷ Current random state.
- (*f* **float-sign** *num-a* [*num-b*_[1]]) ▷ num-b with *num-a*'s sign.
- (*f* **signum** *n*)
▷ Number of magnitude 1 representing sign or phase of *n*.
- (*f* **numerator** *rational*)
(*f* **denominator** *rational*)
▷ Numerator or denominator, respectively, of *rational*'s canonical form.
- (*f* **realpart** *number*)
(*f* **imagpart** *number*)
▷ Real part or imaginary part, respectively, of *number*.
- (*f* **complex** *real* [*imag*_[0]]) ▷ Make a complex number.
- (*f* **phase** *num*) ▷ Angle of *num*'s polar representation.
- (*f* **abs** *n*) ▷ Return |n|.
- (*f* **rational** *real*)
(*f* **rationalize** *real*)
▷ Convert *real* to rational. Assume complete/limited accuracy for *real*.
- (*f* **float** *real* [*prototype*_[0.0F0]])
▷ Convert *real* into float with type of *prototype*.

1.3 Logic Functions

Negative integers are used in two's complement representation.

- (*f* **boole** *operation* *int-a* *int-b*)
▷ Return value of bitwise logical *operation*. *operations* are
- c***boole-1** ▷ int-a.
*c***boole-2** ▷ int-b.
*c***boole-c1** ▷ ¬int-a.
*c***boole-c2** ▷ ¬int-b.
*c***boole-set** ▷ All bits set.
*c***boole-clr** ▷ All bits zero.

- `cboole-eqv` ▷ $\underline{int-a \equiv int-b}$.
`cboole-and` ▷ $\underline{int-a \wedge int-b}$.
`cboole-andc1` ▷ $\underline{\neg int-a \wedge int-b}$.
`cboole-andc2` ▷ $\underline{int-a \wedge \neg int-b}$.
`cboole-nand` ▷ $\underline{\neg(int-a \wedge int-b)}$.
`cboole-ior` ▷ $\underline{int-a \vee int-b}$.
`cboole-orc1` ▷ $\underline{\neg int-a \vee int-b}$.
`cboole-orc2` ▷ $\underline{int-a \vee \neg int-b}$.
`cboole-xor` ▷ $\underline{\neg(int-a \equiv int-b)}$.
`cboole-nor` ▷ $\underline{\neg(int-a \vee int-b)}$.
- `(flognot integer)` ▷ $\underline{\neg integer}$.
- `(flogeqv integer*)`
`(flogand integer*)` ▷ Return value of exclusive-nored or anded integers, respectively. Without any *integer*, return $\underline{-1}$.
- `(flogandc1 int-a int-b)` ▷ $\underline{\neg int-a \wedge int-b}$.
`(flogandc2 int-a int-b)` ▷ $\underline{int-a \wedge \neg int-b}$.
`(flognand int-a int-b)` ▷ $\underline{\neg(int-a \wedge int-b)}$.
- `(flogxor integer*)`
`(flogior integer*)` ▷ Return value of exclusive-ored or ored integers, respectively. Without any *integer*, return $\underline{0}$.
- `(flogorc1 int-a int-b)` ▷ $\underline{\neg int-a \vee int-b}$.
`(flogorc2 int-a int-b)` ▷ $\underline{int-a \vee \neg int-b}$.
`(flognor int-a int-b)` ▷ $\underline{\neg(int-a \vee int-b)}$.
- `(flogbitp i int)` ▷ \underline{T} if zero-indexed *i*th bit of *int* is set.
- `(flogtest int-a int-b)` ▷ Return \underline{T} if there is any bit set in *int-a* which is set in *int-b* as well.
- `(flogcount int)` ▷ Number of 1 bits in *int* ≥ 0 , number of 0 bits in *int* < 0 .

1.4 Integer Functions

- `(finteger-length integer)`
 ▷ Number of bits necessary to represent *integer*.
- `(fldb-test byte-spec integer)`
 ▷ Return \underline{T} if any bit specified by *byte-spec* in *integer* is set.
- `(fash integer count)`
 ▷ Return copy of *integer* arithmetically shifted left by *count* adding zeros at the right, or, for *count* < 0 , shifted right discarding bits.
- `(fldb byte-spec integer)`
 ▷ Extract byte denoted by *byte-spec* from *integer*. **setfable**.
- $\left. \begin{array}{l} \{f\text{deposit-field}\} \\ \{f\text{dpb}\} \end{array} \right\} int-a \text{ byte-spec } int-b$
 ▷ Return *int-b* with bits denoted by *byte-spec* replaced by corresponding bits of *int-a*, or by the low (*fbyte-size* *byte-spec*) bits of *int-a*, respectively.
- `(fmask-field byte-spec integer)`
 ▷ Return copy of *integer* with all bits unset but those denoted by *byte-spec*. **setfable**.
- `(fbyte size position)`
 ▷ Byte specifier for a byte of *size* bits starting at a weight of $2^{position}$.
- `(fbyte-size byte-spec)`
`(fbyte-position byte-spec)`
 ▷ Size or position, respectively, of *byte-spec*.

1.5 Implementation-Dependent

c short-float
 c single-float
 c double-float
 c long-float

$\left. \begin{array}{l} \text{epsilon} \\ \text{negative-epsilon} \end{array} \right\}$

▷ Smallest possible number making a difference when added or subtracted, respectively.

c least-negative
 c least-negative-normalized
 c least-positive
 c least-positive-normalized

$\left. \begin{array}{l} \text{short-float} \\ \text{single-float} \\ \text{double-float} \\ \text{long-float} \end{array} \right\}$

▷ Available numbers closest to -0 or $+0$, respectively.

c most-negative
 c most-positive

$\left. \begin{array}{l} \text{short-float} \\ \text{single-float} \\ \text{double-float} \\ \text{long-float} \\ \text{fixnum} \end{array} \right\}$

▷ Available numbers closest to $-\infty$ or $+\infty$, respectively.

(f decode-float n)

(f integer-decode-float n)

▷ Return significand, exponent, and sign of float n .

(f scale-float n i) ▷ With n 's radix b , return nb^i .

(f float-radix n)

(f float-digits n)

(f float-precision n)

▷ Radix, number of digits in that radix, or precision in that radix, respectively, of float n .

(f upgraded-complex-part-type foo [$environment_{\text{NIL}}$])

▷ Type of most specialized **complex** number able to hold parts of type foo .

2 Characters

The **standard-char** type comprises a-z, A-Z, 0-9, Newline, Space, and `!?"' ' . : ; * + - / \ | ~ _ ^ < = > # % @ & () [] { }`.

(f characterp foo)

(f standard-char-p $char$) ▷ T if argument is of indicated type.

(f graphic-char-p $character$)

(f alpha-char-p $character$)

(f alphanumericp $character$)

▷ T if $character$ is visible, alphabetic, or alphanumeric, respectively.

(f upper-case-p $character$)

(f lower-case-p $character$)

(f both-case-p $character$)

▷ Return T if $character$ is uppercase, lowercase, or able to be in another case, respectively.

(f digit-char-p $character$ [$radix_{10}$])

▷ Return its weight if $character$ is a digit, or NIL otherwise.

(f char= $character^+$)

(f char/= $character^+$)

▷ Return T if all $characters$, or none, respectively, are equal.

(f char-equal $character^+$)

(f char-not-equal $character^+$)

▷ Return T if all $characters$, or none, respectively, are equal ignoring case.

(f char> $character^+$)

(f char>= $character^+$)

(f char< $character^+$)

(f char<= $character^+$)

▷ Return T if $characters$ are monotonically decreasing, monotonically non-increasing, monotonically increasing, or monotonically non-decreasing, respectively.

- (*f*char-greaterp *character*⁺)
 (*f*char-not-lessp *character*⁺)
 (*f*char-lessp *character*⁺)
 (*f*char-not-greaterp *character*⁺)
 ▷ Return T if *characters* are monotonically decreasing, monotonically non-increasing, monotonically increasing, or monotonically non-decreasing, respectively, ignoring case.
- (*f*char-upcase *character*)
 (*f*char-downcase *character*)
 ▷ Return corresponding uppercase/lowercase character, respectively.
- (*f*digit-char *i* [*radix*₁₀]) ▷ Character representing digit *i*.
- (*f*char-name *char*) ▷ *char*'s name if any, or NIL.
- (*f*name-char *foo*) ▷ Character named *foo* if any, or NIL.
- (*f*char-int *character*)
 (*f*char-code *character*) ▷ Code of *character*.
- (*f*code-char *code*) ▷ Character with *code*.
- c*char-code-limit ▷ Upper bound of (*f*char-code *char*); ≥ 96.
- (*f*character *c*) ▷ Return #\c.

3 Strings

Strings can as well be manipulated by array and sequence functions; see pages 10 and 12.

- (*f*stringp *foo*)
 (*f*simple-string-p *foo*) ▷ T if *foo* is of indicated type.
- (*f*string=
*f*string-equal) *foo bar* $\left\{ \begin{array}{l} \text{:start1 } \textit{start-foo}_{\text{0}} \\ \text{:start2 } \textit{start-bar}_{\text{0}} \\ \text{:end1 } \textit{end-foo}_{\text{NIL}} \\ \text{:end2 } \textit{end-bar}_{\text{NIL}} \end{array} \right\}$
- ▷ Return T if subsequences of *foo* and *bar* are equal. Obey/ignore, respectively, case.
- (*f*string{/= | -not-equal}
*f*string{> | -greaterp}
*f*string{>= | -not-lessp}
*f*string{< | -lessp}
*f*string{<= | -not-greaterp}) *foo bar* $\left\{ \begin{array}{l} \text{:start1 } \textit{start-foo}_{\text{0}} \\ \text{:start2 } \textit{start-bar}_{\text{0}} \\ \text{:end1 } \textit{end-foo}_{\text{NIL}} \\ \text{:end2 } \textit{end-bar}_{\text{NIL}} \end{array} \right\}$
- ▷ If *foo* is lexicographically not equal, greater, not less, less, or not greater, respectively, then return position of first mismatching character in *foo*. Otherwise return NIL. Obey/ignore, respectively, case.
- (*f*make-string *size* $\left\{ \begin{array}{l} \text{:initial-element } \textit{char} \\ \text{:element-type } \textit{type}_{\text{character}} \end{array} \right\}$)
- ▷ Return string of length *size*.
- (*f*string *x*)
 (*f*string-capitalize
*f*string-upcase
*f*string-downcase) *x* $\left\{ \begin{array}{l} \text{:start } \textit{start}_{\text{0}} \\ \text{:end } \textit{end}_{\text{NIL}} \end{array} \right\}$
- ▷ Convert *x* (**symbol**, **string**, or **character**) into a string, a string with capitalized words, an all-uppercase string, or an all-lowercase string, respectively.
- (*f*nstring-capitalize
*f*nstring-upcase
*f*nstring-downcase) $\widetilde{\textit{string}}$ $\left\{ \begin{array}{l} \text{:start } \textit{start}_{\text{0}} \\ \text{:end } \textit{end}_{\text{NIL}} \end{array} \right\}$
- ▷ Convert *string* into a string with capitalized words, an all-uppercase string, or an all-lowercase string, respectively.
- (*f*string-trim
*f*string-left-trim
*f*string-right-trim) *char-bag string*
- ▷ Return string with all characters in sequence *char-bag* removed from both ends, from the beginning, or from the end, respectively.

(*f*char *string* *i*)
 (*f*schar *string* *i*)
 ▷ Return zero-indexed *i*th character of *string* ignoring/obeying, respectively, fill pointer. **setfable**.

(*f*parse-integer *string* $\left\{ \begin{array}{l} \text{:start } \text{start}_{\underline{0}} \\ \text{:end } \text{end}_{\underline{\text{NIL}}} \\ \text{:radix } \text{int}_{\underline{10}} \\ \text{:junk-allowed } \text{bool}_{\underline{\text{NIL}}} \end{array} \right\}$)
 ▷ Return integer parsed from *string* and index of parse end.

4 Conses

4.1 Predicates

(*f*consp *foo*)
 (*f*listp *foo*)
 ▷ Return T if *foo* is of indicated type.

(*f*endp *list*)
 (*f*null *foo*)
 ▷ Return T if *list/foo* is NIL.

(*f*atom *foo*)
 ▷ Return T if *foo* is not a **cons**.

(*f*tailp *foo* *list*)
 ▷ Return T if *foo* is a tail of *list*.

(*f*member *foo* *list* $\left\{ \begin{array}{l} \text{:test } \text{function}_{\underline{\#\text{eql}}} \\ \text{:test-not } \text{function} \\ \text{:key } \text{function} \end{array} \right\}$)
 ▷ Return tail of *list* starting with its first element matching *foo*. Return NIL if there is no such element.

$\left\{ \begin{array}{l} \text{fmember-if} \\ \text{fmember-if-not} \end{array} \right\}$ *test* *list* [*:key* *function*])
 ▷ Return tail of *list* starting with its first element satisfying *test*. Return NIL if there is no such element.

(*f*subsetp *list-a* *list-b* $\left\{ \begin{array}{l} \text{:test } \text{function}_{\underline{\#\text{eql}}} \\ \text{:test-not } \text{function} \\ \text{:key } \text{function} \end{array} \right\}$)
 ▷ Return T if *list-a* is a subset of *list-b*.

4.2 Lists

(*f*cons *foo* *bar*)
 ▷ Return new cons (*foo . bar*).

(*f*list *foo**)
 ▷ Return list of foos.

(*f*list* *foo**)
 ▷ Return list of foos with last *foo* becoming cdr of last cons. Return foo if only one *foo* given.

(*f*make-list *num* [*:initial-element* *foo*_{\underline{\text{NIL}}}])
 ▷ New list with *num* elements set to *foo*.

(*f*list-length *list*)
 ▷ Length of list; NIL for circular *list*.

(*f*car *list*)
 ▷ Car of list or NIL if *list* is NIL. **setfable**.

(*f*cdr *list*)
 (*f*rest *list*)
 ▷ Cdr of list or NIL if *list* is NIL. **setfable**.

(*f*nthcdr *n* *list*)
 ▷ Return tail of list after calling *f*cdr *n* times.

($\{ \text{ffirst} | \text{fsecond} | \text{fthird} | \text{ffourth} | \text{ffifth} | \text{fsixth} | \dots | \text{fninth} | \text{ftenth} \}$ *list*)
 ▷ Return nth element of list if any, or NIL otherwise. **setfable**.

(*f*nth *n* *list*)
 ▷ Zero-indexed nth element of *list*. **setfable**.

(*f*cXr *list*)
 ▷ With *X* being one to four **as** and **ds** representing *f*cars and *f*cdrs, e.g. (*f*cadr *bar*) is equivalent to (*f*car (*f*cdr *bar*)). **setfable**.

(*f*last *list* [*num*_{\underline{0}}])
 ▷ Return list of last num conses of *list*.

- $\left\{ \begin{array}{l} \text{fbutlast } list \\ \text{fnbutlast } \widetilde{list} \end{array} \right\} [num_{\square}] \quad \triangleright \text{ } \underline{list}$ excluding last num conses.
- $\left\{ \begin{array}{l} \text{frplaca} \\ \text{frplacd} \end{array} \right\} \widetilde{cons} \text{ object}$
 \triangleright Replace car, or cdr, respectively, of cons with object.
- $(\text{fldiff } list \text{ foo})$
 \triangleright If foo is a tail of $list$, return preceding part of list. Otherwise return list.
- $(\text{fadjoin } foo \text{ list } \left\{ \begin{array}{l} \text{:test } function_{\#'\text{eq}} \\ \text{:test-not } function \\ \text{:key } function \end{array} \right\})$
 \triangleright Return list if foo is already member of $list$. If not, return (fcons foo list).
- $(\text{mpop } \widetilde{place})$
 \triangleright Set $place$ to $(\text{fcdr } place)$, return (fcar place).
- $(\text{mpush } foo \text{ } \widetilde{place}) \quad \triangleright$ Set $place$ to (fcons foo place).
- $(\text{mpushnew } foo \text{ } \widetilde{place} \left\{ \begin{array}{l} \text{:test } function_{\#'\text{eq}} \\ \text{:test-not } function \\ \text{:key } function \end{array} \right\})$
 \triangleright Set $place$ to (fadjoin foo place).
- $(\text{fappend } [proper-list^* \text{foo}_{\square}])$
 $(\text{fnconc } [non-circular-list^* \text{foo}_{\square}])$
 \triangleright Return concatenated list or, with only one argument, foo. foo can be of any type.
- $(\text{frevappend } list \text{ foo})$
 $(\text{fnreconc } \widetilde{list} \text{ foo})$
 \triangleright Return concatenated list after reversing order in $list$.
- $\left\{ \begin{array}{l} \text{fmapcar} \\ \text{fmaplist} \end{array} \right\} function \text{ list}^+$
 \triangleright Return list of return values of $function$ successively invoked with corresponding arguments, either cars or cdrs, respectively, from each $list$.
- $\left\{ \begin{array}{l} \text{fmapcan} \\ \text{fmapcon} \end{array} \right\} function \widetilde{list}^+$
 \triangleright Return list of concatenated return values of $function$ successively invoked with corresponding arguments, either cars or cdrs, respectively, from each $list$. $function$ should return a list.
- $\left\{ \begin{array}{l} \text{fmapc} \\ \text{fmapl} \end{array} \right\} function \text{ list}^+$
 \triangleright Return first list after successively applying $function$ to corresponding arguments, either cars or cdrs, respectively, from each $list$. $function$ should have some side effects.
- $(\text{fcopy-list } list) \quad \triangleright$ Return copy of $list$ with shared elements.

4.3 Association Lists

- $(\text{fpairlis } keys \text{ values } [alist_{\square}])$
 \triangleright Prepend to alist an association list made from lists $keys$ and $values$.
- $(\text{facons } key \text{ value } alist)$
 \triangleright Return alist with a $(key . value)$ pair added.
- $\left\{ \begin{array}{l} \text{fassoc} \\ \text{fassoc} \end{array} \right\} foo \text{ alist } \left\{ \begin{array}{l} \text{:test } test_{\#'\text{eq}} \\ \text{:test-not } test \\ \text{:key } function \end{array} \right\}$
 $\left\{ \begin{array}{l} \text{fassoc-if}[-\text{not}] \\ \text{fassoc-if}[-\text{not}] \end{array} \right\} test \text{ alist } [\text{:key } function]$
 \triangleright First cons whose car, or cdr, respectively, satisfies $test$.
- $(\text{fcopy-alist } alist) \quad \triangleright$ Return copy of $alist$.

4.4 Trees

(*f*tree-equal *foo bar* {**:test** *test*_{#'eq1}
:test-not *test*})

▷ Return T if trees *foo* and *bar* have same shape and leaves satisfying *test*.

{*f*subst *new old tree*
*f*nsubst *new old tree*} {**:test** *function*_{#'eq1}
:test-not *function*
:key *function*}

▷ Make copy of tree with each subtree or leaf matching *old* replaced by *new*.

{**f**subst-if[-not] *new test tree*
fnsubst-if[-not] *new test tree*} [:key *function*]

▷ Make copy of tree with each subtree or leaf satisfying *test* replaced by *new*.

{*f*sublis *association-list tree*
*f*nsublis *association-list tree*} {**:test** *function*_{#'eq1}
:test-not *function*
:key *function*}

▷ Make copy of tree with each subtree or leaf matching a key in *association-list* replaced by that key's value.

(*f*copy-tree *tree*) ▷ Copy of tree with same shape and leaves.

4.5 Sets

{*f*intersection
*f*set-difference
*f*union
*f*set-exclusive-or
*f*nintersection
*f*nset-difference
*f*nunion
*f*nset-exclusive-or} {*a b*
ā b
ā b̄} {**:test** *function*_{#'eq1}
:test-not *function*
:key *function*}

▷ Return $a \cap b$, $a \setminus b$, $a \cup b$, or $a \triangle b$, respectively, of lists *a* and *b*.

5 Arrays

5.1 Predicates

(*f*arrayp *foo*)

(*f*vectorp *foo*)

(*f*simple-vector-p *foo*)

▷ T if *foo* is of indicated type.

(*f*bit-vector-p *foo*)

(*f*simple-bit-vector-p *foo*)

(*f*adjustable-array-p *array*)

(*f*array-has-fill-pointer-p *array*)

▷ T if *array* is adjustable/has a fill pointer, respectively.

(*f*array-in-bounds-p *array* [*subscripts*])

▷ Return T if *subscripts* are in *array*'s bounds.

5.2 Array Functions

{*f*make-array *dimension-sizes* [:adjustable *bool*_{NIL}]
*f*adjust-array *array* *dimension-sizes*
:**element-type** *type*_T
:**fill-pointer** {*num*|*bool*}_{NIL}
:**initial-element** *obj*
:**initial-contents** *tree-or-array*
:**displaced-to** *array*_{NIL} [:displaced-index-offset *i*₀]})

▷ Return fresh, or readjust, respectively, vector or array.

(*f*aref *array* [*subscripts*])

▷ Return array element pointed to by *subscripts*. **setfable**.

(*f*row-major-aref *array* *i*)

▷ Return *i*th element of *array* in row-major order. **setfable**.

- (*f* **array-row-major-index** *array* [*subscripts*])
 ▷ Index in row-major order of the element denoted by *subscripts*.
- (*f* **array-dimensions** *array*)
 ▷ List containing the lengths of *array*'s dimensions.
- (*f* **array-dimension** *array* *i*)
 ▷ Length of *i*th dimension of *array*.
- (*f* **array-total-size** *array*) ▷ Number of elements in *array*.
- (*f* **array-rank** *array*) ▷ Number of dimensions of *array*.
- (*f* **array-displacement** *array*) ▷ Target array and offset.₂
- (*f* **bit** *bit-array* [*subscripts*])
 (*f* **sbit** *simple-bit-array* [*subscripts*])
 ▷ Return element of *bit-array* or of *simple-bit-array*. **setf**-able.
- (*f* **bit-not** *bit-array* [*result-bit-array*_{NIL}])
 ▷ Return result of bitwise negation of *bit-array*. If *result-bit-array* is T, put result in *bit-array*; if it is NIL, make a new array for result.

(*f* **bit-eqv**
f **bit-and**
f **bit-andc1**
f **bit-andc2**
f **bit-nand**
f **bit-ior**
f **bit-orc1**
f **bit-orc2**
f **bit-xor**
f **bit-nor**) *bit-array-a* *bit-array-b* [*result-bit-array*_{NIL}])

▷ Return result of bitwise logical operations (cf. operations of *f* **boole**, page 4) on *bit-array-a* and *bit-array-b*. If *result-bit-array* is T, put result in *bit-array-a*; if it is NIL, make a new array for result.

- c* **array-rank-limit** ▷ Upper bound of array rank; ≥ 8 .
- c* **array-dimension-limit**
 ▷ Upper bound of an array dimension; ≥ 1024 .
- c* **array-total-size-limit** ▷ Upper bound of array size; ≥ 1024 .

5.3 Vector Functions

Vectors can as well be manipulated by sequence functions; see section 6.

- (*f* **vector** *foo**) ▷ Return fresh simple vector of *foos*.
- (*f* **svref** *vector* *i*) ▷ Element *i* of simple *vector*. **setf**able.
- (*f* **vector-push** *foo* *vector*)
 ▷ Return **NIL** if *vector*'s fill pointer equals size of *vector*. Otherwise replace element of *vector* pointed to by fill pointer with *foo*; then increment fill pointer.
- (*f* **vector-push-extend** *foo* *vector* [*num*])
 ▷ Replace element of *vector* pointed to by fill pointer with *foo*, then increment fill pointer. Extend *vector*'s size by \geq *num* if necessary.
- (*f* **vector-pop** *vector*)
 ▷ Return element of *vector* its fillpointer points to after decrementation.
- (*f* **fill-pointer** *vector*) ▷ Fill pointer of *vector*. **setf**able.

6 Sequences

6.1 Sequence Predicates

$\left(\begin{array}{l} \text{every} \\ \text{notevery} \end{array} \right) test\ sequence^+$

▷ Return NIL or T, respectively, as soon as *test* on any set of corresponding elements of *sequences* returns NIL.

$\left(\begin{array}{l} \text{some} \\ \text{notany} \end{array} \right) test\ sequence^+$

▷ Return value of test or NIL, respectively, as soon as *test* on any set of corresponding elements of *sequences* returns non-NIL.

$(\text{mismatch}\ sequence\text{-}a\ sequence\text{-}b\ \left. \begin{array}{l} \text{:from-end}\ bool_{\text{NIL}} \\ \left\{ \begin{array}{l} \text{:test}\ function_{\neq\text{eq}} \\ \text{:test-not}\ function \end{array} \right\} \\ \text{:start1}\ start\text{-}a_{\text{0}} \\ \text{:start2}\ start\text{-}b_{\text{0}} \\ \text{:end1}\ end\text{-}a_{\text{NIL}} \\ \text{:end2}\ end\text{-}b_{\text{NIL}} \\ \text{:key}\ function \end{array} \right\})$

▷ Return position in sequence-a where *sequence-a* and *sequence-b* begin to mismatch. Return NIL if they match entirely.

6.2 Sequence Functions

$(\text{make-sequence}\ sequence\text{-}type\ size\ [\text{:initial-element}\ foo])$

▷ Make sequence of *sequence-type* with *size* elements.

$(\text{concatenate}\ type\ sequence^*)$

▷ Return concatenated sequence of *type*.

$(\text{merge}\ type\ \widetilde{sequence\text{-}a}\ \widetilde{sequence\text{-}b}\ test\ [\text{:key}\ function_{\text{NIL}}])$

▷ Return interleaved sequence of *type*. Merged sequence will be sorted if both *sequence-a* and *sequence-b* are sorted.

$(\text{fill}\ \widetilde{sequence}\ foo\ \left\{ \begin{array}{l} \text{:start}\ start_{\text{0}} \\ \text{:end}\ end_{\text{NIL}} \end{array} \right\})$

▷ Return sequence after setting elements between *start* and *end* to *foo*.

$(\text{length}\ sequence)$

▷ Return length of sequence (being value of fill pointer if applicable).

$(\text{count}\ foo\ sequence\ \left\{ \begin{array}{l} \text{:from-end}\ bool_{\text{NIL}} \\ \left\{ \begin{array}{l} \text{:test}\ function_{\neq\text{eq}} \\ \text{:test-not}\ function \end{array} \right\} \\ \text{:start}\ start_{\text{0}} \\ \text{:end}\ end_{\text{NIL}} \\ \text{:key}\ function \end{array} \right\})$

▷ Return number of elements in *sequence* which match *foo*.

$\left(\begin{array}{l} \text{count-if} \\ \text{count-if-not} \end{array} \right) test\ sequence\ \left\{ \begin{array}{l} \text{:from-end}\ bool_{\text{NIL}} \\ \text{:start}\ start_{\text{0}} \\ \text{:end}\ end_{\text{NIL}} \\ \text{:key}\ function \end{array} \right\})$

▷ Return number of elements in *sequence* which satisfy *test*.

$(\text{elt}\ sequence\ index)$

▷ Return element of sequence pointed to by zero-indexed *index*. **setfable**.

$(\text{subseq}\ sequence\ start\ [end_{\text{NIL}}])$

▷ Return subsequence of sequence between *start* and *end*. **setfable**.

$\left(\begin{array}{l} \text{sort} \\ \text{stable-sort} \end{array} \right) \widetilde{sequence}\ test\ [\text{:key}\ function]$

▷ Return sequence sorted. Order of elements considered equal is not guaranteed/retained, respectively.

$(\text{reverse}\ sequence)$

$(\text{fnreverse}\ \widetilde{sequence})$

▷ Return sequence in reverse order.

$$\left. \begin{array}{l} \{ \text{find} \\ \text{position} \} \end{array} \right\} \text{foo sequence} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:test } \text{function}_{\text{\#'eq}} \\ \text{:test-not } \text{test} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \end{array} \right\}$$

▷ Return first element in *sequence* which matches *foo*, or its position relative to the begin of *sequence*, respectively.

$$\left. \begin{array}{l} \{ \text{find-if} \\ \text{find-if-not} \\ \text{position-if} \\ \text{position-if-not} \} \end{array} \right\} \text{test sequence} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \end{array} \right\}$$

▷ Return first element in *sequence* which satisfies *test*, or its position relative to the begin of *sequence*, respectively.

$$(\text{fsearch } \text{sequence-a } \text{sequence-b}) \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:test } \text{function}_{\text{\#'eq}} \\ \text{:test-not } \text{function} \\ \text{:start1 } \text{start-a}_{\text{0}} \\ \text{:start2 } \text{start-b}_{\text{0}} \\ \text{:end1 } \text{end-a}_{\text{NIL}} \\ \text{:end2 } \text{end-b}_{\text{NIL}} \\ \text{:key } \text{function} \end{array} \right\}$$

▷ Search *sequence-b* for a subsequence matching *sequence-a*. Return position in *sequence-b*, or NIL.

$$\left. \begin{array}{l} \{ \text{remove } \text{foo } \text{sequence} \\ \text{delete } \text{foo } \text{sequence} \} \end{array} \right\} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:test } \text{function}_{\text{\#'eq}} \\ \text{:test-not } \text{function} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \\ \text{:count } \text{count}_{\text{NIL}} \end{array} \right\}$$

▷ Make copy of sequence without elements matching *foo*.

$$\left. \begin{array}{l} \{ \text{remove-if} \\ \text{remove-if-not} \\ \text{delete-if} \\ \text{delete-if-not} \} \end{array} \right\} \begin{array}{l} \text{test sequence} \\ \text{test sequence} \end{array} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \\ \text{:count } \text{count}_{\text{NIL}} \end{array} \right\}$$

▷ Make copy of sequence with all (or *count*) elements satisfying *test* removed.

$$\left. \begin{array}{l} \{ \text{remove-duplicates } \text{sequence} \\ \text{delete-duplicates } \text{sequence} \} \end{array} \right\} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:test } \text{function}_{\text{\#'eq}} \\ \text{:test-not } \text{function} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \end{array} \right\}$$

▷ Make copy of sequence without duplicates.

$$\left. \begin{array}{l} \{ \text{substitute } \text{new } \text{old } \text{sequence} \\ \text{nsubstitute } \text{new } \text{old } \text{sequence} \} \end{array} \right\} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:test } \text{function}_{\text{\#'eq}} \\ \text{:test-not } \text{function} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \\ \text{:count } \text{count}_{\text{NIL}} \end{array} \right\}$$

▷ Make copy of sequence with all (or *count*) *olds* replaced by *new*.

$$\left. \begin{array}{l} \{ \text{substitute-if} \\ \text{substitute-if-not} \\ \text{nsubstitute-if} \\ \text{nsubstitute-if-not} \} \end{array} \right\} \begin{array}{l} \text{new test sequence} \\ \text{new test sequence} \end{array} \left. \begin{array}{l} \text{:from-end } \text{bool}_{\text{NIL}} \\ \text{:start } \text{start}_{\text{0}} \\ \text{:end } \text{end}_{\text{NIL}} \\ \text{:key } \text{function} \\ \text{:count } \text{count}_{\text{NIL}} \end{array} \right\}$$

▷ Make copy of sequence with all (or *count*) elements satisfying *test* replaced by *new*.

$$(\text{freplace } \text{sequence-a } \text{sequence-b}) \left. \begin{array}{l} \text{:start1 } \text{start-a}_{\text{0}} \\ \text{:start2 } \text{start-b}_{\text{0}} \\ \text{:end1 } \text{end-a}_{\text{NIL}} \\ \text{:end2 } \text{end-b}_{\text{NIL}} \end{array} \right\}$$

▷ Replace elements of sequence-a with elements of sequence-b.

(*f* **map** *type function sequence*⁺)

▷ Apply *function* successively to corresponding elements of the *sequences*. Return values as a sequence of *type*. If *type* is NIL, return NIL.

(*f* **map-into** *result-sequence function sequence*^{*})

▷ Store into *result-sequence* successively values of *function* applied to corresponding elements of the *sequences*.

(*f* **reduce** *function sequence* $\left. \begin{array}{l} \text{:initial-value } foo_{\text{NIL}} \\ \text{:from-end } bool_{\text{NIL}} \\ \text{:start } start_{\text{0}} \\ \text{:end } end_{\text{NIL}} \\ \text{:key function} \end{array} \right\}$)

▷ Starting with the first two elements of *sequence*, apply *function* successively to its last return value together with the next element of *sequence*. Return last value of function.

(*f* **copy-seq** *sequence*)

▷ Copy of *sequence* with shared elements.

7 Hash Tables

The Loop Facility provides additional hash table-related functionality; see **loop**, page 21.

Key-value storage similar to hash tables can as well be achieved using association lists and property lists; see pages 9 and 16.

(*f* **hash-table-p** *foo*) ▷ Return T if *foo* is of type **hash-table**.

(*f* **make-hash-table** $\left. \begin{array}{l} \text{:test } \{f\text{eq}|f\text{eql}|f\text{equal}|f\text{equalp}\}_{\text{[#'eq]}} \\ \text{:size } int \\ \text{:rehash-size } num \\ \text{:rehash-threshold } num \end{array} \right\}$)

▷ Make a hash table.

(*f* **gethash** *key hash-table* [*default* NIL])

▷ Return object with *key* if any or *default* otherwise; and T if found, NIL otherwise. **setfable**.

(*f* **hash-table-count** *hash-table*)

▷ Number of entries in *hash-table*.

(*f* **remhash** *key hash-table*)

▷ Remove from *hash-table* entry with *key* and return T if it existed. Return NIL otherwise.

(*f* **clrhash** *hash-table*) ▷ Empty hash-table.

(*f* **maphash** *function hash-table*)

▷ Iterate over *hash-table* calling *function* on key and value. Return NIL.

(*m* **with-hash-table-iterator** (*foo hash-table*) (**declare** *decl*^{*})^{*} *form*^{P*})

▷ Return values of forms. In *forms*, invocations of (*foo*) return: T if an entry is returned; its key; its value.

(*f* **hash-table-test** *hash-table*)

▷ Test function used in *hash-table*.

(*f* **hash-table-size** *hash-table*)

(*f* **hash-table-rehash-size** *hash-table*)

(*f* **hash-table-rehash-threshold** *hash-table*)

▷ Current size, rehash-size, or rehash-threshold, respectively, as used in *f***make-hash-table**.

(*f* **sxhash** *foo*)

▷ Hash code unique for any argument *f***equal** *foo*.

8 Structures

(*m*defstruct

```

(foo
  {
    (:conc-name [slot-prefixfoo-])
    (:constructor [makerMAKE-foo [(ord-λ*)]])
    (:copier [copierCOPY-foo])
    (:include struct {
      (slot [init {
        (:type sl-type)
        (:read-only b̂)
      }])
    })
    (:type {
      list
      vector
      (vector type)
    }) [(initial-offset n̂)]
    (:print-object [o-printer])
    (:print-function [f-printer])
    :named
    (:predicate [p-namefoo-P])
  }
  [doc] {
    (slot [init {
      (:type slot-type)
      (:read-only bool)
    }])
  }
)

```

▷ Define structure *foo* together with functions *MAKE-foo*, *COPY-foo* and *foo-P*; and **setfable** accessors *foo-slot*. Instances are of class *foo* or, if **defstruct** option **:type** is given, of the specified type. They can be created by (*MAKE-foo* {*slot value*}*) or, if *ord-λ* (see page 17) is given, by (*maker arg** {*:key value*}*). In the latter case, *args* and *:keys* correspond to the positional and keyword parameters defined in *ord-λ* whose *vars* in turn correspond to *slots*. **:print-object**/**:print-function** generate a *gprint-object* method for an instance *bar* of *foo* calling (*o-printer bar stream*) or (*f-printer bar stream print-level*), respectively. If **:type** without **:named** is given, no *foo-P* is created.

(*f*copy-structure *structure*)

▷ Return copy of *structure* with shared slot values.

9 Control Structure

9.1 Predicates

(*f*eq *foo bar*) ▷ T if *foo* and *bar* are identical.

(*f*eql *foo bar*)

▷ T if *foo* and *bar* are identical, or the same **character**, or **numbers** of the same type and value.

(*f*equal *foo bar*)

▷ T if *foo* and *bar* are *f*eql, or are equivalent **pathnames**, or are **conses** with *f*equal cars and cdrs, or are **strings** or **bit-vectors** with *f*eql elements below their fill pointers.

(*f*equalp *foo bar*)

▷ T if *foo* and *bar* are identical; or are the same **character** ignoring case; or are **numbers** of the same value ignoring type; or are equivalent **pathnames**; or are **conses** or **arrays** of the same shape with *f*equalp elements; or are structures of the same type with *f*equalp elements; or are **hash-tables** of the same size with the same **:test** function, the same keys in terms of **:test** function, and *f*equalp elements.

(*f*not *foo*)

▷ T if *foo* is NIL; NIL otherwise.

(*f*boundp *symbol*)

▷ T if *symbol* is a special variable.

(*f*constantp *foo* [*environment* NIL])

▷ T if *foo* is a constant form.

- (**f**functionp *foo*) ▷ T if *foo* is of type **function**.
- (**f**boundp $\left\{ \begin{array}{l} \widehat{foo} \\ (\text{setf } \widehat{foo}) \end{array} \right\}$) ▷ T if *foo* is a global function or macro.

9.2 Variables

- $\left\{ \begin{array}{l} \text{mdefconstant} \\ \text{mdefparameter} \end{array} \right\} \widehat{foo} \text{ form } [\widehat{doc}]$
 ▷ Assign value of *form* to global constant/dynamic variable *foo*.
- (**m**defvar \widehat{foo} [*form* [*doc*]])
 ▷ Unless bound already, assign value of *form* to dynamic variable *foo*.
- $\left\{ \begin{array}{l} \text{msetf} \\ \text{mpsetf} \end{array} \right\} \{ \text{place form} \}^*$
 ▷ Set *places* to primary values of *forms*. Return values of last *form*/NIL; work sequentially/in parallel, respectively.
- $\left\{ \begin{array}{l} \text{ssetq} \\ \text{msetq} \end{array} \right\} \{ \text{symbol form} \}^*$
 ▷ Set *symbols* to primary values of *forms*. Return value of last *form*/NIL; work sequentially/in parallel, respectively.
- (**f**set $\widetilde{\text{symbol } foo}$) ▷ Set *symbol*'s value cell to *foo*. Deprecated.
- (**m**multiple-value-setq *vars form*)
 ▷ Set elements of *vars* to the values of *form*. Return *form*'s primary value.
- (**m**shiftf $\widetilde{\text{place}^+ \text{foo}}$)
 ▷ Store value of *foo* in rightmost *place* shifting values of *places* left, returning first *place*.
- (**m**rotatef $\widetilde{\text{place}^*}$)
 ▷ Rotate values of *places* left, old first becoming new last *place*'s value. Return NIL.
- (**f**makunbound \widetilde{foo}) ▷ Delete special variable *foo* if any.
- (**f**get *symbol key* [*default*_{NIL}])
 (**f**getf *place key* [*default*_{NIL}])
 ▷ First entry *key* from property list stored in *symbol*/in *place*, respectively, or *default* if there is no *key*. **setfable**.
- (**f**get-properties *property-list keys*)
 ▷ Return *key* and *value* of first entry from *property-list* matching a key from *keys*, and tail of *property-list* starting with that key. Return NIL, NIL₂, and NIL₃ if there was no matching key in *property-list*.
- (**f**remprop $\widetilde{\text{symbol } key}$)
 (**m**remf $\widetilde{\text{place } key}$)
 ▷ Remove first entry *key* from property list stored in *symbol*/in *place*, respectively. Return T if *key* was there, or NIL otherwise.
- (**s**progv *symbols values form*^{P*})
 ▷ Evaluate *forms* with locally established dynamic bindings of *symbols* to *values* or NIL. Return values of *forms*.
- $\left\{ \begin{array}{l} \text{slet} \\ \text{slet*} \end{array} \right\} \left(\left\{ \begin{array}{l} \text{name} \\ (\text{name } [\text{value}_{\text{NIL}}]) \end{array} \right\}^* \right) (\text{declare } \widehat{\text{decl}}^*)^* \text{ form}^{\text{P}^*}$
 ▷ Evaluate *forms* with *names* lexically bound (in parallel or sequentially, respectively) to *values*. Return values of *forms*.
- (**m**multiple-value-bind ($\widehat{\text{var}}^*$) *values-form* (**declare** $\widehat{\text{decl}}^*$)^{*} *body-form*^{P*})
 ▷ Evaluate *body-forms* with *vars* lexically bound to the return values of *values-form*. Return values of *body-forms*.

(*mdestructuring-bind* *destruct-λ bar (declare \widehat{decl}^*)* form^{P*}*)
 ▷ Evaluate *forms* with variables from tree *destruct-λ* bound to corresponding elements of tree *bar*, and return their values. *destruct-λ* resembles *macro-λ* (section 9.4), but without any **&environment** clause.

9.3 Functions

Below, ordinary lambda list (*ord-λ**) has the form

$$(var^* [\&optional \left\{ \left(var [init_{\text{NIL}} [supplied-p]] \right) \right\}^*] [\&rest var]$$

$$[\&key \left\{ \left(\left(\begin{array}{l} var \\ (:key var) \end{array} \right) [init_{\text{NIL}} [supplied-p]] \right) \right\}^* [\&allow-other-keys]]$$

$$[\&aux \left\{ \left(var [init_{\text{NIL}}] \right) \right\}^*]).$$

supplied-p is T if there is a corresponding argument. *init* forms can refer to any *init* and *supplied-p* to their left.

$$\left(\begin{array}{l} m\text{defun} \left\{ \begin{array}{l} foo (ord-\lambda^*) \\ (\text{setf } foo) (new-value ord-\lambda^*) \end{array} \right\} \left\{ \left(\begin{array}{l} (\text{declare } \widehat{decl}^*)^* \\ \widehat{doc} \end{array} \right) \right\} \\ m\text{lambda} (ord-\lambda^*) \\ form^P \end{array} \right)$$

▷ Define a function named *foo* or (**setf** *foo*), or an anonymous function, respectively, which applies *forms* to *ord-λs*. For *mdefun*, *forms* are enclosed in an implicit **sblock** named *foo*.

$$\left(\begin{array}{l} s\text{flet} \\ s\text{labels} \end{array} \right) \left(\left(\begin{array}{l} foo (ord-\lambda^*) \\ (\text{setf } foo) (new-value ord-\lambda^*) \end{array} \right) \left\{ \left(\begin{array}{l} (\text{declare } \widehat{local-decl}^*)^* \\ \widehat{doc} \end{array} \right) local-form^P \right\}^* (\text{declare } \widehat{decl}^*)^* \right) \\ form^P$$

▷ Evaluate *forms* with locally defined functions *foo*. Globally defined functions of the same name are shadowed. Each *foo* is also the name of an implicit **sblock** around its corresponding *local-form**. Only for **slabels**, functions *foo* are visible inside *local-forms*. Return values of forms.

$$(s\text{function} \left\{ \begin{array}{l} foo \\ (m\text{lambda } form^*) \end{array} \right\})$$

▷ Return lexically innermost function named *foo* or a lexical closure of the **mlambda** expression.

$$(f\text{apply} \left\{ \begin{array}{l} function \\ (\text{setf } function) \end{array} \right\} arg^* args)$$

▷ Values of function called with *args* and the list elements of *args*. **setfable** if *function* is one of **faref**, **fbit**, and **fsbit**.

(**ffuncall** *function arg**) ▷ Values of function called with *args*.

(**smultiple-value-call** *function form**)

▷ Call *function* with all the values of each *form* as its arguments. Return values returned by function.

(**fvalues-list** *list*) ▷ Return elements of list.

(**fvalues** *foo**)

▷ Return as multiple values the primary values of the *foos*. **setfable**.

(**fmultiple-value-list** *form*) ▷ List of the values of form.

(**mnth-value** *n form*)

▷ Zero-indexed nth return value of form.

(**fcomplement** *function*)

▷ Return new function with same arguments and same side effects as *function*, but with complementary truth value.

(**fconstantly** *foo*)

▷ Function of any number of arguments returning *foo*.

(**fidentity** *foo*) ▷ Return foo.

(*f* **function-lambda-expression** *function*)

- ▷ If available, return lambda expression of *function*, NIL if *function* was defined in an environment without bindings, and name of *function*.

(*f* **definition** $\left\{ \begin{array}{l} \textit{foo} \\ (\textit{setf} \textit{foo}) \end{array} \right\}$)

- ▷ Definition of global function *foo*. **setfable**.

(*f* **makunbound** *foo*)

- ▷ Remove global function or macro definition foo.

c **call-arguments-limit**

c **lambda-parameters-limit**

- ▷ Upper bound of the number of function arguments or lambda list parameters, respectively; ≥ 50 .

c **multiple-values-limit**

- ▷ Upper bound of the number of values a multiple value can have; ≥ 20 .

9.4 Macros

Below, macro lambda list (*macro-λ**) has the form of either

(**&whole** *var* [*E*] $\left\{ \begin{array}{l} \textit{var} \\ (\textit{macro-}\lambda^*) \end{array} \right\}^*$ [*E*])

&optional $\left\{ \begin{array}{l} \textit{var} \\ \left(\left\{ \begin{array}{l} \textit{var} \\ (\textit{macro-}\lambda^*) \end{array} \right\} [\textit{init}_{\text{NIL}} [\textit{supplied-p}]] \right) \end{array} \right\}^*$ [*E*]

&rest $\left\{ \begin{array}{l} \textit{rest-var} \\ (\textit{macro-}\lambda^*) \end{array} \right\}$ [*E*]

&key $\left\{ \begin{array}{l} \textit{var} \\ \left(\left\{ \begin{array}{l} \textit{var} \\ (:key \left\{ \begin{array}{l} \textit{var} \\ (\textit{macro-}\lambda^*) \end{array} \right\}) \end{array} \right\} [\textit{init}_{\text{NIL}} [\textit{supplied-p}]] \right) \end{array} \right\}^*$ [*E*]

&allow-other-keys] [**&aux** $\left\{ \begin{array}{l} \textit{var} \\ (\textit{var} [\textit{init}_{\text{NIL}}]) \end{array} \right\}^*$] [*E*])

or

(**&whole** *var* [*E*] $\left\{ \begin{array}{l} \textit{var} \\ (\textit{macro-}\lambda^*) \end{array} \right\}^*$ [*E*] [**&optional** $\left\{ \begin{array}{l} \textit{var} \\ \left(\left\{ \begin{array}{l} \textit{var} \\ (\textit{macro-}\lambda^*) \end{array} \right\} [\textit{init}_{\text{NIL}} [\textit{supplied-p}]] \right) \end{array} \right\}^*$] [*E*] . *rest-var*).

One toplevel [*E*] may be replaced by **&environment** *var*. *supplied-p* is T if there is a corresponding argument. *init* forms can refer to any *init* and *supplied-p* to their left.

$\left\{ \begin{array}{l} \textit{mdefmacro} \\ \textit{mdefine-compiler-macro} \end{array} \right\} \left\{ \begin{array}{l} \textit{foo} \\ (\textit{setf} \textit{foo}) \end{array} \right\} (\textit{macro-}\lambda^*)$
 $\left\{ \begin{array}{l} (\textit{declare} \widehat{\textit{decl}^*})^* \\ \widehat{\textit{doc}} \end{array} \right\} \textit{form}^{\text{P}^*}$

- ▷ Define macro *foo* which on evaluation as (*foo tree*) applies expanded *forms* to arguments from *tree*, which corresponds to *tree-shaped macro-λs*. *forms* are enclosed in an implicit **sblock** named *foo*.

(*m* **define-symbol-macro** *foo form*)

- ▷ Define symbol macro foo which on evaluation evaluates expanded *form*.

(*s* **macrolet** ((*foo* (*macro-λ**) $\left\{ \begin{array}{l} (\textit{declare} \widehat{\textit{local-decl}^*})^* \\ \widehat{\textit{doc}} \end{array} \right\}$))

macro-form^{P*}) (**declare** $\widehat{\textit{decl}^*}$)^{*} *form*^{P*})

- ▷ Evaluate forms with locally defined mutually invisible macros *foo* which are enclosed in implicit **sblocks** of the same name.

(*s* **symbol-macrolet** ((*foo expansion-form*)^{*}) (**declare** $\widehat{\textit{decl}^*}$)^{*} *form*^{P*})

- ▷ Evaluate forms with locally defined symbol macros *foo*.

(*m* **defsetf** *function* $\left\{ \begin{array}{l} \widehat{\textit{updater}} \widehat{\textit{doc}} \\ (\textit{setf-}\lambda^*) (\textit{s-var}^*) \left\{ \begin{array}{l} (\textit{declare} \widehat{\textit{decl}^*})^* \\ \widehat{\textit{doc}} \end{array} \right\} \textit{form}^{\text{P}^*} \end{array} \right\}$)

where defsetf lambda list (*setf-λ**) has the form

$$(var^* [\&optional \left\{ \begin{array}{l} var \\ (var [init_{\underline{NIL}} [supplied-p]]) \end{array} \right\}^*] [\&rest var] \\ [\&key \left\{ \begin{array}{l} var \\ (\{var \\ (:key var)\}) [init_{\underline{NIL}} [supplied-p]]) \end{array} \right\}^*] \\ [\&allow-other-keys] [\&environment var])$$

▷ Specify how to **setf** a place accessed by *function*. **Short form:** (**setf** (*function arg**) *value-form*) is replaced by (*updater arg* value-form*); the latter must return *value-form*. **Long form:** on invocation of (**setf** (*function arg**) *value-form*), *forms* must expand into code that sets the place accessed where *setf-λ* and *s-var** describe the arguments of *function* and the value(s) to be stored, respectively; and that returns the value(s) of *s-var**. *forms* are enclosed in an implicit **sblock** named *function*.

$$(\underline{m}\text{define-setf-expander } function (macro-\lambda^*) \left\{ \left(\begin{array}{l} \text{declare } \widehat{decl}^* \\ \widehat{doc} \end{array} \right)^* \right\} \\ form^P)$$

▷ Specify how to **setf** a place accessed by *function*. On invocation of (**setf** (*function arg**) *value-form*), *form** must expand into code returning *arg-vars*, *args*, *newval-vars*, *set-form*, and *get-form* as described with **fget-setf-expansion** where the elements of macro lambda list *macro-λ** are bound to corresponding *args*. *forms* are enclosed in an implicit **sblock** named *function*.

$$(\underline{f}\text{get-setf-expansion } place [environment_{\underline{NIL}}])$$

▷ Return lists of temporary variables *arg-vars* and of corresponding *args* as given with *place*, list *newval-vars* with temporary variables corresponding to the new values, and *set-form* and *get-form* specifying in terms of *arg-vars* and *newval-vars* how to **setf** and how to read *place*.

$$(\underline{m}\text{define-modify-macro } foo ([\&optional \\ \left\{ \begin{array}{l} var \\ (var [init_{\underline{NIL}} [supplied-p]]) \end{array} \right\}^*] [\&rest var]) function [\widehat{doc}])$$

▷ Define macro *foo* able to modify a place. On invocation of (*foo place arg**), the value of *function* applied to *place* and *args* will be stored into *place* and returned.

λlambda-list-keywords

▷ List of macro lambda list keywords. These are at least:

&whole *var*

▷ Bind *var* to the entire macro call form.

&optional *var**

▷ Bind *vars* to corresponding arguments if any.

{&rest|&body} *var*

▷ Bind *var* to a list of remaining arguments.

&key *var**

▷ Bind *vars* to corresponding keyword arguments.

&allow-other-keys

▷ Suppress keyword argument checking. Callers can do so using **:allow-other-keys T**.

&environment *var*

▷ Bind *var* to the lexical compilation environment.

&aux *var**

▷ Bind *vars* as in **slet***.

9.5 Control Flow

$$(\underline{s}\text{if } test \text{ then } [else_{\underline{NIL}}])$$

▷ Return values of *then* if *test* returns T; return values of *else* otherwise.

$$(\underline{m}\text{cond } (test \text{ then }^P_{\underline{NIL}})^*)$$

▷ Return the values of the first *then** whose *test* returns T; return NIL if all *tests* return NIL.

$$\left(\begin{array}{l} \underline{m}\text{when} \\ \underline{m}\text{unless} \end{array} \right) test \text{ foo}^P)$$

▷ Evaluate *foos* and return their values if *test* returns T or NIL, respectively. Return NIL otherwise.

$(_{m}\text{case } test \left(\left\{ \begin{array}{c} \widehat{key}^* \\ key \end{array} \right\} foo^{P^*} \right)^* \left[\left(\left\{ \begin{array}{c} \text{otherwise} \\ T \end{array} \right\} bar^{P^*} \right) \underline{NIL} \right])$

▷ Return the values of the first foo^* one of whose $keys$ is eq $test$. Return values of $bars$ if there is no matching key .

$\left(\begin{array}{c} \{_{m}\text{ecase} \\ \{_{m}\text{ccase} \end{array} \right\} test \left(\left\{ \begin{array}{c} \widehat{key}^* \\ key \end{array} \right\} foo^{P^*} \right)^*$

▷ Return the values of the first foo^* one of whose $keys$ is eq $test$. Signal non-correctable/correctable **type-error** if there is no matching key .

$(_{m}\text{and } form^* \underline{NIL})$

▷ Evaluate $forms$ from left to right. Immediately return \underline{NIL} if one $form$'s value is \underline{NIL} . Return values of last $form$ otherwise.

$(_{m}\text{or } form^* \underline{NIL})$

▷ Evaluate $forms$ from left to right. Immediately return primary value of first non- \underline{NIL} -evaluating form, or all values if last $form$ is reached. Return \underline{NIL} if no $form$ returns T .

$(_{s}\text{progn } form^* \underline{NIL})$

▷ Evaluate $forms$ sequentially. Return values of last $form$.

$(_{s}\text{multiple-value-prog1 } form\text{-}r \ form^*)$

$(_{m}\text{prog1 } form\text{-}r \ form^*)$

$(_{m}\text{prog2 } form\text{-}a \ form\text{-}r \ form^*)$

▷ Evaluate forms in order. Return values/primary value, respectively, of $form\text{-}r$.

$\left(\begin{array}{c} \{_{m}\text{prog} \\ \{_{m}\text{prog}^* \end{array} \right\} \left(\left\{ \begin{array}{c} name \\ (name \ [value_{\underline{NIL}}]) \end{array} \right\}^* \right) (\text{declare } \widehat{decl}^*)^* \left\{ \begin{array}{c} \widehat{tag} \\ form \end{array} \right\}^*$

▷ Evaluate $_{s}\text{tagbody}$ -like body with $names$ lexically bound (in parallel or sequentially, respectively) to $values$. Return \underline{NIL} or explicitly $_{m}\text{returned}$ values. Implicitly, the whole form is a $_{s}\text{block}$ named \underline{NIL} .

$(_{s}\text{unwind-protect } protected \ cleanup^*)$

▷ Evaluate $protected$ and then, no matter how control leaves $protected$, $cleanups$. Return values of $protected$.

$(_{s}\text{block } name \ form^{P^*})$

▷ Evaluate $forms$ in a lexical environment, and return their values unless interrupted by $_{s}\text{return-from}$.

$(_{s}\text{return-from } foo \ [result_{\underline{NIL}}])$

$(_{m}\text{return } [result_{\underline{NIL}}])$

▷ Have nearest enclosing $_{s}\text{block}$ named foo /named \underline{NIL} , respectively, return with values of $result$.

$(_{s}\text{tagbody } \{\widehat{tag} \mid form\}^*)$

▷ Evaluate $forms$ in a lexical environment. $tags$ (symbols or integers) have lexical scope and dynamic extent, and are targets for $_{s}\text{go}$. Return \underline{NIL} .

$(_{s}\text{go } \widehat{tag})$

▷ Within the innermost possible enclosing $_{s}\text{tagbody}$, jump to a tag $_{f}\text{eq}$ tag .

$(_{s}\text{catch } tag \ form^{P^*})$

▷ Evaluate $forms$ and return their values unless interrupted by $_{s}\text{throw}$.

$(_{s}\text{throw } tag \ form)$

▷ Have the nearest dynamically enclosing $_{s}\text{catch}$ with a tag $_{f}\text{eq}$ tag return with the values of $form$.

$(_{f}\text{sleep } n)$ ▷ Wait n seconds; return \underline{NIL} .

9.6 Iteration

$$\left\{ \begin{array}{l} \{m\text{do}\} \\ \{m\text{do}^*\} \end{array} \right\} \left(\left\{ \begin{array}{l} \{var\} \\ \{var [start [step]]\} \end{array} \right\}^* \right) (stop\ result^P) (\widehat{\text{declare}}\ \widehat{\text{decl}}^*)^* \left\{ \begin{array}{l} \{tag\} \\ \{form\} \end{array} \right\}^*$$

▷ Evaluate $\text{s}\text{tagbody}$ -like body with *vars* successively bound according to the values of the corresponding *start* and *step* forms. *vars* are bound in parallel/sequentially, respectively. Stop iteration when *stop* is T. Return values of *result**. Implicitly, the whole form is a sblock named NIL.

$$(m\text{dotimes}\ (var\ i\ [result_{\text{NIL}}])\ (\widehat{\text{declare}}\ \widehat{\text{decl}}^*)^*\ \{tag|form\}^*)$$

▷ Evaluate $\text{s}\text{tagbody}$ -like body with *var* successively bound to integers from 0 to *i* - 1. Upon evaluation of *result*, *var* is *i*. Implicitly, the whole form is a sblock named NIL.

$$(m\text{dolist}\ (var\ list\ [result_{\text{NIL}}])\ (\widehat{\text{declare}}\ \widehat{\text{decl}}^*)^*\ \{tag|form\}^*)$$

▷ Evaluate $\text{s}\text{tagbody}$ -like body with *var* successively bound to the elements of *list*. Upon evaluation of *result*, *var* is NIL. Implicitly, the whole form is a sblock named NIL.

9.7 Loop Facility

$$(m\text{loop}\ form^*)$$

▷ **Simple Loop.** If *forms* do not contain any atomic Loop Facility keywords, evaluate them forever in an implicit sblock named NIL.

$$(m\text{loop}\ clause^*)$$

▷ **Loop Facility.** For Loop Facility keywords see below and Figure 1.

named n_{NIL} ▷ Give $m\text{loop}$'s implicit sblock a name.

$$\{\text{with}\ \left\{ \begin{array}{l} \{var-s\} \\ \{(var-s^*)\} \end{array} \right\} [d\text{-type}] [= foo]\}^+ \\ \{\text{and}\ \left\{ \begin{array}{l} \{var-p\} \\ \{(var-p^*)\} \end{array} \right\} [d\text{-type}] [= bar]\}^*$$

where destructuring type specifier *d-type* has the form

$$\left\{ \begin{array}{l} \{\text{fixnum}|float|T|NIL|\} \\ \{\text{of-type}\ \left\{ \begin{array}{l} \{type\} \\ \{(type^*)\} \end{array} \right\} \} \end{array} \right\}$$

▷ Initialize (possibly trees of) local variables *var-s* sequentially and *var-p* in parallel.

$$\{\{\text{for|as}\ \left\{ \begin{array}{l} \{var-s\} \\ \{(var-s^*)\} \end{array} \right\} [d\text{-type}]\}^+ \{\text{and}\ \left\{ \begin{array}{l} \{var-p\} \\ \{(var-p^*)\} \end{array} \right\} [d\text{-type}]\}^*$$

▷ Begin of iteration control clauses. Initialize and step (possibly trees of) local variables *var-s* sequentially and *var-p* in parallel. Destructuring type specifier *d-type* as with **with**.

$\{\text{upfrom|from|downfrom}\} start$

▷ Start stepping with *start*

$\{\text{upto|downto|to|below|above}\} form$

▷ Specify *form* as the end value for stepping.

$\{\text{in|on}\} list$

▷ Bind *var* to successive elements/tails, respectively, of *list*.

by $\{step_{\text{1}}|function_{\text{#\text{cdr}}}\}$

▷ Specify the (positive) decrement or increment or the *function* of one argument returning the next part of the list.

$= foo\ \{\text{then}\ bar_{\text{foo}}\}$

▷ Bind *var* initially to *foo* and later to *bar*.

across *vector*

▷ Bind *var* to successive elements of *vector*.

being $\{\text{the|each}\}$

▷ Iterate over a hash table or a package.

$\{\text{hash-key|hash-keys}\} \{\text{of|in}\} hash\text{-table}\ [\text{using}\ (\text{hash-value}\ value)]$

▷ Bind *var* successively to the keys of *hash-table*; bind *value* to corresponding values.

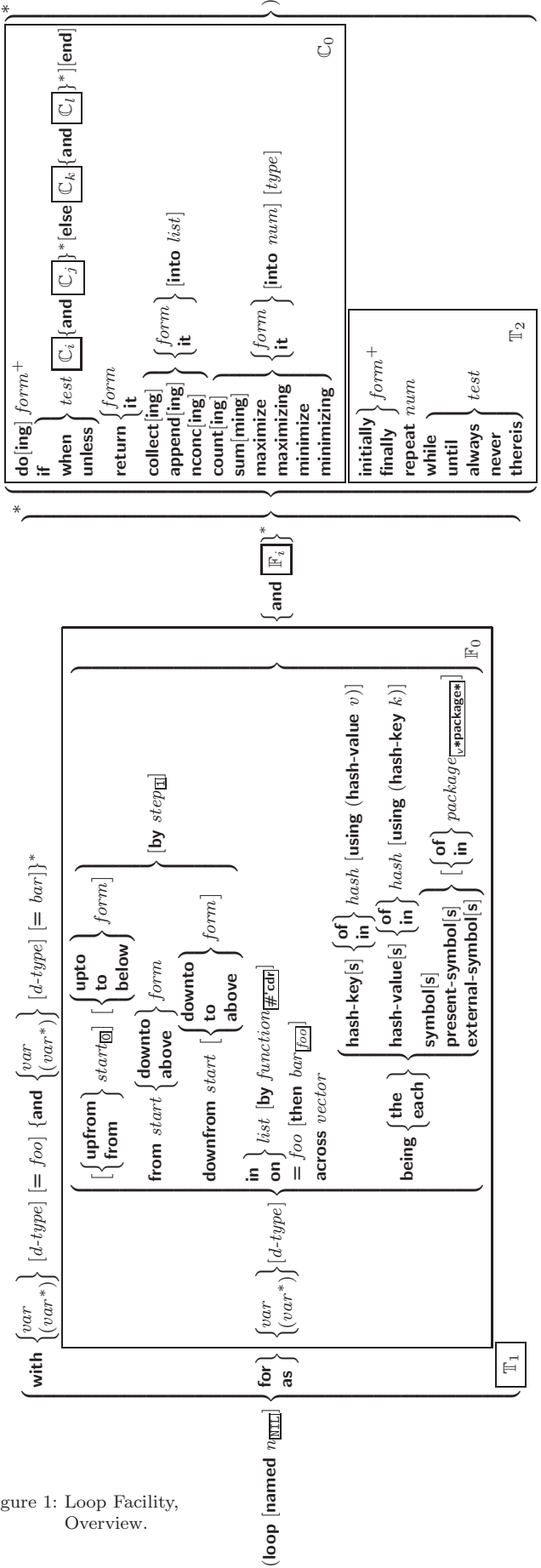


Figure 1: Loop Facility, Overview.

- {**hash-value|hash-values**} {**of|in**} *hash-table* [**using** (**hash-key** *key*)]
- ▷ Bind *var* successively to the values of *hash-table*; bind *key* to corresponding keys.
- {**symbol|symbols|present-symbol|present-symbols|external-symbol|external-symbols**} [{**of|in**} *package*_{*v*}***package***]
- ▷ Bind *var* successively to the accessible symbols, or the present symbols, or the external symbols respectively, of *package*.
- {**do|doing**} *form*⁺
- ▷ Evaluate *forms* in every iteration.
- {**if|when|unless**} *test* *i-clause* {**and** *j-clause*}* [**else** *k-clause* {**and** *l-clause*}*] [**end**]
- ▷ If *test* returns T, T, or NIL, respectively, evaluate *i-clause* and *j-clauses*; otherwise, evaluate *k-clause* and *l-clauses*.
- it** ▷ Inside *i-clause* or *k-clause*: value of *test*.
- return** {*form*|**it**}
- ▷ Return immediately, skipping any **finally** parts, with values of *form* or **it**.
- {**collect|collecting**} {*form*|**it**} [**into** *list*]
- ▷ Collect values of *form* or **it** into *list*. If no *list* is given, collect into an anonymous list which is returned after termination.
- {**append|appending|nconc|nconcing**} {*form*|**it**} [**into** *list*]
- ▷ Concatenate values of *form* or **it**, which should be lists, into *list* by the means of *f***append** or *f***nconc**, respectively. If no *list* is given, collect into an anonymous list which is returned after termination.
- {**count|counting**} {*form*|**it**} [**into** *n*] [*type*]
- ▷ Count the number of times the value of *form* or of **it** is T. If no *n* is given, count into an anonymous variable which is returned after termination.
- {**sum|summing**} {*form*|**it**} [**into** *sum*] [*type*]
- ▷ Calculate the sum of the primary values of *form* or of **it**. If no *sum* is given, sum into an anonymous variable which is returned after termination.
- {**maximize|maximizing|minimize|minimizing**} {*form*|**it**} [**into** *max-min*] [*type*]
- ▷ Determine the maximum or minimum, respectively, of the primary values of *form* or of **it**. If no *max-min* is given, use an anonymous variable which is returned after termination.
- {**initially|finally**} *form*⁺
- ▷ Evaluate *forms* before begin, or after end, respectively, of iterations.
- repeat** *num*
- ▷ Terminate *m***loop** after *num* iterations; *num* is evaluated once.
- {**while|until**} *test*
- ▷ Continue iteration until *test* returns NIL or T, respectively.
- {**always|never**} *test*
- ▷ Terminate *m***loop** returning NIL and skipping any **finally** parts as soon as *test* is NIL or T, respectively. Otherwise continue *m***loop** with its default return value set to T.
- thereis** *test*
- ▷ Terminate *m***loop** when *test* is T and return value of *test*, skipping any **finally** parts. Otherwise continue *m***loop** with its default return value set to NIL.
- (*m***loop-finish**)
- ▷ Terminate *m***loop** immediately executing any **finally** clauses and returning any accumulated results.

10 CLOS

10.1 Classes

(*f***slot-exists-p** *foo bar*) ▷ T if *foo* has a slot *bar*.

(*f*slot-boundp *instance slot*) ▷ T if *slot* in *instance* is bound.

(*m*defclass *foo* (*superclass** standard-object)
 (*slot* {
 {*reader* *reader*}*
 {*writer* {*writer*
 (*setf* *writer*)}}*
 {*accessor* *accessor*}*
 {*allocation* {*instance*
 {*class* }*instance*}* }
 {*initarg* [:]*initarg-name*}*
 initform *form*
 type *type*
 documentation *slot-doc*
 } }*)
 {
 (:*default-initargs* {*name value*}*)
 (:*documentation* *class-doc*)
 (:*metaclass* *name* standard-class)
 })

▷ Define or modify class *foo* as a subclass of *superclasses*. Transform existing instances, if any, by *g*make-instances-obsolete. In a new instance *i* of *foo*, a *slot*'s value defaults to *form* unless set via [:]*initarg-name*; it is readable via (*reader i*) or (*accessor i*), and writable via (*writer value i*) or (*setf (accessor i) value*). *slots* with **:allocation :class** are shared by all instances of class *foo*.

(*f*find-class *symbol* [*errorp*] [*environment*])
 ▷ Return class named *symbol*. **setfable**.

(*g*make-instance *class* {[:]*initarg value*}* *other-keyarg**)
 ▷ Make new instance of *class*.

(*g*reinitialize-instance *instance* {[:]*initarg value*}* *other-keyarg**)
 ▷ Change local slots of *instance* according to *initargs* by means of *g*shared-initialize.

(*f*slot-value *foo slot*) ▷ Return value of *slot* in *foo*. **setfable**.

(*f*slot-makunbound *instance slot*)
 ▷ Make *slot* in *instance* unbound.

{
 {*m*with-slots ({*slot* | (*var slot*)})* }
 {*m*with-accessors ((*var accessor*)*) } } *instance* (*declare decl*)*
*form**)
 ▷ Return values of *forms* after evaluating them in a lexical environment with slots of *instance* visible as **setfable slots** or *vars*/with *accessors* of *instance* visible as **setfable vars**.

(*g*class-name *class*)
 ((*setf* *g*class-name) *new-name class*) ▷ Get/set name of *class*.

(*f*class-of *foo*) ▷ Class *foo* is a direct instance of.

(*g*change-class *instance* *new-class* {[:]*initarg value*}* *other-keyarg**)
 ▷ Change class of *instance* to *new-class*. Retain the status of any slots that are common between *instance*'s original class and *new-class*. Initialize any newly added slots with the *values* of the corresponding *initargs* if any, or with the values of their **:initform** forms if not.

(*g*make-instances-obsolete *class*)
 ▷ Update all existing instances of *class* using *g*update-instance-for-redefined-class.

{
 {*g*initialize-instance *instance*
 {*g*update-instance-for-different-class *previous current*
 {[:]*initarg value*}* *other-keyarg**) }
 }
 ▷ Set slots on behalf of *g*make-instance/of *g*change-class by means of *g*shared-initialize.

(*g*update-instance-for-redefined-class *new-instance* *added-slots*
discarded-slots *discarded-slots-property-list*
 {[:]*initarg value*}* *other-keyarg**)
 ▷ On behalf of *g*make-instances-obsolete and by means of *g*shared-initialize, set any *initarg* slots to their corresponding *values*; set any remaining *added-slots* to the values of their **:initform** forms. Not to be called by user.

(**gallocate-instance** *class* {[:] *initarg value*}* *other-keyarg**)
 ▷ Return uninitialized instance of *class*. Called by *gmake-instance*.

(**gshared-initialize** *instance* $\left\{ \begin{array}{l} \textit{initform-slots} \\ \text{T} \end{array} \right\}$ {[:] *initarg-slot value*}*
*other-keyarg**)
 ▷ Fill the *initarg-slots* of *instance* with the corresponding *values*, and fill those *initform-slots* that are not *initarg-slots* with the values of their **:initform** forms.

(**gslot-missing** *class instance slot* $\left\{ \begin{array}{l} \text{setf} \\ \text{slot-boundp} \\ \text{slot-makunbound} \\ \text{slot-value} \end{array} \right\}$ [*value*])

(**gslot-unbound** *class instance slot*)
 ▷ Called on attempted access to non-existing or unbound *slot*. Default methods signal **error/unbound-slot**, respectively. Not to be called by user.

10.2 Generic Functions

(**fnext-method-p**) ▷ T if enclosing method has a next method.

(**mdefgeneric** $\left\{ \begin{array}{l} \textit{foo} \\ (\text{setf } \textit{foo}) \end{array} \right\}$ (*required-var** [**&optional** {*var*}*]
 [**&rest** *var*] [**&key** {*var* (*:key var*)}*] [**&allow-other-keys**]))
 $\left(\begin{array}{l} (:argument-precedence-order \textit{required-var}^+) \\ (\text{declare } (\text{optimize } \textit{method-selection-optimization})^+) \\ (:documentation \widehat{\textit{string}}) \\ (:generic-function-class \textit{gf-class} \text{standard-generic-function}) \\ (:method-class \textit{method-class} \text{standard-method}) \\ (:method-combination \textit{c-type} \text{standard } \textit{c-arg}^*) \\ (:method \textit{defmethod-args})^* \end{array} \right)$

▷ Define or modify generic function *foo*. Remove any methods previously defined by *defgeneric*. *gf-class* and the lambda parameters *required-var** and *var** must be compatible with existing methods. *defmethod-args* resemble those of *mdefmethod*. For *c-type* see section 10.3.

(**fensure-generic-function** $\left\{ \begin{array}{l} \textit{foo} \\ (\text{setf } \textit{foo}) \end{array} \right\}$
 $\left(\begin{array}{l} (:argument-precedence-order \textit{required-var}^+) \\ (\text{declare } (\text{optimize } \textit{method-selection-optimization}) \\ (:documentation \textit{string} \\ (:generic-function-class \textit{gf-class} \\ (:method-class \textit{method-class} \\ (:method-combination \textit{c-type} \textit{c-arg}^* \\ (:lambda-list \textit{lambda-list} \\ (:environment \textit{environment} \end{array} \right)$

▷ Define or modify generic function *foo*. *gf-class* and *lambda-list* must be compatible with a pre-existing generic function or with existing methods, respectively. Changes to *method-class* do not propagate to existing methods. For *c-type* see section 10.3.

(**mdefmethod** $\left\{ \begin{array}{l} \textit{foo} \\ (\text{setf } \textit{foo}) \end{array} \right\}$ [**:before**
:after
:around $\left\{ \begin{array}{l} \text{primary method} \\ \text{qualifier}^* \end{array} \right\}$]
 $\left(\begin{array}{l} \textit{var} \\ (\textit{spec-var} \left\{ \begin{array}{l} \textit{class} \\ (\text{eql } \textit{bar}) \end{array} \right\})^* \end{array} \right)$ [**&optional**
 $\left(\begin{array}{l} \textit{var} \\ (\textit{var} [\textit{init} [\textit{supplied-p}]])^* \end{array} \right)$ [**&rest** *var*] [**&key**
 $\left(\begin{array}{l} \textit{var} \\ (\textit{var} \left\{ \begin{array}{l} \textit{var} \\ (\textit{:key } \textit{var}) \end{array} \right\} [\textit{init} [\textit{supplied-p}]])^* \end{array} \right)$ [**&allow-other-keys**]
 [**&aux** $\left(\begin{array}{l} \textit{var} \\ (\textit{var} [\textit{init}])^* \end{array} \right)$] $\left(\begin{array}{l} (\text{declare } \widehat{\textit{decl}}^*)^* \\ \widehat{\textit{doc}} \end{array} \right)$ *form*^{P*})

▷ Define new method for generic function *foo*. *spec-vars* specialize to either being of *class* or being **eql** *bar*, respectively. On invocation, *vars* and *spec-vars* of the new method act like parameters of a function with body *form**. *forms* are enclosed in an implicit **block** *foo*. Applicable *qualifiers* depend on the **method-combination** type; see section 10.3.

$\left. \begin{array}{l} (g\text{add-method} \\ (g\text{remove-method}) \end{array} \right\} \text{generic-function method}$

▷ Add (if necessary) or remove (if any) *method* to/from generic-function.

$(g\text{find-method } \textit{generic-function} \textit{qualifiers} \textit{specializers} [\textit{error}\underline{\text{T}}])$

▷ Return suitable method, or signal **error**.

$(g\text{compute-applicable-methods } \textit{generic-function} \textit{args})$

▷ List of methods suitable for *args*, most specific first.

$(f\text{call-next-method } \textit{arg}^* \underline{\textit{current args}})$

▷ From within a method, call next method with *args*; return its values.

$(g\text{no-applicable-method } \textit{generic-function} \textit{arg}^*)$

▷ Called on invocation of *generic-function* on *args* if there is no applicable method. Default method signals **error**. Not to be called by user.

$\left. \begin{array}{l} (f\text{invalid-method-error } \textit{method}) \\ (f\text{method-combination-error}) \end{array} \right\} \textit{control arg}^*$

▷ Signal **error** on applicable method with invalid qualifiers, or on method combination. For *control* and *args* see **format**, page 36.

$(g\text{no-next-method } \textit{generic-function} \textit{method} \textit{arg}^*)$

▷ Called on invocation of **call-next-method** when there is no next method. Default method signals **error**. Not to be called by user.

$(g\text{function-keywords } \textit{method})$

▷ Return list of keyword parameters of *method* and $\frac{\text{T}}{2}$ if other keys are allowed.

$(g\text{method-qualifiers } \textit{method})$ ▷ List of qualifiers of *method*.

10.3 Method Combination Types

standard

▷ Evaluate most specific **:around** method supplying the values of the generic function. From within this method, **fcall-next-method** can call less specific **:around** methods if there are any. If not, or if there are no **:around** methods at all, call all **:before** methods, most specific first, and the most specific primary method which supplies the values of the calling **fcall-next-method** if any, or of the generic function; and which can call less specific primary methods via **fcall-next-method**. After its return, call all **:after** methods, least specific first.

and|or|append|list|nconc|progn|max|min|+

▷ Simple built-in **method-combination** types; have the same usage as the *c-types* defined by the short form of **mdefine-method-combination**.

$(m\text{define-method-combination } \textit{c-type}$
 $\left. \begin{array}{l} \left\{ \begin{array}{l} \text{:documentation } \widehat{\textit{string}} \\ \text{:identity-with-one-argument } \textit{bool}\underline{\text{NIL}} \\ \text{:operator } \textit{operator}\underline{\textit{c-type}} \end{array} \right\} \end{array} \right\})$

▷ **Short Form.** Define new **method-combination** *c-type*. In a generic function using *c-type*, evaluate most specific **:around** method supplying the values of the generic function. From within this method, *f***call-next-method** can call less specific **:around** methods if there are any. If not, or if there are no **:around** methods at all, return from the calling **call-next-method** or from the generic function, respectively, the values of (*operator* (*primary-method* *gen-arg**)*), *gen-arg** being the arguments of the generic function. The *primary-methods* are ordered $\left[\begin{array}{l} \text{:most-specific-first} \\ \text{:most-specific-last} \end{array} \right] \boxed{\text{:most-specific-first}}$ (specified as *c-arg* in *mdefgeneric*). Using *c-type* as the *qualifier* in *mdefmethod* makes the method primary.

(*mdefine-method-combination* *c-type* (*ord-λ**) ((*group* $\left. \begin{array}{l} * \\ (\text{qualifier}^* \text{ [*]}) \\ \text{predicate} \end{array} \right\} \left. \begin{array}{l} \text{:description } \textit{control} \\ \text{:order } \left\{ \begin{array}{l} \text{:most-specific-first} \\ \text{:most-specific-last} \end{array} \right\} \boxed{\text{:most-specific-first}} \end{array} \right\}^*) \left. \begin{array}{l} (\text{:arguments } \textit{method-combination-λ}^*) \\ (\text{:generic-function } \textit{symbol}) \end{array} \right\} \textit{body}^{\mathbb{P}^*}) \left. \begin{array}{l} (\text{declare } \widehat{\text{decl}}^*)^* \\ \widehat{\text{doc}} \end{array} \right\}$

▷ **Long Form.** Define new **method-combination** *c-type*. A call to a generic function using *c-type* will be equivalent to a call to the forms returned by *body** with *ord-λ** bound to *c-arg** (cf. *mdefgeneric*), with *symbol* bound to the generic function, with *method-combination-λ** bound to the arguments of the generic function, and with *groups* bound to lists of methods. An applicable method becomes a member of the left-most *group* whose *predicate* or *qualifiers* match. Methods can be called via *mcall-method*. Lambda lists (*ord-λ**) and (*method-combination-λ**) according to *ord-λ* on page 17, the latter enhanced by an optional **&whole** argument.

(*mcall-method* $\left. \begin{array}{l} \widehat{\text{method}} \\ (\text{mmake-method } \widehat{\text{form}}) \end{array} \right\} \left[\left(\left. \begin{array}{l} \widehat{\text{next-method}} \\ (\text{mmake-method } \widehat{\text{form}}) \end{array} \right\}^* \right) \right]$

▷ From within an effective method form, call *method* with the arguments of the generic function and with information about its *next-methods*; return its values.

11 Conditions and Errors

For standardized condition types cf. Figure 2 on page 31.

(*mdefine-condition* *foo* (*parent-type** $\boxed{\text{condition}}$) $\left. \begin{array}{l} \textit{slot} \\ \left(\textit{slot} \left. \begin{array}{l} \text{:reader } \textit{reader}^* \\ \text{:writer } \left\{ \begin{array}{l} \textit{writer} \\ (\text{setf } \textit{writer}) \end{array} \right\}^* \\ \text{:accessor } \textit{accessor}^* \\ \text{:allocation } \left\{ \begin{array}{l} \text{:instance} \\ \text{:class} \end{array} \right\} \boxed{\text{:instance}} \\ \text{:initarg } [:\textit{initarg-name}]^* \\ \text{:initform } \textit{form} \\ \text{:type } \textit{type} \\ \text{:documentation } \textit{slot-doc} \end{array} \right\} \end{array} \right)^* \left. \begin{array}{l} (\text{:default-initargs } \{ \textit{name value} \}^*) \\ (\text{:documentation } \textit{condition-doc}) \\ (\text{:report } \left\{ \begin{array}{l} \textit{string} \\ \textit{report-function} \end{array} \right\}) \end{array} \right\}$

▷ Define, as a subtype of *parent-types*, condition type *foo*. In a new condition, a *slot*'s value defaults to *form* unless set via *[:initarg-name]*; it is readable via (*reader i*) or (*accessor i*), and writable via (*writer value i*) or (**setf** (*accessor i*) *value*). With **:allocation :class**, *slot* is shared by all conditions of type *foo*. A condition is reported by *string* or by *report-function* of arguments condition and stream.

(*f* **make-condition** *condition-type* {[:]*initarg-name value*}*)

▷ Return new instance of *condition-type*.

$\left. \begin{matrix} \{f \text{signal}\} \\ \{f \text{warn}\} \\ \{f \text{error}\} \end{matrix} \right\} \left\{ \begin{matrix} \text{condition} \\ \text{condition-type } \{[:]\text{initarg-name value}\}^* \\ \text{control arg}^* \end{matrix} \right\}$

▷ Unless handled, signal as **condition**, **warning** or **error**, respectively, *condition* or a new instance of *condition-type* or, with *f* **format** *control* and *args* (see page 36), **simple-condition**, **simple-warning**, or **simple-error**, respectively. From *f* **signal** and *f* **warn**, return NIL.

(*f* **error** *continue-control*

$\left\{ \begin{matrix} \text{condition } \text{continue-arg}^* \\ \text{condition-type } \{[:]\text{initarg-name value}\}^* \\ \text{control arg}^* \end{matrix} \right\}$)

▷ Unless handled, signal as correctable **error** *condition* or a new instance of *condition-type* or, with *f* **format** *control* and *args* (see page 36), **simple-error**. In the debugger, use *f* **format** arguments *continue-control* and *continue-args* to tag the continue option. Return NIL.

(*m* **ignore-errors** *form*^{P*})

▷ Return values of *forms* or, in case of **errors**, NIL and the condition.

(*f* **invoke-debugger** *condition*)

▷ Invoke debugger with *condition*.

(*m* **assert** *test* [(*place**)

$\left[\left\{ \begin{matrix} \text{condition } \text{continue-arg}^* \\ \text{condition-type } \{[:]\text{initarg-name value}\}^* \\ \text{control arg}^* \end{matrix} \right\} \right]$)

▷ If *test*, which may depend on *places*, returns NIL, signal as correctable **error** *condition* or a new instance of *condition-type* or, with *f* **format** *control* and *args* (see page 36), **error**. When using the debugger's continue option, *places* can be altered before re-evaluation of *test*. Return NIL.

(*m* **handler-case** *foo* (*type* ([*var*]) (**declare** $\widehat{\text{decl}}^*$)* *condition-form*^{P*})*
[:**no-error** (*ord-λ**) (**declare** $\widehat{\text{decl}}^*$)* *form*^{P*}]])

▷ If, on evaluation of *foo*, a condition of *type* is signalled, evaluate matching *condition-forms* with *var* bound to the condition, and return their values. Without a condition, bind *ord-λ*s to values of *foo* and return values of *forms* or, without a **:no-error** clause, return values of *foo*. See page 17 for (*ord-λ**)

(*m* **handler-bind** ((*condition-type* *handler-function*)*) *form*^{P*})

▷ Return values of *forms* after evaluating them with *condition-types* dynamically bound to their respective *handler-functions* of argument condition.

(*m* **with-simple-restart** ($\left\{ \begin{matrix} \text{restart} \\ \text{NIL} \end{matrix} \right\}$ *control arg**) *form*^{P*})

▷ Return values of *forms* unless *restart* is called during their evaluation. In this case, describe *restart* using *f* **format** *control* and *args* (see page 36) and return NIL and T.

(*m* **restart-case** *form* (*restart* (*ord-λ**) $\left\{ \begin{matrix} \text{:interactive } \text{arg-function} \\ \text{:report } \left\{ \begin{matrix} \text{report-function} \\ \text{string}^{\text{"restart"}} \end{matrix} \right\} \\ \text{:test } \text{test-function}^{\square} \end{matrix} \right\}$)

(**declare** $\widehat{\text{decl}}^*$)* *restart-form*^{P*}*)
▷ Return values of *form* or, if during evaluation of *form* one of the dynamically established *restarts* is called, the values of its *restart-forms*. A *restart* is visible under *condition* if (**funcall** **#'***test-function* *condition*) returns T. If presented in the debugger, *restarts* are described by *string* or by **#'***report-function* (of a stream). A *restart* can be called by (**invoke-restart** *restart* *arg**), where *args* match *ord-λ**, or by (**invoke-restart-interactively** *restart*) where a list of the respective *args* is supplied by **#'***arg-function*. See page 17 for *ord-λ**

- (*m*restart-bind (($\widehat{\text{restart}}$ _{NIL}) restart-function
 {
 :**interactive-function** arg-function
 :**report-function** report-function
 :**test-function** test-function
 }*) form^{P*})
 ▷ Return values of forms evaluated with dynamically established *restarts* whose *restart-functions* should perform a non-local transfer of control. A restart is visible under *condition* if (*test-function condition*) returns T. If presented in the debugger, *restarts* are described by *restart-function* (of a stream). A *restart* can be called by (**invoke-restart** restart arg*), where *args* must be suitable for the corresponding *restart-function*, or by (**invoke-restart-interactively** restart) where a list of the respective *args* is supplied by *arg-function*.
- (*f*invoke-restart restart arg*)
 (*f*invoke-restart-interactively restart)
 ▷ Call function associated with *restart* with arguments given or prompted for, respectively. If *restart* function returns, return its values.
- {
*f*find-restart
*f*compute-restarts name } [condition]
 ▷ Return innermost restart name, or a list of all restarts, respectively, out of those either associated with *condition* or un-associated at all; or, without *condition*, out of all restarts. Return NIL if search is unsuccessful.
- (*f*restart-name restart) ▷ Name of restart.
- {
*f*abort
*f*muffle-warning
*f*continue
*f*store-value value
*f*use-value value } [condition_{NIL}]
 ▷ Transfer control to innermost applicable restart with same name (i.e. **abort**, ..., **continue** ...) out of those either associated with *condition* or un-associated at all; or, without *condition*, out of all restarts. If no restart is found, signal **control-error** for *f*abort and *f*muffle-warning, or return NIL for the rest.
- (*m*with-condition-restarts condition restarts form^{P*})
 ▷ Evaluate *forms* with *restarts* dynamically associated with *condition*. Return values of forms.
- (*f*arithmetic-error-operation condition)
 (*f*arithmetic-error-operands condition)
 ▷ List of function or of its operands respectively, used in the operation which caused *condition*.
- (*f*cell-error-name condition)
 ▷ Name of cell which caused *condition*.
- (*f*unbound-slot-instance condition)
 ▷ Instance with unbound slot which caused *condition*.
- (*f*print-not-readable-object condition)
 ▷ The object not readably printable under *condition*.
- (*f*package-error-package condition)
 (*f*file-error-pathname condition)
 (*f*stream-error-stream condition)
 ▷ Package, path, or stream, respectively, which caused the *condition* of indicated type.
- (*f*type-error-datum condition)
 (*f*type-error-expected-type condition)
 ▷ Object which caused *condition* of type **type-error**, or its expected type, respectively.
- (*f*simple-condition-format-control condition)
 (*f*simple-condition-format-arguments condition)
 ▷ Return fformat control or list of fformat arguments, respectively, of *condition*.
- √*break-on-signals*_{NIL}
 ▷ Condition type debugger is to be invoked on.

v*debugger-hook*_{NIL}

▷ Function of condition and function itself. Called before debugger.

12 Types and Classes

For any class, there is always a corresponding type of the same name.

(**f**typep *foo type* [*environment*_{NIL}]) ▷ T if *foo* is of *type*.

(**f**subtypep *type-a type-b* [*environment*])

▷ Return T if *type-a* is a recognizable subtype of *type-b*, and NIL if the relationship could not be determined.

(**s**the *type form*) ▷ Declare values of form to be of *type*.

(**f**coerce *object type*) ▷ Coerce object into *type*.

(**m**typecase *foo* (*type a-form*^P)* [(otherwise T) *b-form*_{NIL}^P])

▷ Return values of the first a-form* whose *type* is *foo* of. Return values of b-forms if no *type* matches.

(etyp *foo* (*type form*^P)*)

▷ Return values of the first form* whose *type* is *foo* of. Signal non-correctable/correctable **type-error** if no *type* matches.

(**f**type-of *foo*) ▷ Type of foo.

(**m**check-type *place type* [*string*_{{a an} type}])

▷ Signal correctable **type-error** if *place* is not of *type*. Return NIL.

(**f**stream-element-type *stream*) ▷ Type of *stream* objects.

(**f**array-element-type *array*) ▷ Element type *array* can hold.

(**f**upgraded-array-element-type *type* [*environment*_{NIL}])

▷ Element type of most specialized array capable of holding elements of *type*.

(**m**deftype *foo* (*macro-λ**) $\left\{ \left(\frac{\text{declare } \widehat{decl}^*}{\widehat{doc}} \right)^* \right\}$ *form*^P)

▷ Define type *foo* which when referenced as (*foo* *arg*^{*}) (or as *foo* if *macro-λ* doesn't contain any required parameters) applies expanded *forms* to *args* returning the new type. For (*macro-λ**) see page 18 but with default value of * instead of NIL. *forms* are enclosed in an implicit **sblock** named *foo*.

(**eql** *foo*)

(**member** *foo**) ▷ Specifier for a type comprising *foo* or *foos*.

(**satisfies** *predicate*)

▷ Type specifier for all objects satisfying *predicate*.

(**mod** *n*) ▷ Type specifier for all non-negative integers < *n*.

(**not** *type*) ▷ Complement of *type*.

(**and** *type*^{*}_□) ▷ Type specifier for intersection of *types*.

(**or** *type*^{*}_{NIL}) ▷ Type specifier for union of *types*.

(**values** *type*^{*} [**&optional** *type*^{*} [**&rest** *other-args*]])

▷ Type specifier for multiple values.

* ▷ As a type argument (cf. Figure 2): no restriction.

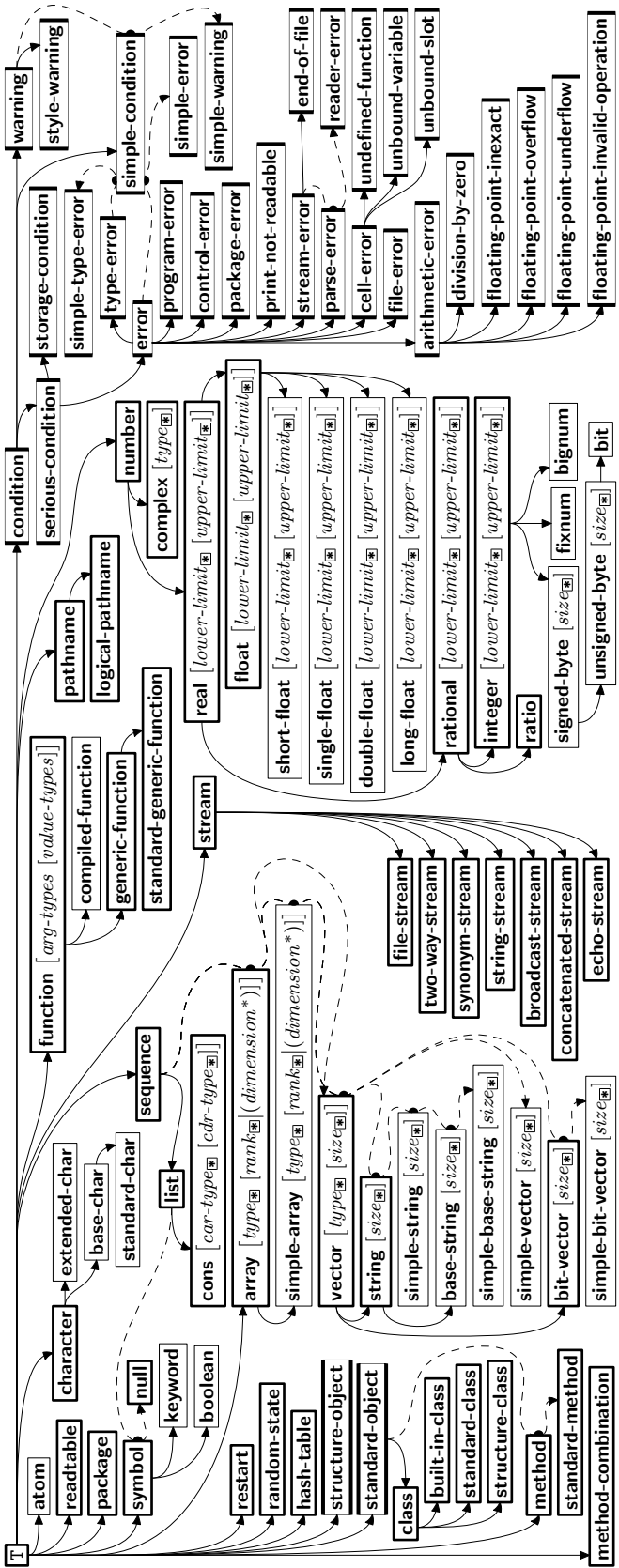


Figure 2: Precedence Order of System Classes (□), Classes (▢), Types (▨), and Condition Types (▤).

Every type is also a supertype of NIL, the empty type.

13 Input/Output

13.1 Predicates

(*f* **streamp** *foo*)

(*f* **pathnamep** *foo*) ▷ T if *foo* is of indicated type.

(*f* **readablep** *foo*)

(*f* **input-stream-p** *stream*)

(*f* **output-stream-p** *stream*)

(*f* **interactive-stream-p** *stream*)

(*f* **open-stream-p** *stream*)

▷ Return T if *stream* is for input, for output, interactive, or open, respectively.

(*f* **pathname-match-p** *path wildcard*)

▷ T if *path* matches *wildcard*.

(*f* **wild-pathname-p** *path* [{:**host**[:**device**[:**directory**]:**name**]:**type**]:**version**][NIL]})

▷ Return T if indicated component in *path* is wildcard. (NIL indicates any component.)

13.2 Reader

(*f* **y-or-n-p** } [*control arg**])

▷ Ask user a question and return T or NIL depending on their answer. See page 36, *f* **format**, for *control* and *args*.

(*m* **with-standard-io-syntax** *form^P**)

▷ Evaluate *forms* with standard behaviour of reader and printer. Return values of forms.

(*f* **read** } [*stream* v*standard-input* [*eof-err* T [*eof-val* NIL [*recursive* NIL]]]])

▷ Read printed representation of object.

(*f* **read-from-string** *string* [*eof-error* T [*eof-val* NIL

[{:**start** *start* T :**end** *end* NIL :**preserve-whitespace** *bool* NIL }]]])

▷ Return object read from string and zero-indexed position of next character.

(*f* **read-delimited-list** *char* [*stream* v*standard-input* [*recursive* NIL]])

▷ Continue reading until encountering *char*. Return list of objects read. Signal error if no *char* is found in stream.

(*f* **read-char** [*stream* v*standard-input* [*eof-err* T [*eof-val* NIL [*recursive* NIL]]]])

▷ Return next character from *stream*.

(*f* **read-char-no-hang** [*stream* v*standard-input* [*eof-error* T [*eof-val* NIL [*recursive* NIL]]]])

▷ Next character from *stream* or NIL if none is available.

(*f* **peek-char** [*mode* NIL [*stream* v*standard-input* [*eof-error* T [*eof-val* NIL [*recursive* NIL]]]])

▷ Next, or if *mode* is T, next non-whitespace character, or if *mode* is a character, next instance of it, from *stream* without removing it there.

(*f* **unread-char** *character* [*stream* v*standard-input*])

▷ Put last *f* **read-char**ed *character* back into *stream*; return NIL.

(*f* **read-byte** [*stream* [*eof-err* T [*eof-val* NIL]]])

▷ Read next byte from binary *stream*.

(*f* **read-line** [*stream* v*standard-input* [*eof-err* T [*eof-val* NIL [*recursive* NIL]]]])

▷ Return a line of text from *stream* and T if line has been ended by end of file.

- (*f* **read-sequence** *sequence stream* [:start *start*₀] [:end *end*_{NIL}])
 ▷ Replace elements of *sequence* between *start* and *end* with elements from binary or character *stream*. Return index of *sequence*'s first unmodified element.
- (*f* **readtable-case** *readtable*)upcase
 ▷ Case sensitivity attribute (one of **:upcase**, **:downcase**, **:preserve**, **:invert**) of *readtable*. **setfable**.
- (*f* **copy-readtable** [*from-readtable* v*readtable*] [*to-readtable* NIL])
 ▷ Return copy of from-readtable.
- (*f* **set-syntax-from-char** *to-char from-char* [*to-readtable* v*readtable*] [*from-readtable* standard-readtable])
 ▷ Copy syntax of *from-char* to *to-readtable*. Return T.
- v*readtable*** ▷ Current readtable.
- v*read-base***₁₀ ▷ Radix for reading **integers** and **ratios**.
- v*read-default-float-format***single-float
 ▷ Floating point format to use when not indicated in the number read.
- v*read-suppress***NIL
 ▷ If T, reader is syntactically more tolerant.
- (*f* **set-macro-character** *char function* [*non-term-p* NIL] [*rt* v*readtable*])
 ▷ Make *char* a macro character associated with *function* of stream and *char*. Return T.
- (*f* **get-macro-character** *char* [*rt* v*readtable*])
 ▷ Reader macro function associated with *char*, and T if *char* is a non-terminating macro character.
- (*f* **make-dispatch-macro-character** *char* [*non-term-p* NIL] [*rt* v*readtable*])
 ▷ Make *char* a dispatching macro character. Return T.
- (*f* **set-dispatch-macro-character** *char sub-char function* [*rt* v*readtable*])
 ▷ Make *function* of stream, *n*, *sub-char* a dispatch function of *char* followed by *n*, followed by *sub-char*. Return T.
- (*f* **get-dispatch-macro-character** *char sub-char* [*rt* v*readtable*])
 ▷ Dispatch function associated with *char* followed by *sub-char*.

13.3 Character Syntax

#| *multi-line-comment** **|#**

; *one-line-comment**

▷ Comments. There are stylistic conventions:

- ;;;** *title* ▷ Short title for a block of code.
;;; *intro* ▷ Description before a block of code.
;; *state* ▷ State of program or of following code.
; *explanation* ▷ Regarding line on which it appears.
; *continuation*

(*foo** [*bar* NIL]) ▷ List of *foos* with the terminating cdr *bar*.

" ▷ Begin and end of a string.

'foo ▷ (**squote** *foo*); *foo* unevaluated.

` ([*foo*] [*bar*] [**@***baz*] [*quux*] [*bing*])

▷ Backquote. **squote** *foo* and *bing*; evaluate *bar* and splice the lists *baz* and *quux* into their elements. When nested, outermost commas inside the innermost backquote expression belong to this backquote.

#\c ▷ (**fcharacter** "c"), the character *c*.

#Bn; **#On**; *n*.; **#Xn**; **#rRn**

▷ Integer of radix 2, 8, 10, 16, or *r*; $2 \leq r \leq 36$.

- n/d ▷ The **ratio** $\frac{n}{d}$.
- $\{[m].n[\{\mathbf{S|F|D|L|E}\}x_{\underline{\mathbb{E}}}]|m[.n][\{\mathbf{S|F|D|L|E}\}x]\}$
 ▷ $m.n \cdot 10^x$ as **short-float**, **single-float**, **double-float**, **long-float**, or the type from ***read-default-float-format***.
- #C**($a\ b$) ▷ ($_f$ **complex** $a\ b$), the complex number $a + bi$.
- #'** foo ▷ ($_s$ **function** foo); the function named foo .
- #nA** $sequence$ ▷ n -dimensional array.
- #**[n](foo^*)
 ▷ Vector of some (or n) $foos$ filled with last foo if necessary.
- #**[n]* b^*
 ▷ Bit vector of some (or n) bs filled with last b if necessary.
- #S**($type\ \{\text{slot value}\}^*$) ▷ Structure of $type$.
- #P** $string$ ▷ A pathname.
- #:** foo ▷ Uninterned symbol foo .
- #.** $form$ ▷ Read-time value of $form$.
- ν ***read-eval*** \square ▷ If NIL, a **reader-error** is signalled at **#.**
- #integer=** foo ▷ Give foo the label $integer$.
- #integer#** ▷ Object labelled $integer$.
- #<** ▷ Have the reader signal **reader-error**.
- #+feature when-feature**
#-feature unless-feature
 ▷ Means *when-feature* if *feature* is T; means *unless-feature* if *feature* is NIL. *feature* is a symbol from ν ***features***, or (**{and |or}** $feature^*$), or (**not** $feature$).
- ν ***features***
 ▷ List of symbols denoting implementation-dependent features.
- $|c^*|; \backslash c$
 ▷ Treat arbitrary character(s) c as alphabetic preserving case.

13.4 Printer

- $\left\{ \begin{array}{l} \mathit{f}\mathbf{prin1} \\ \mathit{f}\mathbf{print} \\ \mathit{f}\mathbf{pprint} \\ \mathit{f}\mathbf{princ} \end{array} \right\} foo\ [\widetilde{stream}_{\nu\mathbf{*standard-output*}}]$
 ▷ Print foo to $stream$ f **readably**, f **readably** between a newline and a space, f **readably** after a newline, or human-readably without any extra characters, respectively. $\mathit{f}\mathbf{prin1}$, $\mathit{f}\mathbf{print}$ and $\mathit{f}\mathbf{princ}$ return foo .
- ($\mathit{f}\mathbf{prin1-to-string}\ foo$)
 ($\mathit{f}\mathbf{princ-to-string}\ foo$)
 ▷ Print foo to string f **readably** or human-readably, respectively.
- ($\mathit{g}\mathbf{print-object}\ object\ \widetilde{stream}$)
 ▷ Print object to $stream$. Called by the Lisp printer.
- ($\mathit{m}\mathbf{print-unreadable-object}\ (foo\ \widetilde{stream}\ \left\{ \begin{array}{l} \mathbf{:type}\ bool_{\underline{NIL}} \\ \mathbf{:identity}\ bool_{\underline{NIL}} \end{array} \right\})\ form^P$)
 ▷ Enclosed in **#<** and **>**, print foo by means of $forms$ to $stream$. Return NIL.
- ($\mathit{f}\mathbf{terpri}\ [\widetilde{stream}_{\nu\mathbf{*standard-output*}}]$)
 ▷ Output a newline to $stream$. Return NIL.
- ($\mathit{f}\mathbf{fresh-line}\ [\widetilde{stream}_{\nu\mathbf{*standard-output*}}]$)
 ▷ Output a newline to $stream$ and return T unless $stream$ is already at the start of a line.

(**fwrite-char** *char* [*stream* v*standard-output*])

▷ Output *char* to *stream*.

(**fwrite-string** / **fwrite-line**) *string* [*stream* v*standard-output* [**:start** *start*₀]]])

▷ Write *string* to *stream* without/with a trailing newline.

(**fwrite-byte** *byte* *stream*)

▷ Write *byte* to binary *stream*.

(**fwrite-sequence** *sequence* *stream* [**:start** *start*₀]]])

▷ Write elements of *sequence* to binary or character *stream*.

(**fwrite** / **fwrite-to-string**) *foo* {

- :array** *bool*
- :base** *radix*
- :case** {
 :upcase
 :downcase
 :capitalize
- :circle** *bool*
- :escape** *bool*
- :gensym** *bool*
- :length** {*int*|*NIL*}
- :level** {*int*|*NIL*}
- :lines** {*int*|*NIL*}
- :miser-width** {*int*|*NIL*}
- :pprint-dispatch** *dispatch-table*
- :pretty** *bool*
- :radix** *bool*
- :readably** *bool*
- :right-margin** {*int*|*NIL*}
- :stream** *stream* v*standard-output*

▷ Print *foo* to *stream* and return *foo*, or print *foo* into *string*, respectively, after dynamically setting printer variables corresponding to keyword parameters (***print-bar*** becoming **:bar**). (**:stream** keyword with **fwrite** only.)

(**fpprint-fill** *stream* *foo* [*parenthesis*_m [*noop*]])

(**fpprint-tabular** *stream* *foo* [*parenthesis*_m [*noop* [*n*_g]])])

(**fpprint-linear** *stream* *foo* [*parenthesis*_m [*noop*]])

▷ Print *foo* to *stream*. If *foo* is a list, print as many elements per line as possible; do the same in a table with a column width of *n* ems; or print either all elements on one line or each on its own line, respectively. Return *NIL*. Usable with **fformat** directive *~//*.

(**mpprint-logical-block** (*stream* *list* {
 :prefix *string*
 :per-line-prefix *string*
 :suffix *string*_m}))

(**declare** *decl*^{*})^{*} *form*^P^{*})

▷ Evaluate *forms*, which should print *list*, with *stream* locally bound to a pretty printing stream which outputs to the original *stream*. If *list* is in fact not a list, it is printed by **fwrite**. Return *NIL*.

(**mpprint-pop**)

▷ Take next element off *list*. If there is no remaining tail of *list*, or **v*print-length*** or **v*print-circle*** indicate printing should end, send element together with an appropriate indicator to *stream*.

(**fpprint-tab** {
 :line
 :line-relative
 :section
 :section-relative}) *c* *i* [*stream* v*standard-output*])

▷ Move cursor forward to column number $c + ki$, $k \geq 0$ being as small as possible.

(**fpprint-indent** {
 :block
 :current}) *n* [*stream* v*standard-output*])

▷ Specify indentation for innermost logical block relative to leftmost position/to current position. Return *NIL*.

(**mpprint-exit-if-list-exhausted**)

▷ If *list* is empty, terminate logical block. Return *NIL* otherwise.

(*f*pprint-newline $\left. \begin{array}{l} \text{:linear} \\ \text{:fill} \\ \text{:miser} \\ \text{:mandatory} \end{array} \right\} [\widehat{stream} \underline{v}*\text{standard-output}*])$

▷ Print a conditional newline if *stream* is a pretty printing stream. Return NIL.

*v**print-array* ▷ If T, print arrays *f*readably.

*v**print-base*10 ▷ Radix for printing rationals, from 2 to 36.

*v**print-case*upcase

▷ Print symbol names all uppercase (:upcase), all lowercase (:downcase), capitalized (:capitalize).

*v**print-circle*NIL

▷ If T, avoid indefinite recursion while printing circular structure.

*v**print-escape*T

▷ If NIL, do not print escape characters and package prefixes.

*v**print-gensym*T ▷ If T, print #: before uninterned symbols.

*v**print-length*NIL

*v**print-level*NIL

*v**print-lines*NIL

▷ If integer, restrict printing of objects to that number of elements per level/to that depth/to that number of lines.

*v**print-miser-width*

▷ If integer and greater than the width available for printing a substructure, switch to the more compact miser style.

*v**print-pretty* ▷ If T, print prettily.

*v**print-radix*NIL ▷ If T, print rationals with a radix indicator.

*v**print-readably*NIL

▷ If T, print *f*readably or signal error **print-not-readable**.

*v**print-right-margin*NIL

▷ Right margin width in ems while pretty-printing.

(*f*set-pprint-dispatch *type function* [*priority*]

[*table* *v**print-pprint-dispatch*])

▷ Install entry comprising *function* of arguments *stream* and object to print; and *priority* as *type* into *table*. If *function* is NIL, remove *type* from *table*. Return NIL.

(*f*pprint-dispatch *foo* [*table* *v**print-pprint-dispatch*])

▷ Return highest priority *function* associated with type of *foo* and T if there was a matching type specifier in *table*.

(*f*copy-pprint-dispatch [*table* *v**print-pprint-dispatch*])

▷ Return copy of *table* or, if *table* is NIL, initial value of *v**print-pprint-dispatch*.

*v**print-pprint-dispatch* ▷ Current pretty print dispatch table.

13.5 Format

(*m*formatter $\widehat{control}$)

▷ Return function of *stream* and *arg** applying *f*format to *stream*, *control*, and *arg** returning NIL or any excess *args*.

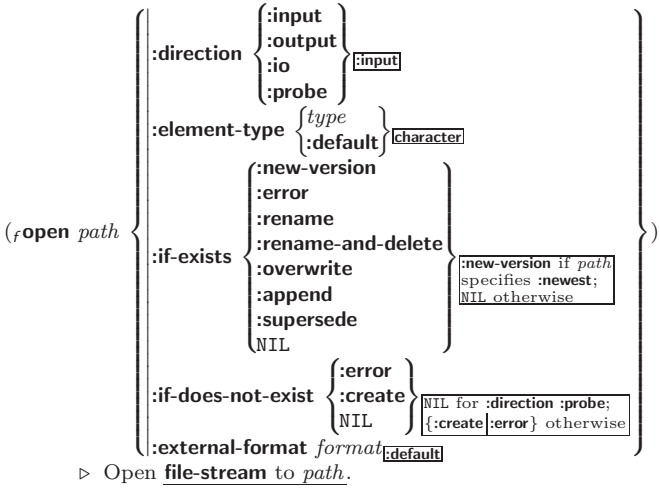
(*f*format {T|NIL|*out-string*|*out-stream*} *control arg**)

▷ Output string *control* which may contain ~ directives possibly taking some *args*. Alternatively, *control* can be a function returned by *m*formatter which is then applied to *out-stream* and *arg**. Output to *out-string*, *out-stream* or, if first argument is T, to *v**standard-output*. Return NIL. If first argument is NIL, return formatted output.

- ~ [*min-col*_□] [, [*col-inc*_□] [, [*min-pad*_□] [, '*pad-char*_■]]] [:] [Ⓞ] {**A**|**S**}
- ▷ **Aesthetic/Standard**. Print argument of any type for consumption by humans/by the reader, respectively. With :, print NIL as () rather than nil; with Ⓞ, add *pad-chars* on the left rather than on the right.
- ~ [*radix*_□] [, [*width*] [, [*pad-char*_■] [, [*comma-char*_□] [, [*comma-interval*_□]]]]] [:] [Ⓞ] **R**
- ▷ **Radix**. (With one or more prefix arguments.) Print argument as number; with :, group digits *comma-interval* each; with Ⓞ, always prepend a sign.
- {~**R**|~:**R**|~Ⓞ**R**|~Ⓞ:**R**}
- ▷ **Roman**. Take argument as number and print it as English cardinal number, as English ordinal number, as Roman numeral, or as old Roman numeral, respectively.
- ~ [*width*] [, [*pad-char*_■] [, [*comma-char*_□] [, [*comma-interval*_□]]]] [:] [Ⓞ] {**D**|**B**|**O**|**X**}
- ▷ **Decimal/Binary/Octal/Hexadecimal**. Print integer argument as number. With :, group digits *comma-interval* each; with Ⓞ, always prepend a sign.
- ~ [*width*] [, [*dec-digits*] [, [*shift*_□] [, [*overflow-char*] [, [*pad-char*_■]]]]] [Ⓞ] **F**
- ▷ **Fixed-Format Floating-Point**. With Ⓞ, always prepend a sign.
- ~ [*width*] [, [*dec-digits*] [, [*exp-digits*] [, [*scale-factor*_□] [, [*overflow-char*] [, [*pad-char*_■] [, [*exp-char*]]]]]]] [Ⓞ] {**E**|**G**}
- ▷ **Exponential/General Floating-Point**. Print argument as floating-point number with *dec-digits* after decimal point and *exp-digits* in the signed exponent. With ~**G**, choose either ~**E** or ~**F**. With Ⓞ, always prepend a sign.
- ~ [*dec-digits*_□] [, [*int-digits*_□] [, [*width*_□] [, [*pad-char*_■]]]] [:] [Ⓞ] **S**
- ▷ **Monetary Floating-Point**. Print argument as fixed-format floating-point number. With :, put sign before any padding; with Ⓞ, always prepend a sign.
- {~**C**|~:**C**|~Ⓞ**C**|~Ⓞ:**C**}
- ▷ **Character**. Print, spell out, print in #\ syntax, or tell how to type, respectively, argument as (possibly non-printing) character.
- {~(*text* ~)|~:(*text* ~)|~Ⓞ(*text* ~)|~Ⓞ:(*text* ~)}
- ▷ **Case-Conversion**. Convert *text* to lowercase, convert first letter of each word to uppercase, capitalize first word and convert the rest to lowercase, or convert to uppercase, respectively.
- {~**P**|~:**P**|~Ⓞ**P**|~Ⓞ:**P**}
- ▷ **Plural**. If argument **eq1** print nothing, otherwise print **s**; do the same for the previous argument; if argument **eq2** print **y**, otherwise print **ies**; do the same for the previous argument, respectively.
- ~ [*n*_□] % ▷ **Newline**. Print *n* newlines.
- ~ [*n*_□] &
- ▷ **Fresh-Line**. Print *n* – 1 newlines if output stream is at the beginning of a line, or *n* newlines otherwise.
- {~_|~:~|~Ⓞ_|~Ⓞ:~}
- ▷ **Conditional Newline**. Print a newline like **pprint-newline** with argument **:linear**, **:fill**, **:miser**, or **:mandatory**, respectively.
- {~:~<|~Ⓞ<|~<~}
- ▷ **Ignored Newline**. Ignore newline, or whitespace following newline, or both, respectively.
- ~ [*n*_□] | ▷ **Page**. Print *n* page separators.
- ~ [*n*_□] ~ ▷ **Tilde**. Print *n* tildes.
- ~ [*min-col*_□] [, [*col-inc*_□] [, [*min-pad*_□] [, [*pad-char*_■]]]] [:] [Ⓞ] < [*nl-text* ~[*spare*_□ [, *width*]]:] {*text* ~;}* *text* ~>
- ▷ **Justification**. Justify text produced by *texts* in a field of at least *min-col* columns. With :, right justify; with Ⓞ, left justify. If this would leave less than *spare* characters on the current line, output *nl-text* first.

- ~ [:] [C] < { [prefix_m ~:] [per-line-prefix ~C:] } body [~;
 suffix_m] ~: [C] >
 ▷ **Logical Block.** Act like **pprint-logical-block** using *body* as *f***format** control string on the elements of the list argument or, with **C**, on the remaining arguments, which are extracted by **pprint-pop**. With **:**, *prefix* and *suffix* default to (and). When closed by ~C:>, spaces in *body* are replaced with conditional newlines.
- {~ [n_C] i|~ [n_C] :i}
 ▷ **Indent.** Set indentation to *n* relative to leftmost/to current position.
- ~ [c_C] [,i_C] [:] [C] T
 ▷ **Tabulate.** Move cursor forward to column number $c + ki$, $k \geq 0$ being as small as possible. With **:**, calculate column numbers relative to the immediately enclosing section. With **C**, move to column number $c_0 + c + ki$ where c_0 is the current position.
- {~ [m_C] *|~ [m_C] :*|~ [n_C] C*}
 ▷ **Go-To.** Jump *m* arguments forward, or backward, or to argument *n*.
- ~ [limit] [:] [C] { text ~}
 ▷ **Iteration.** Use *text* repeatedly, up to *limit*, as control string for the elements of the list argument or (with **C**) for the remaining arguments. With **:** or **C:**, list elements or remaining arguments should be lists of which a new one is used at each iteration step.
- ~ [x [,y [,z]]] ^
 ▷ **Escape Upward.** Leave immediately ~< ~>, ~< ~:>, ~{ ~}, ~?, or the entire *f***format** operation. With one to three prefixes, act only if $x = 0$, $x = y$, or $x \leq y \leq z$, respectively.
- ~ [i] [:] [C] [[{text ~;} * text] [~:: default] ~]
 ▷ **Conditional Expression.** Use the zero-indexed argument (or *i*th if given) *text* as a *f***format** control subclass. With **:**, use the first *text* if the argument value is NIL, or the second *text* if it is T. With **C**, do nothing for an argument value of NIL. Use the only *text* and leave the argument to be read again if it is T.
- {~?|~C?}
 ▷ **Recursive Processing.** Process two arguments as control string and argument list, or take one argument as control string and use then the rest of the original arguments.
- ~ [prefix {,prefix}*] [:] [C] / [package [:] :cl-user] function/
 ▷ **Call Function.** Call all-uppercase *package::function* with the arguments stream, format-argument, colon-p, at-sign-p and *prefixes* for printing format-argument.
- ~ [:] [C] W
 ▷ **Write.** Print argument of any type obeying every printer control variable. With **:**, pretty-print. With **C**, print without limits on length or depth.
- {V|#}
 ▷ In place of the comma-separated prefix parameters: use next argument or number of remaining unprocessed arguments, respectively.

13.6 Streams



(*f* **make-concatenated-stream** *input-stream**)

(*f* **make-broadcast-stream** *output-stream**)

(*f* **make-two-way-stream** *input-stream-part* *output-stream-part*)

(*f* **make-echo-stream** *from-input-stream* *to-output-stream*)

(*f* **make-synonym-stream** *variable-bound-to-stream*)

▷ Return stream of indicated type.

(*f* **make-string-input-stream** *string* [*start* 0] [*end* NIL])

▷ Return a string-stream supplying the characters from *string*.

(*f* **make-string-output-stream** [:element-type *type* :character])

▷ Return a string-stream accepting characters (available via *f* **get-output-stream-string**).

(*f* **concatenated-stream-streams** *concatenated-stream*)

(*f* **broadcast-stream-streams** *broadcast-stream*)

▷ Return list of streams *concatenated-stream* still has to read from/*broadcast-stream* is broadcasting to.

(*f* **two-way-stream-input-stream** *two-way-stream*)

(*f* **two-way-stream-output-stream** *two-way-stream*)

(*f* **echo-stream-input-stream** *echo-stream*)

(*f* **echo-stream-output-stream** *echo-stream*)

▷ Return source stream or sink stream of *two-way-stream*/*echo-stream*, respectively.

(*f* **synonym-stream-symbol** *synonym-stream*)

▷ Return symbol of *synonym-stream*.

(*f* **get-output-stream-string** *string-stream*)

▷ Clear and return as a string characters on *string-stream*.

(*f* **file-position** *stream* [{ :start
:end
:position }])

▷ Return position within *stream*, or set it to position and return T on success.

(*f* **file-string-length** *stream* *foo*)

▷ Length *foo* would have in *stream*.

(*f* **listen** [*stream* v*standard-input*])

▷ T if there is a character in input *stream*.

(*f* **clear-input** [*stream* v*standard-input*])

▷ Clear input from *stream*, return NIL.

{
 f **clear-output**
 f **force-output**
 f **finish-output**
}

[*stream* v*standard-output*])

▷ End output to *stream* and return NIL immediately, after initiating flushing of buffers, or after flushing of buffers, respectively.

(*f*close *stream* [:abort *bool*_{NIL}])
 ▷ Close *stream*. Return **T** if *stream* had been open. If **:abort** is T, delete associated file.

(*m*with-open-file (*stream path open-arg**) (declare *decl**)* *form*^{P*})
 ▷ Use *f*open with *open-args* to temporarily create *stream* to *path*; return values of forms.

(*m*with-open-stream (*foo stream*) (declare *decl**)* *form*^{P*})
 ▷ Evaluate *forms* with *foo* locally bound to *stream*. Return values of forms.

(*m*with-input-from-string (*foo string* { :index *index*
 :start *start*₀
 :end *end*_{NIL} }) (declare
*decl**)* *form*^{P*})
 ▷ Evaluate *forms* with *foo* locally bound to input **string-stream** from *string*. Return values of forms; store next reading position into *index*.

(*m*with-output-to-string (*foo* [*string*_{NIL} [:element-type *type*_{character}]])
 (declare *decl**)* *form*^{P*})
 ▷ Evaluate *forms* with *foo* locally bound to an output **string-stream**. Append output to *string* and return values of forms if *string* is given. Return string containing output otherwise.

(*f*stream-external-format *stream*)
 ▷ External file format designator.

terminal-io ▷ Bidirectional stream to user terminal.

standard-input

standard-output

error-output

▷ Standard input stream, standard output stream, or standard error output stream, respectively.

debug-io

query-io

▷ Bidirectional streams for debugging and user interaction.

13.7 Pathnames and Files

(*f*make-pathname
 { :host {*host*|NIL|:unspecific}
 :device {*device*|NIL|:unspecific}
 :directory { {*directory*|:wild|NIL|:unspecific}
 { :absolute {*directory*}*
 :relative { :wild
 :wild-inferiors
 :up
 :back } } })
 :name {*file-name*|:wild|NIL|:unspecific}
 :type {*file-type*|:wild|NIL|:unspecific}
 :version { :newest |*version*|:wild|NIL|:unspecific }
 :defaults *path*_{host from *v**default-pathname-defaults*}
 :case { :local | :common }_{:local} })

▷ Construct a logical pathname if there is a logical pathname translation for *host*, otherwise construct a physical pathname. For **:case :local**, leave case of components unchanged. For **:case :common**, leave mixed-case components unchanged; convert all-uppercase components into local customary case; do the opposite with all-lowercase components.

{ *f*pathname-host
*f*pathname-device
*f*pathname-directory
*f*pathname-name
*f*pathname-type } *path-or-stream* [:case { :local
 :common }_{:local}]

(*f*pathname-version *path-or-stream*)

▷ Return pathname component.

- (**f** **parse-namestring** *foo* [*host* [*default-pathname* **v****default-pathname-defaults** {**:start** *start*₀ **:end** *end*_{NIL} **:junk-allowed** *bool*_{NIL}}]])
- ▷ Return pathname converted from string, pathname, or stream *foo*; and position where parsing stopped.
- (**f** **merge-pathnames** *path-or-stream* [*default-path-or-stream* **v****default-pathname-defaults** [*default-version* **.newest**]])
- ▷ Return pathname made by filling in components missing in *path-or-stream* from *default-path-or-stream*.
- v****default-pathname-defaults**
- ▷ Pathname to use if one is needed and none supplied.
- (**f** **user-homedir-pathname** [*host*]) ▷ User's home directory.
- (**f** **enough-namestring** *path-or-stream* [*root-path* **v****default-pathname-defaults**])
- ▷ Return minimal path string that sufficiently describes the path of *path-or-stream* relative to *root-path*.
- (**f** **namestring** *path-or-stream*)
f **file-namestring** *path-or-stream*)
f **directory-namestring** *path-or-stream*)
f **host-namestring** *path-or-stream*)
- ▷ Return string representing full pathname; name, type, and version; directory name; or host name, respectively, of *path-or-stream*.
- (**f** **translate-pathname** *path-or-stream* *wildcard-path-a* *wildcard-path-b*)
- ▷ Translate the path of *path-or-stream* from *wildcard-path-a* into *wildcard-path-b*. Return new path.
- (**f** **pathname** *path-or-stream*) ▷ Pathname of *path-or-stream*.
- (**f** **logical-pathname** *logical-path-or-stream*)
- ▷ Logical pathname of *logical-path-or-stream*. Logical pathnames are represented as all-uppercase "[*host* :] [;] { { *dir* | * }⁺ } ; } * { *name* | * } * [. { { *type* | * }⁺ }] [. { *version* | * | **newest** | **NEWEST** }]]".
- (**f** **logical-pathname-translations** *logical-host*)
- ▷ List of (from-wildcard to-wildcard) translations for *logical-host*. **setfable**.
- (**f** **load-logical-pathname-translations** *logical-host*)
- ▷ Load *logical-host*'s translations. Return **NIL** if already loaded; return **T** if successful.
- (**f** **translate-logical-pathname** *path-or-stream*)
- ▷ Physical pathname corresponding to (possibly logical) pathname of *path-or-stream*.
- (**f** **probe-file** *file*)
f **truename** *file*)
- ▷ Canonical name of *file*. If *file* does not exist, return **NIL**/signal **file-error**, respectively.
- (**f** **file-write-date** *file*) ▷ Time at which *file* was last written.
- (**f** **file-author** *file*) ▷ Return name of file owner.
- (**f** **file-length** *stream*) ▷ Return length of stream.
- (**f** **rename-file** *foo* *bar*)
- ▷ Rename file *foo* to *bar*. Unspecified components of path *bar* default to those of *foo*. Return new pathname, old physical file name, and new physical file name.
- (**f** **delete-file** *file*) ▷ Delete *file*. Return **T**.
- (**f** **directory** *path*) ▷ List of pathnames matching *path*.
- (**f** **ensure-directories-exist** *path* [**:verbose** *bool*])
- ▷ Create parts of path if necessary. Second return value is **T** if something has been created.

14 Packages and Symbols

The Loop Facility provides additional means of symbol handling; see `loop`, page 21.

14.1 Predicates

(*f*symbolp *foo*)
 (*f*packagep *foo*) ▷ T if *foo* is of indicated type.
 (*f*keywordp *foo*)

14.2 Packages

:*bar*|keyword:*bar* ▷ Keyword, evaluates to :*bar*.

package:*symbol* ▷ Exported *symbol* of *package*.

package::*symbol* ▷ Possibly unexported *symbol* of *package*.

(*m*defpackage *foo* {
 (:nicknames *nick**)*
 (:documentation *string*)
 (:intern *interned-symbol**)*
 (:use *used-package**)*
 (:import-from *pkg* *imported-symbol**)*
 (:shadowing-import-from *pkg* *shd-symbol**)*
 (:shadow *shd-symbol**)*
 (:export *exported-symbol**)*
 (:size *int*)
 })

▷ Create or modify package *foo* with *interned-symbols*, symbols from *used-packages*, *imported-symbols*, and *shd-symbols*. Add *shd-symbols* to *foo*'s shadowing list.

(*f*make-package *foo* {
 (:nicknames (*nick**)[NIL])
 (:use (*used-package**)*)
 })

▷ Create package *foo*.

(*f*rename-package *package* *new-name* [*new-nicknames*[NIL]])

▷ Rename *package*. Return renamed package.

(*m*in-package *foo*) ▷ Make package *foo* current.

{
 (*f*use-package)
 (*f*unuse-package)
 } *other-packages* [*package*[*v**package*]]

▷ Make exported symbols of *other-packages* available in *package*, or remove them from *package*, respectively. Return T.

(*f*package-use-list *package*)

(*f*package-used-by-list *package*)

▷ List of other packages used by/using *package*.

(*f*delete-package *package*)

▷ Delete *package*. Return T if successful.

*v**package*[common-lisp-user] ▷ The current package.

(*f*list-all-packages) ▷ List of registered packages.

(*f*package-name *package*) ▷ Name of *package*.

(*f*package-nicknames *package*) ▷ Nicknames of *package*.

(*f*find-package *name*) ▷ Package with *name* (case-sensitive).

(*f*find-all-symbols *foo*)

▷ List of symbols *foo* from all registered packages.

{
 (*f*intern)
 (*f*find-symbol)
 } *foo* [*package*[*v**package*]]

▷ Intern or find, respectively, symbol *foo* in *package*. Second return value is one of *internal*, *external*, or *inherited* (or *NIL* if *f*intern has created a fresh symbol).

(*f*unintern *symbol* [*package*[*v**package*]])

▷ Remove *symbol* from *package*, return T on success.

- $\left\{ \begin{array}{l} \text{import} \\ \text{shadowing-import} \end{array} \right\} symbols [package_{v*package*}]$
- ▷ Make *symbols* internal to *package*. Return T. In case of a name conflict signal correctable **package-error** or shadow the old symbol, respectively.
- $(\text{shadow } symbols [package_{v*package*}])$
- ▷ Make *symbols* of *package* shadow any otherwise accessible, equally named symbols from other packages. Return T.
- $(\text{package-shadowing-symbols } package)$
- ▷ List of symbols of *package* that shadow any otherwise accessible, equally named symbols from other packages.
- $(\text{export } symbols [package_{v*package*}])$
- ▷ Make *symbols* external to *package*. Return T.
- $(\text{unexport } symbols [package_{v*package*}])$
- ▷ Revert *symbols* to internal status. Return T.
- $\left\{ \begin{array}{l} \text{do-symbols} \\ \text{do-external-symbols} \\ \text{do-all-symbols} \end{array} \right\} (\widehat{var} [package_{v*package*} [result_{NIL}]])$
- $(\text{declare } \widehat{decl}^*)^* \left\{ \begin{array}{l} \widehat{tag} \\ \widehat{form} \end{array} \right\}^*$
- ▷ Evaluate \widehat{s} **tagbody**-like body with *var* successively bound to every symbol from *package*, to every external symbol from *package*, or to every symbol from all registered packages, respectively. Return values of result. Implicitly, the whole form is a \widehat{s} **block** named NIL.
- $(\text{mwith-package-iterator } (foo \text{ packages } [:internal|:external|:inherited]) (\text{declare } \widehat{decl}^*)^* \text{ form}^*)$
- ▷ Return values of forms. In *forms*, successive invocations of (*foo*) return: T if a symbol is returned; a symbol from *packages*; accessibility (**:internal**, **:external**, or **:inherited**); and the package the symbol belongs to.
- $(\text{require } module [paths_{NIL}])$
- ▷ If not in $v*modules*$, try *paths* to load *module* from. Signal **error** if unsuccessful. Deprecated.
- $(\text{provide } module)$
- ▷ If not already there, add *module* to $v*modules*$. Deprecated.
- $v*modules*$ ▷ List of names of loaded modules.

14.3 Symbols

A **symbol** has the attributes *name*, home **package**, property list, and optionally value (of global constant or variable *name*) and function (**function**, macro, or special operator *name*).

- $(\text{make-symbol } name)$
- ▷ Make fresh, uninterned symbol name.
- $(\text{gensym } [s_{\square}])$
- ▷ Return fresh, uninterned symbol #:sn with *n* from $v*gensym-counter*$. Increment $v*gensym-counter*$.
- $(\text{gentemp } [prefix_{\square} [package_{v*package*}]])$
- ▷ Intern fresh symbol in package. Deprecated.
- $(\text{copy-symbol } symbol [props_{NIL}])$
- ▷ Return uninterned copy of *symbol*. If *props* is T, give copy the same value, function and property list.
- $(\text{symbol-name } symbol)$
- $(\text{symbol-package } symbol)$
- ▷ Name or package, respectively, of *symbol*.
- $(\text{symbol-plist } symbol)$
- $(\text{symbol-value } symbol)$
- $(\text{symbol-function } symbol)$
- ▷ Property list, value, or function, respectively, of *symbol*. **setfable**.

$(\{g \text{documentation}\} (\text{setf } g \text{documentation}) \text{new-doc}) \text{foo} \left\{ \begin{array}{l} \text{'variable} | \text{'function} \\ \text{'compiler-macro} \\ \text{'method-combination} \\ \text{'structure} | \text{'type} | \text{'setf} | \text{T} \end{array} \right\}$

▷ Get/set documentation string of *foo* of given type.

ct

▷ Truth; the supertype of every type including **t**; the superclass of every class except **t**; v ***terminal-io***.

cnil_c()

▷ Falsity; the empty list; the empty type, subtype of every type; v ***standard-input***; v ***standard-output***; the global environment.

14.4 Standard Packages

common-lisp_{cl}

▷ Exports the defined names of Common Lisp except for those in the **keyword** package.

common-lisp-user_{cl-user}

▷ Current package after startup; uses package **common-lisp**.

keyword

▷ Contains symbols which are defined to be of type **keyword**.

15 Compiler

15.1 Predicates

$(f \text{special-operator-p } foo)$ ▷ T if *foo* is a special operator.

$(f \text{compiled-function-p } foo)$

▷ T if *foo* is of type **compiled-function**.

15.2 Compilation

$(f \text{compile } \left\{ \begin{array}{l} \text{NIL } \text{definition} \\ \left\{ \begin{array}{l} \text{name} \\ (\text{setf } \text{name}) \end{array} \right\} [\text{definition}] \end{array} \right\})$

▷ Return compiled function or replace *name*'s function definition with the compiled function. Return T in case of **warnings** or **errors**, and T in case of **warnings** or **errors** excluding **style-warnings**.

$(f \text{compile-file } \text{file} \left\{ \begin{array}{l} \text{:output-file } \text{out-path} \\ \text{:verbose } \text{bool}_{v* \text{compile-verbose} *} \\ \text{:print } \text{bool}_{v* \text{compile-print} *} \\ \text{:external-format } \text{file-format}_{\text{:default}} \end{array} \right\})$

▷ Write compiled contents of *file* to *out-path*. Return true output path or NIL, T in case of **warnings** or **errors**, T in case of **warnings** or **errors** excluding **style-warnings**.

$(f \text{compile-file-pathname } \text{file} [\text{:output-file } \text{path}] [\text{other-keyargs}])$

▷ Pathname *f compile-file* writes to if invoked with the same arguments.

$(f \text{load } \text{path} \left\{ \begin{array}{l} \text{:verbose } \text{bool}_{v* \text{load-verbose} *} \\ \text{:print } \text{bool}_{v* \text{load-print} *} \\ \text{:if-does-not-exist } \text{bool}_{\text{NIL}} \\ \text{:external-format } \text{file-format}_{\text{:default}} \end{array} \right\})$

▷ Load source file or compiled file into Lisp environment. Return T if successful.

$v* \text{compile-file} \left\{ \begin{array}{l} \text{pathname} *_{\text{NIL}} \\ \text{truename} *_{\text{NIL}} \end{array} \right\}$

▷ Input file used by *f compile-file*/by *f load*.

$v* \text{compile} \left\{ \begin{array}{l} \text{print} * \\ \text{verbose} * \end{array} \right\}$

▷ Defaults used by *f compile-file*/by *f load*.

(*s*eval-when ({ { :compile-toplevel | compile }
 { :load-toplevel | load }
 { :execute | eval } }) *form*^{P*})

▷ Return values of forms if *s*eval-when is in the top-level of a file being compiled, in the top-level of a compiled file being loaded, or anywhere, respectively. Return NIL if *forms* are not evaluated. (**compile**, **load** and **eval** deprecated.)

(*s*locally (declare *decl*^{*})* *form*^{P*})

▷ Evaluate *forms* in a lexical environment with declarations *decl* in effect. Return values of forms.

(*m*with-compilation-unit ([:override *bool*_{NIL}]) *form*^{P*})

▷ Return values of forms. Warnings deferred by the compiler until end of compilation are deferred until the end of evaluation of *forms*.

(*s*load-time-value *form* [*read-only*_{NIL}])

▷ Evaluate *form* at compile time and treat its value as literal at run time.

(*s*quote *foo*) ▷ Return unevaluated foo.

(*g*make-load-form *foo* [*environment*])

▷ Its methods are to return a creation form which on evaluation at *f*load time returns an object equivalent to foo, and an optional initialization form which on evaluation performs some initialization² of the object.

(*f*make-load-form-saving-slots *foo* { :slot-names *slots*_[all local slots]
 :environment *environment* })

▷ Return a creation form and an initialization form which on evaluation construct an object equivalent to *foo* with *slots* initialized with the corresponding values from *foo*.

(*f*macro-function *symbol* [*environment*])

(*f*compiler-macro-function { *name*
 (setf *name*) } [*environment*])

▷ Return specified macro function, or compiler macro function, respectively, if any. Return NIL otherwise. **setfable**.

(*f*eval *arg*)

▷ Return values of value of arg evaluated in global environment.

15.3 REPL and Debugging

v+ | *v*++ | *v*+++

*v** | *v*** | *v****

v/ | *v*// | *v*///

▷ Last, penultimate, or antepenultimate form evaluated in the REPL, or their respective primary value, or a list of their respective values.

v- ▷ Form currently being evaluated by the REPL.

(*f*apropos *string* [*package*_{NIL}])

▷ Print interned symbols containing *string*.

(*f*apropos-list *string* [*package*_{NIL}])

▷ List of interned symbols containing *string*.

(*f*dribble [*path*])

▷ Save a record of interactive session to file at *path*. Without *path*, close that file.

(*f*ed [*file-or-function*_{NIL}])

▷ Invoke editor if possible.

({ *f*macroexpand-1 }
 { *f*macroexpand }) *form* [*environment*_{NIL}])

▷ Return macro expansion, once or entirely, respectively, of *form* and T if *form* was a macro form. Return form and NIL otherwise.²

*v**macroexpand-hook*

▷ Function of arguments expansion function, macro form, and environment called by *f*macroexpand-1 to generate macro expansions.

- (*mtrace* $\left\{ \begin{array}{l} \text{function} \\ \text{(setf function)} \end{array} \right\}^*$)
 ▷ Cause *functions* to be traced. With no arguments, return list of traced functions.
- (*muntrace* $\left\{ \begin{array}{l} \text{function} \\ \text{(setf function)} \end{array} \right\}^*$)
 ▷ Stop *functions*, or each currently traced function, from being traced.
- v*trace-output**
 ▷ Output stream *mtrace* and *mtime* send their output to.
- (*mstep* *form*)
 ▷ Step through evaluation of *form*. Return values of form.
- (*fbreak* [*control arg**])
 ▷ Jump directly into debugger; return NIL. See page 36, *fformat*, for *control* and *args*.
- (*mtime* *form*)
 ▷ Evaluate *forms* and print timing information to *v*trace-output**. Return values of form.
- (*finspect* *foo*) ▷ Interactively give information about *foo*.
- (*fdescribe* *foo* [*stream* *v*standard-output**])
 ▷ Send information about *foo* to *stream*.
- (*gdescribe-object* *foo* [*stream*])
 ▷ Send information about *foo* to *stream*. Called by *fdescribe*.
- (*fdisassemble* *function*)
 ▷ Send disassembled representation of *function* to *v*standard-output**. Return NIL.
- (*froom* [*{NIL|:default|T|:default}*])
 ▷ Print information about internal storage management to **standard-output**.

15.4 Declarations

- (*fproclaim* *decl*)
 (*mdeclaim* \widehat{decl}^*)
 ▷ Globally make declaration(s) *decl*. *decl* can be: **declaration**, **type**, **ftype**, **inline**, **notinline**, **optimize**, or **special**. See below.
- (*declare* \widehat{decl}^*)
 ▷ Inside certain forms, locally make declarations *decl**. *decl* can be: **dynamic-extent**, **type**, **ftype**, **ignorable**, **ignore**, **inline**, **notinline**, **optimize**, or **special**. See below.
- (**declaration** *foo**)
 ▷ Make *foos* names of declarations.
- (**dynamic-extent** *variable** (**function** *function*)*)
 ▷ Declare lifetime of *variables* and/or *functions* to end when control leaves enclosing block.
- (**[type]** *type variable**)
 (**ftype** *type function**)
 ▷ Declare *variables* or *functions* to be of *type*.
- ($\left\{ \begin{array}{l} \text{ignorable} \\ \text{ignore} \end{array} \right\} \left\{ \begin{array}{l} \text{var} \\ \text{(function function)} \end{array} \right\}^*$)
 ▷ Suppress warnings about used/unused bindings.
- (**inline** *function**)
 (**notinline** *function**)
 ▷ Tell compiler to integrate/not to integrate, respectively, called *functions* into the calling routine.
- (**optimize** $\left\{ \begin{array}{l} \text{compilation-speed} | (\text{compilation-speed } n_{\text{3}}) \\ \text{debug} | (\text{debug } n_{\text{3}}) \\ \text{safety} | (\text{safety } n_{\text{3}}) \\ \text{space} | (\text{space } n_{\text{3}}) \\ \text{speed} | (\text{speed } n_{\text{3}}) \end{array} \right\}$)
 ▷ Tell compiler how to optimize. *n* = 0 means unimportant, *n* = 1 is neutral, *n* = 3 means important.
- (**special** *var**) ▷ Declare *vars* to be dynamic.

16 External Environment

(*f*get-internal-real-time)

(*f*get-internal-run-time)

▷ Current time, or computing time, respectively, in clock ticks.

*c*internal-time-units-per-second

▷ Number of clock ticks per second.

(*f*encode-universal-time *sec min hour date month year* [*zone*curr])

(*f*get-universal-time)

▷ Seconds from 1900-01-01, 00:00, ignoring leap seconds.

(*f*decode-universal-time *universal-time* [*time-zone*current])

(*f*get-decoded-time)

▷ Return second, minute, hour, date, month, year, day, daylight-p, and zone.

(*f*short-site-name)

(*f*long-site-name)

▷ String representing physical location of computer.

(*f*lisp-implementation) {*f*software
*f*machine} - {*type*
version}

▷ Name or version of implementation, operating system, or hardware, respectively.

(*f*machine-instance)

▷ Computer name.

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- LEAST-POSITIVE-
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