Quick Reference

Common lisp

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Typographic Conventions

name; $_f$**name**; $_g$**name**; $_m$**name**; $_s$**name**; $_v$***name***; $_c$**name**
▷ Symbol defined in Common Lisp; esp. function, generic function, macro, special operator, variable, constant.

them ▷ Placeholder for actual code.

`me` ▷ Literal text.

[*foo*`bar`] ▷ Either one *foo* or nothing; defaults to `bar`.

foo*; {*foo*}* ▷ Zero or more *foo*s.

foo$^+$; {*foo*}$^+$ ▷ One or more *foo*s.

foos ▷ English plural denotes a list argument.

{*foo* | *bar* | *baz*}; $\begin{cases} foo \\ bar \\ baz \end{cases}$ ▷ Either *foo*, or *bar*, or *baz*.

$\left\{\middle|\begin{matrix} foo \\ bar \\ baz \end{matrix}\right.$ ▷ Anything from none to each of *foo*, *bar*, and *baz*.

$\widehat{foo}$ ▷ Argument *foo* is not evaluated.

$\widetilde{bar}$ ▷ Argument *bar* is possibly modified.

foo^{P*} ▷ *foo** is evaluated as in $_s$**progn**; see page 21.

$\underline{foo}$; $\underline{\underline{bar}}$; $\underline{\underline{\underline{baz}}}$ ▷ Primary, secondary, and nth return value.

`T`; `NIL` ▷ **t**, or truth in general; and **nil** or **()**.

1 Numbers

1.1 Predicates

($_f$= $number^+$)
($_f$/= $number^+$)
▷ T if all *number*s, or none, respectively, are equal in value.

($_f$> $number^+$)
($_f$>= $number^+$)
($_f$< $number^+$)
($_f$<= $number^+$)
▷ Return T if *number*s 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

($_f$+ $a_{[0]}^*$)
($_f$* $a_{[1]}^*$)
▷ Return $\sum a$ or $\prod a$, respectively.

($_f$− a b^*)
($_f$/ a b^*)
▷ Return $a - \sum b$ or $a / \prod b$, respectively. Without any bs, return $-a$ or $1/a$, respectively.

($_f$**1+** a)
($_f$**1−** a)
▷ Return $a + 1$ or $a - 1$, respectively.

($\left\{{}_m\textbf{incf} \atop {}_m\textbf{decf}\right.$ $\widetilde{place}$ [$delta_{[1]}$])
▷ Increment or decrement the value of *place* by *delta*. Return new value.

($_f$**exp** p)
($_f$**expt** b p)
▷ Return e^p or b^p, respectively.

($_f$**log** a [$b_{[e]}$])
▷ Return $\log_b a$ or, without b, $\ln a$.

($_f$**sqrt** n)
($_f$**isqrt** n)
▷ $\sqrt{n}$ in complex numbers/natural numbers.

($_f$**lcm** $integer^*_{[1]}$)
($_f$**gcd** $integer^*$)
▷ Least common multiple or greatest common denominator, respectively, of *integer*s. (**gcd**) returns 0.

$_c$**pi**
▷ **long-float** approximation of π, Ludolph's number.

($_f$**sin** a)
($_f$**cos** a)
($_f$**tan** a)
▷ $\sin a$, $\cos a$, or $\tan a$, respectively. (a in radians.)

($_f$**asin** a)
($_f$**acos** a)
▷ $\arcsin a$ or $\arccos a$, respectively, in radians.

(*f*__atan__ *a* [*b*1]) ▷ arctan $\frac{a}{b}$ in radians.

(*f*__sinh__ *a*)
(*f*__cosh__ *a*) ▷ sinh *a*, cosh *a*, or tanh *a*, respectively.
(*f*__tanh__ *a*)

(*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 *num*s.

(
$$\left\{\begin{array}{l}\{_f\textbf{round}\,|\,_f\textbf{round}\}\\ \{_f\textbf{floor}\,|\,_f\textbf{ffloor}\}\\ \{_f\textbf{ceiling}\,|\,_f\textbf{fceiling}\}\\ \{_f\textbf{truncate}\,|\,_f\textbf{ftruncate}\}\end{array}\right\}$$
n [*d*1])
▷ Return as **integer** or **float**, respectively, *n*/*d* rounded, or rounded towards $-\infty$, $+\infty$, or 0, respectively; and remainder$_2$.

(
$$\left\{\begin{array}{l}{}_f\textbf{mod}\\ {}_f\textbf{rem}\end{array}\right\}$$
n d)
▷ Same as *f***floor** or *f***truncate**, respectively, but return remainder only.

(*f*__random__ *limit* [$\widetilde{state}$*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*. *operation*s are

- *c*__boole-1__ ▷ *int-a*.
- *c*__boole-2__ ▷ *int-b*.
- *c*__boole-c1__ ▷ $\neg$*int-a*.
- *c*__boole-c2__ ▷ $\neg$*int-b*.
- *c*__boole-set__ ▷ All bits set.
- *c*__boole-clr__ ▷ All bits zero.
- *c*__boole-eqv__ ▷ *int-a* $\equiv$ *int-b*.
- *c*__boole-and__ ▷ *int-a* $\wedge$ *int-b*.
- *c*__boole-andc1__ ▷ $\neg$*int-a* $\wedge$ *int-b*.
- *c*__boole-andc2__ ▷ *int-a* $\wedge \neg$*int-b*.
- *c*__boole-nand__ ▷ $\neg$(*int-a* $\wedge$ *int-b*).
- *c*__boole-ior__ ▷ *int-a* $\vee$ *int-b*.
- *c*__boole-orc1__ ▷ $\neg$*int-a* $\vee$ *int-b*.
- *c*__boole-orc2__ ▷ *int-a* $\vee \neg$*int-b*.
- *c*__boole-xor__ ▷ $\neg$(*int-a* $\equiv$ *int-b*).
- *c*__boole-nor__ ▷ $\neg$(*int-a* $\vee$ *int-b*).

(*f*__lognot__ *integer*) ▷ $\neg$*integer*.

(*f*__logeqv__ *integer**)
(*f*__logand__ *integer**)
▷ Return value of exclusive-nored or anded *integer*s, respectively. Without any *integer*, return -1.

(*f*__logandc1__ *int-a int-b*) ▷ $\neg$*int-a* $\wedge$ *int-b*.

(*f*__logandc2__ *int-a int-b*) ▷ *int-a* $\wedge \neg$*int-b*.

(*f*__lognand__ *int-a int-b*) ▷ $\neg$(*int-a* $\wedge$ *int-b*).

(*f*__logxor__ *integer**)
(*f*__logior__ *integer**)
▷ Return value of exclusive-ored or ored *integer*s, respectively. Without any *integer*, return 0.

(*f*__logorc1__ *int-a int-b*) ▷ $\neg$*int-a* $\vee$ *int-b*.

(*f*__logorc2__ *int-a int-b*) ▷ *int-a* $\vee \neg$*int-b*.

(*f*__lognor__ *int-a int-b*) ▷ $\neg$(*int-a* $\vee$ *int-b*).

(*f*__logbitp__ *i int*) ▷ T if zero-indexed *i*th bit of *int* is set.

(*f*__logtest__ *int-a int-b*)
▷ Return T if there is any bit set in *int-a* which is set in *int-b* as well.

(*f*__logcount__ *int*)
▷ Number of 1 bits in *int* ≥ 0, number of 0 bits in *int* < 0.

1.4 Integer Functions

(*f*__integer-length__ *integer*)
▷ Number of bits necessary to represent *integer*.

(*f*__ldb-test__ *byte-spec integer*)
▷ Return T if any bit specified by *byte-spec* in *integer* is set.

(*f*__ash__ *integer count*)
▷ Return copy of *integer* arithmetically shifted left by *count* adding zeros at the right, or, for $count < 0$, shifted right discarding bits.

(*f*__ldb__ *byte-spec integer*)
▷ Extract byte denoted by *byte-spec* from *integer*. **setf**able.

(*f*__deposit-field__ / *f*__dpb__ *int-a byte-spec int-b*)
▷ Return *int-b* with bits denoted by *byte-spec* replaced by corresponding bits of *int-a*, or by the low (*f*__byte-size__ *byte-spec*) bits of *int-a*, respectively.

(*f*__mask-field__ *byte-spec integer*)
▷ Return copy of *integer* with all bits unset but those denoted by *byte-spec*. **setf**able.

(*f*__byte__ *size position*)
▷ Byte specifier for a byte of *size* bits starting at a weight of $2^{position}$.

(*f*__byte-size__ *byte-spec*)
(*f*__byte-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__ - __epsilon__ / __negative-epsilon__
▷ 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__ - __short-float__ / __single-float__ / __double-float__ / __long-float__
▷ Available numbers closest to −0 or +0, respectively.

*c*__most-negative__, *c*__most-positive__ - __short-float__ / __single-float__ / __double-float__ / __long-float__ / __fixnum__
▷ 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*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 `!?$"'‘.:,;*+-/|\~_^<=>#%@&()[]{}`.

(ƒ**characterp** *foo*)
(ƒ**standard-char-p** *char*) ▷ T if argument is of indicated type.

(ƒ**graphic-char-p** *character*)
(ƒ**alpha-char-p** *character*)
(ƒ**alphanumericp** *character*)
▷ T if *character* is visible, alphabetic, or alphanumeric, respectively.

(ƒ**upper-case-p** *character*)
(ƒ**lower-case-p** *character*)
(ƒ**both-case-p** *character*)
▷ Return T if *character* is uppercase, lowercase, or able to be in another case, respectively.

(ƒ**digit-char-p** *character* [*radix*$_{10}$])
▷ Return its weight if *character* is a digit, or NIL otherwise.

(ƒ**char=** *character*$^+$)
(ƒ**char/=** *character*$^+$)
▷ Return T if all *character*s, or none, respectively, are equal.

(ƒ**char-equal** *character*$^+$)
(ƒ**char-not-equal** *character*$^+$)
▷ Return T if all *character*s, or none, respectively, are equal ignoring case.

(ƒ**char>** *character*$^+$)
(ƒ**char>=** *character*$^+$)
(ƒ**char<** *character*$^+$)
(ƒ**char<=** *character*$^+$)
▷ Return T if *character*s are monotonically decreasing, monotonically non-increasing, monotonically increasing, or monotonically non-decreasing, respectively.

(ƒ**char-greaterp** *character*$^+$)
(ƒ**char-not-lessp** *character*$^+$)
(ƒ**char-lessp** *character*$^+$)
(ƒ**char-not-greaterp** *character*$^+$)
▷ Return T if *character*s are monotonically decreasing, monotonically non-increasing, monotonically increasing, or monotonically non-decreasing, respectively, ignoring case.

(ƒ**char-upcase** *character*)
(ƒ**char-downcase** *character*)
▷ Return corresponding uppercase/lowercase character, respectively.

(ƒ**digit-char** *i* [*radix*$_{10}$]) ▷ Character representing digit *i*.

(ƒ**char-name** *char*) ▷ *char*'s name if any, or NIL.

(ƒ**name-char** *foo*) ▷ Character named *foo* if any, or NIL.

(ƒ**char-int** *character*)
(ƒ**char-code** *character*) ▷ Code of *character*.

(ƒ**code-char** *code*) ▷ Character with *code*.

c**char-code-limit** ▷ Upper bound of (ƒ**char-code** *char*); ≥ 96.

(ƒ**character** *c*) ▷ Return #*c*.

3 Strings

Strings can as well be manipulated by array and sequence functions; see pages 11 and 12.

(*f* **stringp** *foo*)
(*f* **simple-string-p** *foo*)
▷ T if *foo* is of indicated type.

(*f* {**string=** | **string-equal**} *foo bar* {**:start1** *start-foo*0 | **:start2** *start-bar*0 | **:end1** *end-foo*NIL | **:end2** *end-bar*NIL})
▷ Return T if subsequences of *foo* and *bar* are equal. Obey/ignore, respectively, case.

(*f* {**string**{/= | -**not-equal**} | **string**{> | -**greaterp**} | **string**{>= | -**not-lessp**} | **string**{< | -**lessp**} | **string**{<= | -**not-greaterp**}} *foo bar* {**:start1** *start-foo*0 | **:start2** *start-bar*0 | **:end1** *end-foo*NIL | **:end2** *end-bar*NIL})
▷ 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* {**:initial-element** *char* | **:element-type** *type*character})
▷ Return string of length *size*.

(*f* **string** *x*)
(*f* {**string-capitalize** | **string-upcase** | **string-downcase**} *x* {**:start** *start*0 | **:end** *end*NIL})
▷ 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** | **nstring-upcase** | **nstring-downcase**} ~~*string*~~ {**:start** *start*0 | **:end** *end*NIL})
▷ Convert *string* into a string with capitalized words, an all-uppercase string, or an all-lowercase string, respectively.

(*f* {**string-trim** | **string-left-trim** | **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. **setf**able.

(*f* **parse-integer** *string* {**:start** *start*0 | **:end** *end*NIL | **:radix** *int*10 | **:junk-allowed** *bool*NIL})
▷ Return integer parsed from *string* and index (2) 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.

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

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

(ƒ**member** *foo list* { | { | **:test** *function* [#'eql] | **:test-not** *function* } | **:key** *function* })
▷ Return tail of *list* starting with its first element matching *foo*. Return NIL if there is no such element.

({ ƒ**member-if** | ƒ**member-if-not** } *test list* [**:key** *function*])
▷ Return tail of *list* starting with its first element satisfying *test*. Return NIL if there is no such element.

(ƒ**subsetp** *list-a list-b* { | { | **:test** *function* [#'eql] | **:test-not** *function* } | **:key** *function* })
▷ Return T if *list-a* is a subset of *list-b*.

4.2 Lists

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

(ƒ**list** *foo**) ▷ Return list of *foo*s.

(ƒ**list*** *foo*⁺)
▷ Return list of *foo*s with last *foo* becoming cdr of last cons. Return *foo* if only one *foo* given.

(ƒ**make-list** *num* [**:initial-element** *foo* NIL])
▷ New list with *num* elements set to *foo*.

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

(ƒ**car** *list*) ▷ Car of *list* or NIL if *list* is NIL. **setf**able.

(ƒ**cdr** *list*)
(ƒ**rest** *list*) ▷ Cdr of *list* or NIL if *list* is NIL. **setf**able.

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

({ƒ**first**|ƒ**second**|ƒ**third**|ƒ**fourth**|ƒ**fifth**|ƒ**sixth**|...|ƒ**ninth**|ƒ**tenth**} *list*)
▷ Return nth element of *list* if any, or NIL otherwise. **setf**able.

(ƒ**nth** *n list*) ▷ Zero-indexed *n*th element of *list*. **setf**able.

(ƒ**c***X***r** *list*)
▷ With *X* being one to four **a**s and **d**s representing ƒ**car**s and ƒ**cdr**s, e.g. (ƒ**cadr** *bar*) is equivalent to (ƒ**car** (ƒ**cdr** *bar*)). **setf**able.

(ƒ**last** *list* [*num*[1]]) ▷ Return list of last *num* conses of *list*.

({ ƒ**butlast** *list* | ƒ**nbutlast** *list* } [*num*[1]]) ▷ *list* excluding last *num* conses.

({ ƒ**rplaca** | ƒ**rplacd** } *cons object*)
▷ Replace car, or cdr, respectively, of *cons* with *object*.

(ƒ**ldiff** *list foo*)
▷ If *foo* is a tail of *list*, return preceding part of *list*. Otherwise return *list*.

(ƒ**adjoin** *foo list* { | { | **:test** *function* [#'eql] | **:test-not** *function* } | **:key** *function* })
▷ Return *list* if *foo* is already member of *list*. If not, return (ƒ**cons** *foo list*).

(*m***pop** *place*) ▷ Set *place* to (ƒ**cdr** *place*), return (ƒ**car** *place*).

(*m*push *foo* *place*) ▷ Set *place* to (*f*cons *foo* *place*).

(*m*pushnew *foo* *place* {:test *function*[#'eql] | :test-not *function* | :key *function*})
▷ Set *place* to (*f*adjoin *foo* *place*).

(*f*append [*proper-list** *foo*[NIL]])
(*f*nconc [*non-circular-list** *foo*[NIL]])
▷ Return concatenated list or, with only one argument, *foo*. *foo* can be of any type.

(*f*revappend *list* *foo*)
(*f*nreconc *list* *foo*)
▷ Return concatenated list after reversing order in *list*.

({*f*mapcar | *f*maplist} *function* *list*+)
▷ Return list of return values of *function* successively invoked with corresponding arguments, either cars or cdrs, respectively, from each *list*.

({*f*mapcan | *f*mapcon} *function* *list*+)
▷ 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.

({*f*mapc | *f*mapl} *function* *list*+)
▷ Return first *list* after successively applying *function* to corresponding arguments, either cars or cdrs, respectively, from each *list*. *function* should have some side effects.

(*f*copy-list *list*) ▷ Return copy of *list* with shared elements.

4.3 Association Lists

(*f*pairlis *keys* *values* [*alist*[NIL]])
▷ Prepend to *alist* an association list made from lists *keys* and *values*.

(*f*acons *key* *value* *alist*)
▷ Return *alist* with a (*key* . *value*) pair added.

({*f*assoc | *f*rassoc} *foo* *alist* {:test *test*[#'eql] | :test-not *test* | :key *function*})
({*f*assoc-if[-not] | *f*rassoc-if[-not]} *test* *alist* [:key *function*])
▷ First cons whose car, or cdr, respectively, satisfies *test*.

(*f*copy-alist *alist*) ▷ Return copy of *alist*.

4.4 Trees

(*f*tree-equal *foo* *bar* {:test *test*[#'eql] | :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*[#'eql] | :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* | *f*nsubst-if[-not] *new* *test* *tree*} [:key *function*])
▷ Make copy of *tree* with each subtree or leaf satisfying *test* replaced by *new*.

($\left\{\begin{array}{l}f\textbf{sublis}\ \textit{association-list}\ \textit{tree}\\ f\textbf{nsublis}\ \textit{association-list}\ \widetilde{\textit{tree}}\end{array}\right\}$ $\left\{\left|\begin{array}{l}\textbf{:test}\ \textit{function}_{\#\text{'eql}}\\ \textbf{:test-not}\ \textit{function}\\ \textbf{:key}\ \textit{function}\end{array}\right.\right\}$)

▷ 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

($\left\{\begin{array}{l}f\textbf{intersection}\\ f\textbf{set-difference}\\ f\textbf{union}\\ f\textbf{set-exclusive-or}\end{array}\right\}\ a\ b$ $\left\{\begin{array}{l}f\textbf{nintersection}\\ f\textbf{nset-difference}\end{array}\right\}\ \widetilde{a}\ b$ $\left\{\begin{array}{l}f\textbf{nunion}\\ f\textbf{nset-exclusive-or}\end{array}\right\}\ \widetilde{a}\ \widetilde{b}$ $\left\{\left|\begin{array}{l}\textbf{:test}\ \textit{function}_{\#\text{'eql}}\\ \textbf{:test-not}\ \textit{function}\\ \textbf{:key}\ \textit{function}\end{array}\right.\right\}$)

▷ 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

($\left\{\begin{array}{l}f\textbf{make-array}\ \textit{dimension-sizes}\ [\textbf{:adjustable}\ \textit{bool}_{\text{NIL}}]\\ f\textbf{adjust-array}\ \widetilde{\textit{array}}\ \textit{dimension-sizes}\end{array}\right\}$
$\left\{\left|\begin{array}{l}\textbf{:element-type}\ \textit{type}_{\text{T}}\\ \textbf{:fill-pointer}\ \{\textit{num}\,|\,\textit{bool}\}_{\text{NIL}}\\ \left\{\begin{array}{l}\textbf{:initial-element}\ \textit{obj}\\ \textbf{:initial-contents}\ \textit{tree-or-array}\\ \textbf{:displaced-to}\ \textit{array}_{\text{NIL}}\ [\textbf{:displaced-index-offset}\ \textit{i}_{0}]\end{array}\right.\end{array}\right.\right\}$)

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

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

▷ Return array element pointed to by *subscripts*. **setf**able.

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

▷ Return ith element of *array* in row-major order. **setf**able.

(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 ith dimension of *array*.

(f**array-total-size** *array*) ▷ Number of elements in *array*.

(f**array-rank** *array*) ▷ Number of dimensions of *array*.

(ƒ**array-displacement** *array*) ▷ Target array and offset.

(ƒ**bit** *bit-array* [*subscripts*])
(ƒ**sbit** *simple-bit-array* [*subscripts*])
▷ Return element of *bit-array* or of *simple-bit-array*. **setf**able.

(ƒ**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.

(ƒ{**bit-eqv** | **bit-and** | **bit-andc1** | **bit-andc2** | **bit-nand** | **bit-ior** | **bit-orc1** | **bit-orc2** | **bit-xor** | **bit-nor**} *bit-array-a bit-array-b* [*result-bit-array*NIL])
▷ Return result of bitwise logical operations (cf. operations of ƒ**boole**, page 5) 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.

(ƒ**vector** *foo**) ▷ Return fresh simple vector of *foo*s.

(ƒ**svref** *vector i*) ▷ Element *i* of simple *vector*. **setf**able.

(ƒ**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.

(ƒ**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 ≥ *num* if necessary.

(ƒ**vector-pop** *vector*)
▷ Return element of *vector* its fillpointer points to after decrementation.

(ƒ**fill-pointer** *vector*) ▷ Fill pointer of *vector*. **setf**able.

6 Sequences

6.1 Sequence Predicates

(ƒ{**every** | **notevery**} *test sequence*+)
▷ Return NIL or T, respectively, as soon as *test* on any set of corresponding elements of *sequence*s returns NIL.

($\left\{\begin{matrix}f\textbf{some}\\ f\textbf{notany}\end{matrix}\right\}$ *test sequence*$^+$)

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

(f**mismatch** *sequence-a sequence-b* $\left\{\begin{matrix}\textbf{:from-end}\ bool_{\texttt{NIL}}\\ \left\{\begin{matrix}\textbf{:test}\ function_{\#\text{'}\textbf{eql}}\\ \textbf{:test-not}\ function\end{matrix}\right.\\ \textbf{:start1}\ start\text{-}a_{0}\\ \textbf{:start2}\ start\text{-}b_{0}\\ \textbf{:end1}\ end\text{-}a_{\texttt{NIL}}\\ \textbf{:end2}\ end\text{-}b_{\texttt{NIL}}\\ \textbf{:key}\ function\end{matrix}\right\}$)

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

6.2 Sequence Functions

(f**make-sequence** *sequence-type size* [**:initial-element** *foo*])

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

(f**concatenate** *type sequence**)

▷ Return concatenated sequence of *type*.

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

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

(f**fill** $\widetilde{sequence}$ *foo* $\left\{\begin{matrix}\textbf{:start}\ start_{0}\\ \textbf{:end}\ end_{\texttt{NIL}}\end{matrix}\right\}$)

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

(f**length** *sequence*)

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

(f**count** *foo sequence* $\left\{\begin{matrix}\textbf{:from-end}\ bool_{\texttt{NIL}}\\ \left\{\begin{matrix}\textbf{:test}\ function_{\#\text{'}\textbf{eql}}\\ \textbf{:test-not}\ function\end{matrix}\right.\\ \textbf{:start}\ start_{0}\\ \textbf{:end}\ end_{\texttt{NIL}}\\ \textbf{:key}\ function\end{matrix}\right\}$)

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

($\left\{\begin{matrix}f\textbf{count-if}\\ f\textbf{count-if-not}\end{matrix}\right\}$ *test sequence* $\left\{\begin{matrix}\textbf{:from-end}\ bool_{\texttt{NIL}}\\ \textbf{:start}\ start_{0}\\ \textbf{:end}\ end_{\texttt{NIL}}\\ \textbf{:key}\ function\end{matrix}\right\}$)

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

(f**elt** *sequence index*)

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

(f**subseq** *sequence start* [$end_{\texttt{NIL}}$])

▷ Return subsequence of *sequence* between *start* and *end*. **setf**able.

($\left\{\begin{matrix}f\textbf{sort}\\ f\textbf{stable-sort}\end{matrix}\right\}$ $\widetilde{sequence}$ *test* [**:key** *function*])

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

(f**reverse** *sequence*)
(f**nreverse** $\widetilde{sequence}$)

▷ Return *sequence* in reverse order.

({f**find** / f**position**} *foo sequence* { **:from-end** *bool*[NIL] / { **:test** *function*[#'eql] / **:test-not** *test* } / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* })

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

({f**find-if** / f**find-if-not** / f**position-if** / f**position-if-not**} *test sequence* { **:from-end** *bool*[NIL] / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* })

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

(f**search** *sequence-a sequence-b* { **:from-end** *bool*[NIL] / { **:test** *function*[#'eql] / **:test-not** *function* } / **:start1** *start-a*[0] / **:start2** *start-b*[0] / **:end1** *end-a*[NIL] / **:end2** *end-b*[NIL] / **:key** *function* })

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

({f**remove** *foo sequence* / f**delete** *foo sequence*} { **:from-end** *bool*[NIL] / { **:test** *function*[#'eql] / **:test-not** *function* } / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* / **:count** *count*[NIL] })

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

({f**remove-if** / f**remove-if-not** *test sequence* / f**delete-if** / f**delete-if-not** *test sequence*} { **:from-end** *bool*[NIL] / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* / **:count** *count*[NIL] })

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

({f**remove-duplicates** *sequence* / f**delete-duplicates** *sequence*} { **:from-end** *bool*[NIL] / { **:test** *function*[#'eql] / **:test-not** *function* } / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* })

▷ Make copy of *sequence* without duplicates.

({f**substitute** *new old sequence* / f**nsubstitute** *new old sequence*} { **:from-end** *bool*[NIL] / { **:test** *function*[#'eql] / **:test-not** *function* } / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* / **:count** *count*[NIL] })

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

({f**substitute-if** / f**substitute-if-not** *new test sequence* / f**nsubstitute-if** / f**nsubstitute-if-not** *new test sequence*} { **:from-end** *bool*[NIL] / **:start** *start*[0] / **:end** *end*[NIL] / **:key** *function* / **:count** *count*[NIL] })

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

(ƒ**replace** *sequence-a sequence-b* { **:start1** *start-a*[0] | **:start2** *start-b*[0] | **:end1** *end-a*[NIL] | **:end2** *end-b*[NIL] })

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

(ƒ**map** *type function sequence*$^+$)

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

(ƒ**map-into** *result-sequence function sequence**)

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

(ƒ**reduce** *function sequence* { **:initial-value** *foo*[NIL] | **:from-end** *bool*[NIL] | **:start** *start*[0] | **:end** *end*[NIL] | **:key** *function* })

▷ 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.

(ƒ**copy-seq** *sequence*)

▷ Copy of *sequence* with shared elements.

7 Hash Tables

The Loop Facility provides additional hash table-related functionality; see **loop**, page 22.

Key-value storage similar to hash tables can as well be achieved using association lists and property lists; see pages 10 and 17.

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

(ƒ**make-hash-table** { **:test** {ƒ**eq** | ƒ**eql** | ƒ**equal** | ƒ**equalp**}[#'eql] | **:size** *int* | **:rehash-size** *num* | **:rehash-threshold** *num* })

▷ Make a hash table.

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

▷ Return object with *key* if any or *default* otherwise; and `T`$_2$ if found, `NIL`$_2$ otherwise. **setf**able.

(ƒ**hash-table-count** *hash-table*)

▷ Number of entries in *hash-table*.

(ƒ**remhash** *key hash-table*)

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

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

(ƒ**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 *form*s. In *form*s, invocations of (*foo*) return: `T` if an entry is returned; its key; its value.

(ƒ**hash-table-test** *hash-table*)

▷ Test function used in *hash-table*.

(ƒ**hash-table-size** *hash-table*)
(ƒ**hash-table-rehash-size** *hash-table*)
(ƒ**hash-table-rehash-threshold** *hash-table*)

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

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

8 Structures

(*m*defstruct
$$\left\{\begin{array}{l} foo \\ \left(foo \left\{\begin{array}{l} \left\{\begin{array}{l}\textbf{:conc-name}\\ (\textbf{:conc-name}\ [\widehat{slot\text{-}prefix_{\boxed{foo\text{-}}}}])\end{array}\right. \\ \left\{\begin{array}{l}\textbf{:constructor}\\ (\textbf{:constructor}\ [\widehat{maker}_{\boxed{\texttt{MAKE-}foo}}\ [(\widehat{ord\text{-}\lambda}^*)]])\end{array}\right\}^* \\ \left\{\begin{array}{l}\textbf{:copier}\\ (\textbf{:copier}\ [\widehat{copier}_{\boxed{\texttt{COPY-}foo}}])\end{array}\right. \\ (\textbf{:include}\ \widehat{struct}\left\{\begin{array}{l} slot \\ (\widehat{slot}\ [init\left\{\begin{array}{l}\textbf{:type}\ \widehat{sl\text{-}type}\\ \textbf{:read-only}\ \widehat{b}\end{array}\right.])\end{array}\right\}^*) \\ \left\{\begin{array}{l}(\textbf{:type}\left\{\begin{array}{l}\textbf{list}\\ \textbf{vector}\\ (\textbf{vector}\ \widehat{type})\end{array}\right.)\\ \left\{\begin{array}{l}\textbf{:named}\\ (\textbf{:initial-offset}\ \widehat{n})\end{array}\right.\end{array}\right. \\ \left\{\begin{array}{l}(\textbf{:print-object}\ [\widehat{o\text{-}printer}])\\ (\textbf{:print-function}\ [\widehat{f\text{-}printer}])\end{array}\right. \\ \left\{\begin{array}{l}\textbf{:predicate}\\ (\textbf{:predicate}\ [\widehat{p\text{-}name}_{\boxed{foo\text{-P}}}])\end{array}\right. \end{array}\right.\right) \\ [\widehat{doc}]\left\{\begin{array}{l} slot \\ (slot\ [init\left\{\begin{array}{l}\textbf{:type}\ \widehat{slot\text{-}type}\\ \textbf{:read-only}\ \widehat{bool}\end{array}\right.])\end{array}\right\}^*) \end{array}\right\}$$

▷ Define structure *foo* together with functions `MAKE-`*foo*, `COPY-`*foo* and *foo*`-P`; and **setf**able 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 18) is given, by (*maker arg** {**:***key value*}*). In the latter case, *arg*s and **:***key*s correspond to the positional and keyword parameters defined in *ord-λ* whose *var*s in turn correspond to *slot*s. **:print-object**/**:print-function** generate a *g***print-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 **number**s of the same type and value.

(*f*equal *foo bar*)
▷ `T` if *foo* and *bar* are *f*eql, or are equivalent **pathname**s, or are **cons**es with *f*equal cars and cdrs, or are **string**s or **bit-vector**s 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 **number**s of the same value ignoring type; or are equivalent **pathname**s; or are **cons**es or **array**s of the same shape with *f*equalp elements; or are structures of the same type with *f*equalp elements; or are **hash-table**s 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*$_{\text{NIL}}$])
▷ T if *foo* is a constant form.

(*f* **functionp** *foo*) ▷ T if *foo* is of type **function**.

(*f* **fboundp** $\left\{\begin{matrix} foo \\ (\textbf{setf}\ foo) \end{matrix}\right\}$) ▷ T if *foo* is a global function or macro.

9.2 Variables

($\left\{\begin{matrix} m\textbf{defconstant} \\ m\textbf{defparameter} \end{matrix}\right\}$ $\widehat{foo}$ *form* [$\widehat{doc}$])
▷ Assign value of *form* to global constant/dynamic variable *foo*.

(*m* **defvar** $\widehat{foo}$ [*form* [$\widehat{doc}$]])
▷ Unless bound already, assign value of *form* to dynamic variable *foo*.

($\left\{\begin{matrix} m\textbf{setf} \\ m\textbf{psetf} \end{matrix}\right\}$ {*place form*}*)
▷ Set *place*s to primary values of *form*s. Return values of last *form*/NIL; work sequentially/in parallel, respectively.

($\left\{\begin{matrix} s\textbf{setq} \\ m\textbf{psetq} \end{matrix}\right\}$ {*symbol form*}*)
▷ Set *symbol*s to primary values of *form*s. Return value of last *form*/NIL; work sequentially/in parallel, respectively.

(*f* **set** $\widetilde{symbol}$ *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** $\widetilde{place}^{+}$ *foo*)
▷ Store value of *foo* in rightmost *place* shifting values of *place*s left, returning first *place*.

(*m* **rotatef** $\widetilde{place}^{*}$)
▷ Rotate values of *place*s 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*$_{\text{NIL}}$])
(*f* **getf** *place key* [*default*$_{\text{NIL}}$])
▷ First entry *key* from property list stored in *symbol*/in *place*, respectively, or *default* if there is no *key*. **setf**able.

(*f* **get-properties** *property-list keys*)
▷ Return key and value$_2$ of first entry from *property-list* matching a key from *keys*, and tail of *property-list*$_3$ starting with that key. Return NIL, NIL$_2$, and NIL$_3$ if there was no matching key in *property-list*.

(*f* **remprop** $\widetilde{symbol}$ *key*)
(*m* **remf** $\widetilde{place}$ *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 *form*s with locally established dynamic bindings of *symbols* to *values* or NIL. Return values of *form*s.

($\left\{{}_{s}\textbf{let} \atop {}_{s}\textbf{let*}\right.$ ($\left\{\left|{name \atop (name\ [value_{\boxed{\texttt{NIL}}}])}\right.\right\}^{*}$) (**declare** $\widehat{decl^{*}})^{*}$ $form^{P_{*}}$)

▷ Evaluate *form*s with *name*s lexically bound (in parallel or sequentially, respectively) to *value*s. Return values of *form*s.

(${}_{m}$**multiple-value-bind** ($\widehat{var^{*}}$) *values-form* (**declare** $\widehat{decl^{*}})^{*}$ *body-form*$^{P_{*}}$)

▷ Evaluate *body-form*s with *var*s lexically bound to the return values of *values-form*. Return values of *body-form*s.

(${}_{m}$**destructuring-bind** *destruct-λ bar* (**declare** $\widehat{decl^{*}})^{*}$ $form^{P_{*}}$)

▷ Evaluate *form*s 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** $\left\{{var \atop (var\ [init_{\boxed{\texttt{NIL}}}\ [supplied\text{-}p]])}\right.^{*}$] [**&rest** *var*]
[**&key** $\left\{{var \atop (\left\{{var \atop (:key\ var)}\right.\ [init_{\boxed{\texttt{NIL}}}\ [supplied\text{-}p]])}\right.^{*}$ [**&allow-other-keys**]]
[**&aux** $\left\{{var \atop (var\ [init_{\boxed{\texttt{NIL}}}])}\right.^{*}$]).

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

($\left\{{}_{m}\textbf{defun}\ \left\{{foo\ (ord\text{-}\lambda^{*}) \atop (\textbf{setf}\ foo)\ (new\text{-}value\ ord\text{-}\lambda^{*})}\right.\ \right\}\ \left\{\left|{(\textbf{declare}\ \widehat{decl^{*}})^{*} \atop \widehat{doc}}\right.\right\}$
$form^{P_{*}}$)

▷ Define a function named *foo* or (**setf** *foo*), or an anonymous function, respectively, which applies *form*s to *ord-λ*s. For ${}_{m}$**defun**, *form*s are enclosed in an implicit ${}_{s}$**block** named *foo*.

($\left\{{}_{s}\textbf{flet} \atop {}_{s}\textbf{labels}\right.$ (($\left\{{foo\ (ord\text{-}\lambda^{*}) \atop (\textbf{setf}\ foo)\ (new\text{-}value\ ord\text{-}\lambda^{*})}\right.\ \right\}\ \left\{\left|{(\textbf{declare}\ \widehat{local\text{-}decl^{*}})^{*} \atop \widehat{doc}}\right.\right\}$
$local\text{-}form^{P_{*}}$)*) (**declare** $\widehat{decl^{*}})^{*}$ $form^{P_{*}}$)

▷ Evaluate *form*s with locally defined functions *foo*. Globally defined functions of the same name are shadowed. Each *foo* is also the name of an implicit ${}_{s}$**block** around its corresponding *local-form**. Only for ${}_{s}$**labels**, functions *foo* are visible inside *local-forms*. Return values of *form*s.

(${}_{s}$**function** $\left\{{foo \atop ({}_{m}\textbf{lambda}\ form^{*})}\right.$)

▷ Return lexically innermost function named *foo* or a lexical closure of the ${}_{m}$**lambda** expression.

(${}_{f}$**apply** $\left\{{function \atop (\textbf{setf}\ function)}\right.$ arg^{*} *args*)

▷ Values of *function* called with *arg*s and the list elements of *args*. **setf**able if *function* is one of ${}_{f}$**aref**, ${}_{f}$**bit**, and ${}_{f}$**sbit**.

(${}_{f}$**funcall** *function* arg*) ▷ Values of *function* called with *arg*s.

(${}_{s}$**multiple-value-call** *function form**)

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

(${}_{f}$**values-list** *list*) ▷ Return elements of *list*.

(${}_{f}$**values** *foo**)

▷ Return as multiple values the primary values of the *foo*s. **setf**able.

(${}_{f}$**multiple-value-list** *form*) ▷ List of the values of *form*.

(*m*nth-value *n form*)
▷ Zero-indexed *n*th return value of *form*.

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

(*f*constantly *foo*)
▷ Function of any number of arguments returning *foo*.

(*f*identity *foo*) ▷ Return *foo*.

(*f*function-lambda-expression *function*)
▷ If available, return lambda expression of *function*, NIL[2] if *function* was defined in an environment without bindings, and name[3] of *function*.

(*f*fdefinition $\left\{\begin{matrix} foo \\ (\textbf{setf}\ foo) \end{matrix}\right\}$)
▷ Definition of global function *foo*. **setf**able.

(*f*fmakunbound *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*] $\left\{\begin{matrix} var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}^*$ [*E*]
[**&optional** $\left\{\begin{matrix} var \\ (\left\{\begin{matrix} var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}\ [init_{\texttt{NIL}}\ [supplied\text{-}p]]) \end{matrix}\right\}^*$] [*E*]
[$\left\{\begin{matrix} \textbf{\&rest} \\ \textbf{\&body} \end{matrix}\right\}$ $\left\{\begin{matrix} rest\text{-}var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}$] [*E*]
[**&key** $\left\{\begin{matrix} var \\ (\left\{\begin{matrix} var \\ (\textbf{:}key\ \left\{\begin{matrix} var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}) \end{matrix}\right\}\ [init_{\texttt{NIL}}\ [supplied\text{-}p]]) \end{matrix}\right\}^*$ [*E*]
[**&allow-other-keys**]] [**&aux** $\left\{\begin{matrix} var \\ (var\ [init_{\texttt{NIL}}]) \end{matrix}\right\}^*$] [*E*])
or
([**&whole** *var*] [*E*] $\left\{\begin{matrix} var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}^*$ [*E*]
[**&optional** $\left\{\begin{matrix} var \\ (\left\{\begin{matrix} var \\ (macro\text{-}\lambda^*) \end{matrix}\right\}\ [init_{\texttt{NIL}}\ [supplied\text{-}p]]) \end{matrix}\right\}^*$] [*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.

($\left\{\begin{matrix} m\textbf{defmacro} \\ f\textbf{define-compiler-macro} \end{matrix}\right\}$ $\left\{\begin{matrix} foo \\ (\textbf{setf}\ foo) \end{matrix}\right\}$ (*macro-λ**)
$\left\{\begin{matrix} (\textbf{declare}\ \widehat{decl^*})^* \\ \widehat{doc} \end{matrix}\right\}$ $form^{P_*}$)
▷ Define macro *foo* which on evaluation as (*foo tree*) applies expanded *form*s to arguments from *tree*, which corresponds to *tree*-shaped *macro-λ*s. *form*s are enclosed in an implicit *s***block** named *foo*.

(*m*__define-symbol-macro__ *foo form*)
▷ Define symbol macro *foo* which on evaluation evaluates expanded *form*.

(*s*__macrolet__ ((*foo* (*macro-λ**) $\left\{\left|\begin{array}{l}\widehat{\text{(}\textbf{declare}\ \widehat{local\text{-}decl^*}\text{)}^*}\\ \widehat{doc}\end{array}\right.\right\}$ *macro-form*^{P,*})*)
(__declare__ $\widehat{decl^*}$)* *form*^{P,*})
▷ Evaluate *forms* with locally defined mutually invisible macros *foo* which are enclosed in implicit *s*__block__s of the same name.

(*s*__symbol-macrolet__ ((*foo expansion-form*)*) (__declare__ $\widehat{decl^*}$)* *form*^{P,*})
▷ Evaluate *forms* with locally defined symbol macros *foo*.

(*m*__defsetf__ $\widehat{function}$ $\left\{\begin{array}{l}\widehat{updater}\ [\widehat{doc}]\\ (setf\text{-}\lambda^*)\ (s\text{-}var^*)\ \left\{\left|\begin{array}{l}\widehat{\text{(}\textbf{declare}\ \widehat{decl^*}\text{)}^*}\\ \widehat{doc}\end{array}\right.\right\}\ form^{P,*}\end{array}\right\}$)
where defsetf lambda list (*setf-λ**) has the form
(*var** [__&optional__ $\left\{\begin{array}{l}var\\ (var\ [init_{\boxed{\text{NIL}}}\ [supplied\text{-}p]])\end{array}\right\}^*$] [__&rest__ *var*]
[__&key__ $\left\{\begin{array}{l}var\\ (\left\{\begin{array}{l}var\\ (\textbf{:}key\ var)\end{array}\right\}\ [init_{\boxed{\text{NIL}}}\ [supplied\text{-}p]])\end{array}\right\}^*$
[__&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*), *form*s 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**. *form*s are enclosed in an implicit *s*__block__ named *function*.

(*m*__define-setf-expander__ *function* (*macro-λ**) $\left\{\left|\begin{array}{l}\widehat{\text{(}\textbf{declare}\ \widehat{decl^*}\text{)}^*}\\ \widehat{doc}\end{array}\right.\right\}$
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 *f*__get-setf-expansion__ where the elements of macro lambda list *macro-λ** are bound to corresponding *arg*s. *form*s are enclosed in an implicit *s*__block__ named *function*.

(*f*__get-setf-expansion__ *place* [*environment*$_{\boxed{\text{NIL}}}$])
▷ 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*.

(*m*__define-modify-macro__ *foo* ([__&optional__ $\left\{\begin{array}{l}var\\ (var\ [init_{\boxed{\text{NIL}}}\ [supplied\text{-}p]])\end{array}\right\}^*$]
[__&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 *arg*s will be stored into *place* and returned.

*c*__lambda-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 *var*s to corresponding arguments if any.

{__&rest__|__&body__} *var*
▷ Bind *var* to a list of remaining arguments.

__&key__ *var**
▷ Bind *var*s 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 *var*s as in ₛ**let∗**.

9.5 Control Flow

(ₛ**if** *test then* [*else*`NIL`])
▷ Return values of *then* if *test* returns `T`; return values of *else* otherwise.

(ₘ**cond** (*test* *then*P*)*)
▷ Return the values of the first *then** whose *test* returns `T`; return `NIL` if all *test*s return `NIL`.

({ₘ**when** / ₘ**unless**} *test* *foo*P*)
▷ Evaluate *foo*s and return their values if *test* returns `T` or `NIL`, respectively. Return `NIL` otherwise.

(ₘ**case** *test* ({(*key**) / *key*}P* *foo*)* [({**otherwise** / `T`} *bar*P*)`NIL`])
▷ Return the values of the first *foo** one of whose *key*s is **eql** *test*. Return values of *bar*s if there is no matching *key*.

({ₘ**ecase** / ₘ**ccase**} *test* ({(*key**) / *key*}P* *foo*P*)*)
▷ Return the values of the first *foo** one of whose *key*s is **eql** *test*. Signal non-correctable/correctable **type-error** if there is no matching *key*.

(ₘ**and** *form**`T`)
▷ Evaluate *form*s from left to right. Immediately return `NIL` if one *form*'s value is `NIL`. Return values of last *form* otherwise.

(ₘ**or** *form**`NIL`)
▷ Evaluate *form*s from left to right. Immediately return primary value of first non-`NIL`-evaluating form, or all values if last *form* is reached. Return `NIL` if no *form* returns `T`.

(ₛ**progn** *form**`NIL`)
▷ Evaluate *form*s sequentially. Return values of last *form*.

(ₛ**multiple-value-prog1** *form-r form**)
(ₘ**prog1** *form-r form**)
(ₘ**prog2** *form-a form-r form**)
▷ Evaluate forms in order. Return values/primary value, respectively, of *form-r*.

({ₘ**prog** / ₘ**prog∗**} ({*name* / (*name* [*value*`NIL`])}*) (**declare** (*decl**)* {*tag* / *form*}*)
▷ Evaluate ₛ**tagbody**-like body with *name*s lexically bound (in parallel or sequentially, respectively) to *value*s. Return `NIL` or explicitly ₘ**return**ed values. Implicitly, the whole form is a ₛ**block** named `NIL`.

(ₛ**unwind-protect** *protected cleanup**)
▷ Evaluate *protected* and then, no matter how control leaves *protected*, *cleanup*s. Return values of *protected*.

(ₛ**block** *name form*P*)
▷ Evaluate *form*s in a lexical environment, and return their values unless interrupted by ₛ**return-from**.

(ₛ**return-from** *foo* [*result*`NIL`])
(ₘ**return** [*result*`NIL`])
▷ Have nearest enclosing ₛ**block** named *foo*/named `NIL`, respectively, return with values of *result*.

(*s*__tagbody__ {$\widehat{tag}$|*form*}*)
▷ Evaluate *form*s in a lexical environment. *tag*s (symbols or integers) have lexical scope and dynamic extent, and are targets for *s*__go__. Return NIL.

(*s*__go__ $\widehat{tag}$)
▷ Within the innermost possible enclosing *s*__tagbody__, jump to a tag *f*__eql__ *tag*.

(*s*__catch__ *tag* *form*P*)
▷ Evaluate *form*s and return their values unless interrupted by *s*__throw__.

(*s*__throw__ *tag* *form*)
▷ Have the nearest dynamically enclosing *s*__catch__ with a tag *f*__eq__ *tag* return with the values of *form*.

(*f*__sleep__ *n*) ▷ Wait *n* seconds; return NIL.

9.6 Iteration

({*m*__do__ / *m*__do*__} ({*var* / (*var* [*start* [*step*]])}*) (*stop* *result*P*) (__declare__ $\widehat{decl}$*)* {$\widehat{tag}$ / *form*}*)
▷ Evaluate *s*__tagbody__-like body with *var*s successively bound according to the values of the corresponding *start* and *step* forms. *var*s are bound in parallel/sequentially, respectively. Stop iteration when *stop* is T. Return values of *result**. Implicitly, the whole form is a *s*__block__ named NIL.

(*m*__dotimes__ (*var* *i* [*result*NIL]) (__declare__ $\widehat{decl}$*)* {$\widehat{tag}$|*form*}*)
▷ Evaluate *s*__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 *s*__block__ named NIL.

(*m*__dolist__ (*var* *list* [*result*NIL]) (__declare__ $\widehat{decl}$*)* {$\widehat{tag}$|*form*}*)
▷ Evaluate *s*__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 *s*__block__ named NIL.

9.7 Loop Facility

(*m*__loop__ *form**)
▷ **Simple Loop.** If *form*s do not contain any atomic Loop Facility keywords, evaluate them forever in an implicit *s*__block__ named NIL.

(*m*__loop__ *clause**)
▷ **Loop Facility.** For Loop Facility keywords see below and Figure 1.

__named__ *n*NIL ▷ Give *m*__loop__'s implicit *s*__block__ a name.

{__with__ {*var-s* / (*var-s**)} [*d-type*] [= *foo*]}+
{__and__ {*var-p* / (*var-p**)} [*d-type*] [= *bar*]}*
where destructuring type specifier *d-type* has the form
{__fixnum__|__float__|T|NIL|{__of-type__ {*type* / (*type**)}}}
▷ Initialize (possibly trees of) local variables *var-s* sequentially and *var-p* in parallel.

{{__for__|__as__} {*var-s* / (*var-s**)} [*d-type*]}+ {__and__ {*var-p* / (*var-p**)} [*d-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__.

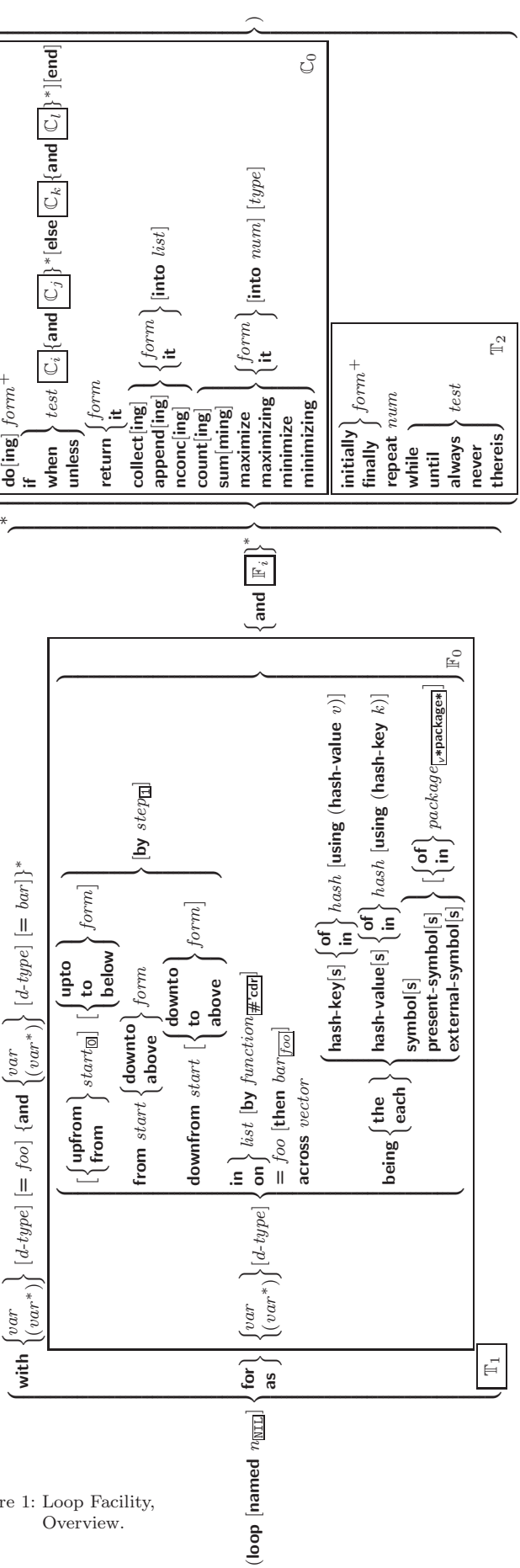

Figure 1: Loop Facility, Overview.

{**upfrom**|**from**|**downfrom**} *start*
▷ Start stepping with *start*

{**upto**|**downto**|**to**|**below**|**above**} *form*
▷ Specify *form* as the end value for stepping.

{**in**|**on**} *list*
▷ Bind *var* to successive elements/tails, respectively, of *list*.

by {*step*[1]|*function*[#'cdr]}
▷ Specify the (positive) decrement or increment or the *function* of one argument returning the next part of the list.

= *foo* [**then** *bar*[*foo*]]
▷ Bind *var* initially to *foo* and later to *bar*.

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

being {**the**|**each**}
▷ Iterate over a hash table or a package.

{**hash-key**|**hash-keys**} {**of**|**in**} *hash-table* [**using** (**hash-value** *value*)]
▷ Bind *var* successively to the keys of *hash-table*; bind *value* to corresponding values.

{**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*[*#*package**]]
▷ Bind *var* successively to the accessible symbols, or the present symbols, or the external symbols respectively, of *package*.

{**do**|**doing**} *form*$^+$ ▷ Evaluate *form*s 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-clause*s; otherwise, evaluate *k-clause* and *l-clause*s.

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 *form*s 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
|
(*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 *superclass*es. 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*). *slot*s with **:allocation :class** are shared by all instances of class *foo*.

($_f$**find-class** *symbol* [*errorp* **t** [*environment*]])
▷ Return class named *symbol*. **setf**able.

($_g$**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 *initarg*s by means of $_g$**shared-initialize**.

($_f$**slot-value** *foo slot*) ▷ Return value of *slot* in *foo*. **setf**able.

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

($_m$**with-slots** ({$\widehat{slot}$ | ($\widehat{var}$ $\widehat{slot}$)}*) / $_m$**with-accessors** (($\widehat{var}$ $\widehat{accessor}$)*)) *instance* (**declare** $\widehat{decl}$*)* *form*^{P}*)
▷ Return values of *forms* after evaluating them in a lexical environment with slots of *instance* visible as **setf**able *slot*s or *var*s/with *accessor*s of *instance* visible as **setf**able *var*s.

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

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

($_g$**change-class** $\widehat{instance}$ *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 *value*s of the corresponding *initarg*s 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 *value*s; set any remaining *added-slots* to the values of their **:initform** forms. Not to be called by user.

($_g$**allocate-instance** *class* {**:***initarg value*}* *other-keyarg**)
▷ Return uninitialized instance of *class*. Called by $_g$**make-instance**.

($_g$**shared-initialize** *instance* {*initform-slots* | T} {**:***initarg-slot value*}* *other-keyarg**)
▷ Fill the *initarg-slot*s of *instance* with the corresponding *value*s, and fill those *initform-slots* that are not *initarg-slot*s with the values of their **:initform** forms.

($_g$**slot-missing** *class instance slot* {**setf** | **slot-boundp** | **slot-makunbound** | **slot-value**} [*value*])
($_g$**slot-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

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

($_m$**defgeneric** {*foo* | (**setf** *foo*)} (*required-var** [**&optional** {*var* | (*var*)}*] [**&rest** *var*] [**&key** {*var* | (*var* | (**:***key var*))}* [**&allow-other-keys**]])
{
(**:argument-precedence-order** *required-var*+)
(**declare** (**optimize** *method-selection-optimization*)+)
(**:documentation** $\widehat{string}$)
(**:generic-function-class** *gf-class* standard-generic-function)
(**:method-class** *method-class* standard-method)
(**:method-combination** *c-type* standard *c-arg**)
(**:method** *defmethod-args*)*
})

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

($_f$**ensure-generic-function** {*foo* | (**setf** *foo*)}
{| **:argument-precedence-order** *required-var*$^+$
| **:declare** (**optimize** *method-selection-optimization*)
| **:documentation** *string*
| **:generic-function-class** *gf-class*
| **:method-class** *method-class*
| **:method-combination** *c-type c-arg** |
| **:lambda-list** *lambda-list*
| **:environment** *environment* |}*)

▷ 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.

($_m$**defmethod** {*foo* | (**setf** *foo*)} [{**:before** | **:after** | **:around** | *qualifier**} primary method]
({*var* | (*spec-var* {*class* | (**eql** *bar*)})}* [**&optional**
{*var* | (*var* [*init* [*supplied-p*]])}*] [**&rest** *var*] [**&key**
{*var* | ({*var* | (**:***key var*)} [*init* [*supplied-p*]])}* [**&allow-other-keys**]]
[**&aux** {*var* | (*var* [*init*])}*])
{| (**declare** $\widehat{decl*}$)* | $\widehat{doc}$} $form^{P*}$)

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

({$_g$**add-method** | $_g$**remove-method**} *generic-function method*)

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

($_g$**find-method** *generic-function qualifiers specializers* [*error*$_{\boxed{\mathrm{T}}}$])

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

($_g$**compute-applicable-methods** *generic-function args*)

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

($_f$**call-next-method** *arg** current args)

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

($_g$**no-applicable-method** *generic-function arg**)

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

({$_f$**invalid-method-error** *method* | $_f$**method-combination-error**} *control arg**)

▷ Signal **error** on applicable method with invalid qualifiers, or on method combination. For *control* and *arg*s see **format**, page 38.

($_g$**no-next-method** *generic-function method 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*function-keywords *method*)
▷ Return list of keyword parameters of *method* and T if other keys are allowed.

(*g*method-qualifiers *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, *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, call all **:before** methods, most specific first, and the most specific primary method which supplies the values of the calling *f*call-next-method if any, or of the generic function; and which can call less specific primary methods via *f*call-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-type*s defined by the short form of *m*define-method-combination.

(*m*define-method-combination *c-type*
{ | **:documentation** *string*^ | **:identity-with-one-argument** *bool*[NIL] | **:operator** *operator*[*c-type*] | }*)
▷ **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-method*s are ordered [{**:most-specific-first** | **:most-specific-last**}[**:most-specific-first**]] (specified as *c-arg* in *m*defgeneric). Using *c-type* as the *qualifier* in *m*defmethod makes the method primary.

(*m*define-method-combination *c-type* (*ord-λ**) ((*group*
{ | * | (*qualifier** [*]) | *predicate* | }
{ | **:description** *control* | **:order** {**:most-specific-first** | **:most-specific-last**}[**:most-specific-first**] | **:required** *bool* | }*)
{ | (**:arguments** *method-combination-λ**) | (**:generic-function** *symbol*) | {(**declare** *decl**)* | *doc*^ | } | }
*body*P*)
▷ **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. *m*defgeneric), with *symbol* bound to the generic function, with *method-combination-λ** bound to the arguments of the generic function, and with *group*s bound to lists of methods. An applicable method becomes a member of the leftmost *group* whose *predicate* or *qualifier*s match. Methods can be called via *m*call-method. Lambda lists (*ord-λ**) and (*method-combination-λ**) according to *ord-λ* on page 18, the latter enhanced by an optional **&whole** argument.

(*m*call-method
{*method*^ | (*m*make-method *form*^)}[({*next-method*^ | (*m*make-method *form*^)}*)])

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

11 Conditions and Errors

For standardized condition types cf. Figure 2 on page 32.

(*m*define-condition *foo* (*parent-type** condition)
({ *slot*
| (*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 *condition-doc*)
| (:report { *string* | *report-function* }) })

▷ Define, as a subtype of *parent-type*s, 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*.

({ *f*signal | *f*warn | *f*error } { *condition* | *condition-type* {:*initarg-name value*}* | *control arg** })

▷ Unless handled, signal as condition, warning or error, respectively, *condition* or a new instance of *condition-type* or, with *f*format *control* and *arg*s (see page 38), simple-condition, simple-warning, or simple-error, respectively. From *f*signal and *f*warn, return NIL.

(*f*cerror *continue-control* { *condition continue-arg** | *condition-type* {:*initarg-name value*}* | *control arg** })

▷ Unless handled, signal as correctable error *condition* or a new instance of *condition-type* or, with *f*format *control* and *arg*s (see page 38), simple-error. In the debugger, use *f*format arguments *continue-control* and *continue-arg*s to tag the continue option. Return NIL.

(*m*ignore-errors *form*P*)

▷ Return values of *form*s or, in case of error*s*, NIL and the condition.
2

(*f*invoke-debugger *condition*)

▷ Invoke debugger with *condition*.

(*m*assert *test* [(*place**) [{ *condition continue-arg** | *condition-type* {:*initarg-name value*}* | *control arg** }]])

▷ If *test*, which may depend on *place*s, returns NIL, signal as correctable error *condition* or a new instance of *condition-type* or, with *f*format *control* and *arg*s (see page 38), error. When using the debugger's continue option, *place*s can be altered before re-evaluation of *test*. Return NIL.

(*m*handler-case *foo* (*type* ([*var*]) (declare $\widehat{decl^*}$)* *condition-form*^{P_*})*
[(:no-error (*ord*-λ*) (declare $\widehat{decl^*}$)* *form*^{P_*})])
▷ If, on evaluation of *foo*, a condition of *type* is signalled, evaluate matching *condition-form*s with *var* bound to the condition, and return their values. Without a condition, bind *ord*-λs to values of *foo* and return values of *form*s or, without a :no-error clause, return values of *foo*. See page 18 for (*ord*-λ*).

(*m*handler-bind ((*condition-type handler-function*)*) *form*^{P_*})
▷ Return values of *form*s after evaluating them with *condition-type*s dynamically bound to their respective *handler-function*s of argument condition.

(*m*with-simple-restart ([*restart* | NIL] *control arg**) *form*^{P_*})
▷ Return values of *form*s unless *restart* is called during their evaluation. In this case, describe *restart* using *f*format *control* and *arg*s (see page 38) and return NIL and T.

(*m*restart-case *form* (*restart* (*ord*-λ*) { :interactive *arg-function* | :report [*report-function* | *string* "*restart*"] | :test *test-function* T }
(declare $\widehat{decl^*}$)* *restart-form*^{P_*})*)
▷ Return values of *form* or, if during evaluation of *form* one of the dynamically established *restart*s is called, the values of its *restart-form*s. A *restart* is visible under *condition* if (funcall #'*test-function condition*) returns T. If presented in the debugger, *restart*s are described by *string* or by #'*report-function* (of a stream). A *restart* can be called by (invoke-restart *restart arg**), where *arg*s match *ord*-λ*, or by (invoke-restart-interactively *restart*) where a list of the respective *arg*s is supplied by #'*arg-function*. See page 18 for *ord*-λ*.

(*m*restart-bind (([$\widehat{restart}$ | NIL] *restart-function*
{ :interactive-function *arg-function* | :report-function *report-function* | :test-function *test-function* }*) *form*^{P_*})
▷ Return values of *form*s evaluated with dynamically established *restart*s whose *restart-function*s should perform a nonlocal transfer of control. A restart is visible under *condition* if (*test-function condition*) returns T. If presented in the debugger, *restart*s are described by *restart-function* (of a stream). A *restart* can be called by (invoke-restart *restart arg**), where *arg*s must be suitable for the corresponding *restart-function*, or by (invoke-restart-interactively *restart*) where a list of the respective *arg*s 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 unassociated 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 $_f$**format** control or list of $_f$**format** arguments, respectively, of *condition*.

$_v$***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.
2

($_s$**the** $\widehat{type}$ *form*) ▷ Declare values of *form* to be of *type*.

($_f$**coerce** *object type*) ▷ Coerce *object* into *type*.

($_m$**typecase** *foo* ($\widehat{type}$ *a-form*^{P*})* [($\left\{\begin{matrix}\textbf{otherwise}\\ \textbf{T}\end{matrix}\right\}$ *b-form*$^{P*}_{NIL}$)])
▷ Return values of the first *a-form** whose *type* is *foo* of. Return values of *b-forms* if no *type* matches.

($\left\{\begin{matrix}_m\textbf{etypecase}\\ _m\textbf{ctypecase}\end{matrix}\right\}$ *foo* ($\widehat{type}$ *form*^{P*})*)
▷ Return values of the first *form** whose *type* is *foo* of. Signal non-correctable/correctable **type-error** if no *type* matches.

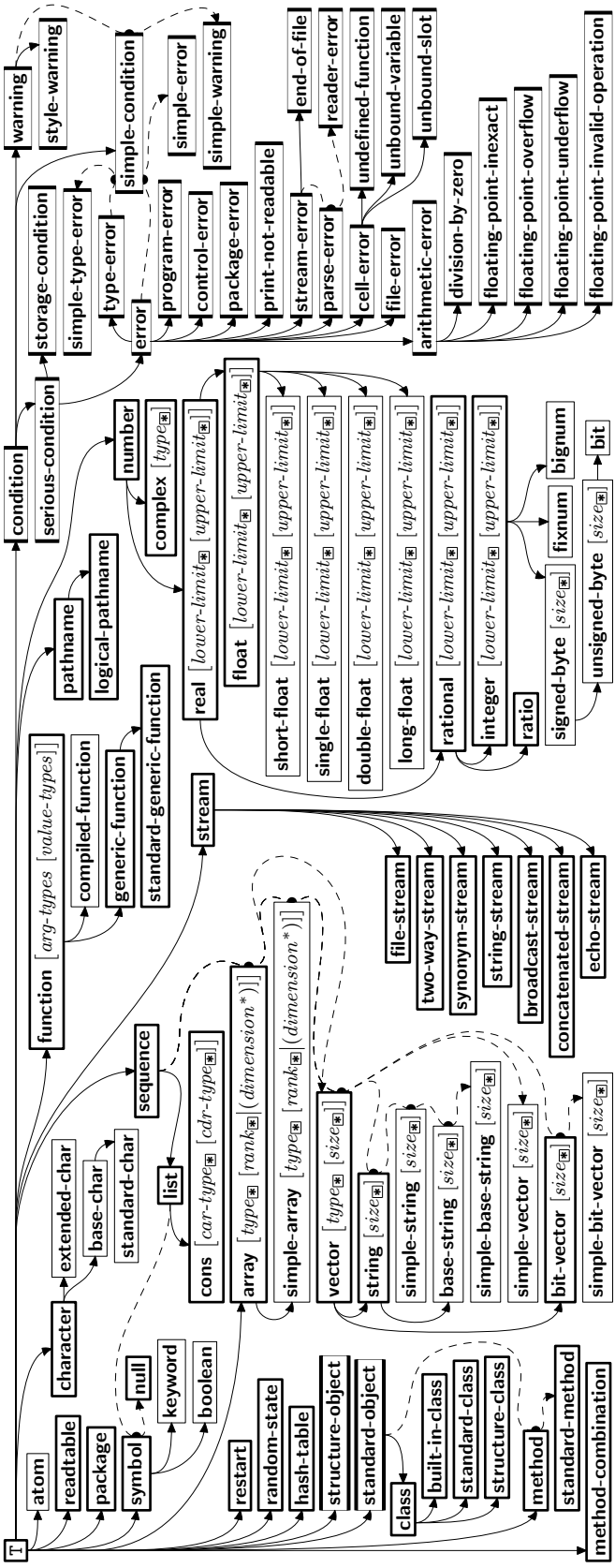

Figure 2: Precedence Order of System Classes (▭), Classes (▬), Types (▭), and Condition Types (▭).
Every type is also a supertype of `NIL`, the empty type.

(*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**) { (__declare__ *decl**)* | *doc* } *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 *form*s to *arg*s returning the new type. For (*macro-λ**) see page 19 but with default value of * instead of NIL. *form*s are enclosed in an implicit *s*__block__ named *foo*.

(__eql__ *foo*)
(__member__ *foo**) ▷ Specifier for a type comprising *foo* or *foo*s.

(__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**T) ▷ Type specifier for intersection of *type*s.

(__or__ *type**NIL) ▷ Type specifier for union of *type*s.

(__values__ *type** [__&optional__ *type** [__&rest__ *other-args*]])
▷ Type specifier for multiple values.

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

13 Input/Output

13.1 Predicates

(*f*__streamp__ *foo*)
(*f*__pathnamep__ *foo*) ▷ T if *foo* is of indicated type.
(*f*__readtablep__ *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

($\left\{\begin{matrix}_f\textbf{y-or-n-p}\\ _f\textbf{yes-or-no-p}\end{matrix}\right\}$ [*control* *arg**])
▷ Ask user a question and return `T` or `NIL` depending on their answer. See page 38, $_f$**format**, for *control* and *arg*s.

($_m$**with-standard-io-syntax** *form*^{P*})
▷ Evaluate *form*s with standard behaviour of reader and printer. Return values of *form*s.

($\left\{\begin{matrix}_f\textbf{read}\\ _f\textbf{read-preserving-whitespace}\end{matrix}\right\}$ [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*eof-err*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [*recursive*$_{\texttt{NIL}}$]]]])
▷ Read printed representation of object.

($_f$**read-from-string** *string* [*eof-error*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [$\left\{\begin{matrix}\textbf{:start}\ start_{0}\\ \textbf{:end}\ end_{\texttt{NIL}}\\ \textbf{:preserve-whitespace}\ bool_{\texttt{NIL}}\end{matrix}\right\}$]]])
▷ Return object read from string and zero-indexed position$_2$ of next character.

($_f$**read-delimited-list** *char* [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*recursive*$_{\texttt{NIL}}$]])
▷ Continue reading until encountering *char*. Return list of objects read. Signal error if no *char* is found in stream.

($_f$**read-char** [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*eof-err*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [*recursive*$_{\texttt{NIL}}$]]]])
▷ Return next character from *stream*.

($_f$**read-char-no-hang** [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*eof-error*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [*recursive*$_{\texttt{NIL}}$]]]])
▷ Next character from *stream* or `NIL` if none is available.

($_f$**peek-char** [*mode*$_{\texttt{NIL}}$ [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*eof-error*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [*recursive*$_{\texttt{NIL}}$]]]])
▷ 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* [$\widetilde{stream}_{_v\textbf{*standard-input*}}$])
▷ Put last $_f$**read-char**ed *character* back into *stream*; return `NIL`.

($_f$**read-byte** $\widetilde{stream}$ [*eof-err*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$]])
▷ Read next byte from binary *stream*.

($_f$**read-line** [$\widetilde{stream}_{_v\textbf{*standard-input*}}$ [*eof-err*$_{\texttt{T}}$ [*eof-val*$_{\texttt{NIL}}$ [*recursive*$_{\texttt{NIL}}$]]]])
▷ Return a line of text from *stream* and `T`$_2$ if line has been ended by end of file.

($_f$**read-sequence** $\widetilde{sequence}$ $\widetilde{stream}$ [**:start** *start*$_0$][**:end** *end*$_{\texttt{NIL}}$])
▷ 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*)$_{\textbf{:upcase}}$
▷ Case sensitivity attribute (one of **:upcase**, **:downcase**, **:preserve**, **:invert**) of *readtable*. **setf**able.

($_f$**copy-readtable** [*from-readtable*$_{_v\textbf{*readtable*}}$ [*to-*$\widetilde{readtable}_{\texttt{NIL}}$]])
▷ Return copy of *from-readtable*.

($_f$**set-syntax-from-char** *to-char* *from-char* [*to-*$\widetilde{readtable}_{_v\textbf{*readtable*}}$ [*from-readtable*$_{\text{standard readtable}}$]])
▷ Copy syntax of *from-char* to *to-readtable*. Return `T`.

$_v$***readtable*** ▷ Current readtable.

*v****read-base*** 10 ▷ Radix for reading **integer**s and **ratio**s.

*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*
; *continuation* ▷ Regarding line on which it appears.

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

" ▷ Begin and end of a string.

'*foo* ▷ (*s* **quote** *foo*); *foo* unevaluated.

`([*foo*] [**,***bar*] [**,@***baz*] [**,.***quux*] [*bing*])
▷ Backquote. *s* **quote** *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* ▷ (*f* **character "***c***"**), the character *c*.

#B*n*; **#O***n*; *n***.**; **#X***n*; **#***r***R***n*
▷ Integer of radix 2, 8, 10, 16, or *r*; $2 \le r \le 36$.

*n***/***d* ▷ The **ratio** $\frac{n}{d}$.

$\Big\{[m].n[\{\mathbf{S}|\mathbf{F}|\mathbf{D}|\mathbf{L}|\mathbf{E}\}x_{\boxed{\mathbf{E0}}}]\Big|m[.[n]]\{\mathbf{S}|\mathbf{F}|\mathbf{D}|\mathbf{L}|\mathbf{E}\}x\Big\}$
▷ $m.n \cdot 10^x$ 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*.

#*n***A***sequence* ▷ *n*-dimensional array.

#[*n*]**(***foo**)
▷ Vector of some (or *n*) *foo*s filled with last *foo* if necessary.

#[n]*****b^*
▷ Bit vector of some (or n) bs filled with last b if necessary.

#S(*type* {*slot value*}***)** ▷ Structure of *type*.

#P*string* ▷ A pathname.

#:*foo* ▷ Uninterned symbol *foo*.

#.*form* ▷ Read-time value of *form*.

$_v$***read-eval*** T ▷ 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 $_v$***features***, or ({**and**|**or**} *feature**), or (**not** *feature*).

$_v$***features***
▷ List of symbols denoting implementation-dependent features.

|c^*|; \c
▷ Treat arbitrary character(s) c as alphabetic preserving case.

13.4 Printer

($\left\{\begin{matrix}{}_f\textbf{prin1}\\ {}_f\textbf{print}\\ {}_f\textbf{pprint}\\ {}_f\textbf{princ}\end{matrix}\right\}$ *foo* [*stream*$_{v\textbf{*standard-output*}}$])
▷ Print *foo* to *stream* $_f$**read**ably, $_f$**read**ably between a newline and a space, $_f$**read**ably after a newline, or human-readably without any extra characters, respectively. $_f$**prin1**, $_f$**print** and $_f$**princ** return *foo*.

($_f$**prin1-to-string** *foo*)
($_f$**princ-to-string** *foo*)
▷ Print *foo* to *string* $_f$**read**ably or human-readably, respectively.

($_g$**print-object** *object stream*)
▷ Print *object* to *stream*. Called by the Lisp printer.

($_m$**print-unreadable-object** (*foo stream* $\left\{\begin{matrix}\textbf{:type}\ bool_{\texttt{NIL}}\\ \textbf{:identity}\ bool_{\texttt{NIL}}\end{matrix}\right\}$) $form^{P*}$)
▷ Enclosed in **#<** and **>**, print *foo* by means of *form*s to *stream*. Return NIL.

($_f$**terpri** [*stream*$_{v\textbf{*standard-output*}}$])
▷ Output a newline to *stream*. Return NIL.

($_f$**fresh-line** [*stream*$_{v\textbf{*standard-output*}}$])
▷ Output a newline to *stream* and return T unless *stream* is already at the start of a line.

($_f$**write-char** *char* [*stream*$_{v\textbf{*standard-output*}}$])
▷ Output *char* to *stream*.

($\left\{\begin{matrix}{}_f\textbf{write-string}\\ {}_f\textbf{write-line}\end{matrix}\right\}$ *string* [*stream*$_{v\textbf{*standard-output*}}$ [$\left\{\begin{matrix}\textbf{:start}\ start_{0}\\ \textbf{:end}\ end_{\texttt{NIL}}\end{matrix}\right\}$]])
▷ Write *string* to *stream* without/with a trailing newline.

($_f$**write-byte** *byte stream*) ▷ Write *byte* to binary *stream*.

($_f$**write-sequence** *sequence* $\widetilde{stream}$ $\left\{\begin{array}{l|l}\textbf{:start} & start_{\boxed{0}}\\ \textbf{:end} & end_{\boxed{\texttt{NIL}}}\end{array}\right\}$)

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

($\left\{\begin{array}{l}{}_f\textbf{write}\\ {}_f\textbf{write-to-string}\end{array}\right\}$ *foo* $\left\{\begin{array}{l|l}\textbf{:array} & bool\\ \textbf{:base} & radix\\ \textbf{:case} & \left\{\begin{array}{l}\textbf{:upcase}\\ \textbf{:downcase}\\ \textbf{:capitalize}\end{array}\right.\\ \textbf{:circle} & bool\\ \textbf{:escape} & bool\\ \textbf{:gensym} & bool\\ \textbf{:length} & \{int\,|\,\texttt{NIL}\}\\ \textbf{:level} & \{int\,|\,\texttt{NIL}\}\\ \textbf{:lines} & \{int\,|\,\texttt{NIL}\}\\ \textbf{:miser-width} & \{int\,|\,\texttt{NIL}\}\\ \textbf{:pprint-dispatch} & dispatch\text{-}table\\ \textbf{:pretty} & bool\\ \textbf{:radix} & bool\\ \textbf{:readably} & bool\\ \textbf{:right-margin} & \{int\,|\,\texttt{NIL}\}\\ \textbf{:stream} & \widetilde{stream}_{\boxed{{}_v\textbf{*standard-output*}}}\end{array}\right.$)

▷ 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 $_f$**write** only.)

($_f$**pprint-fill** $\widetilde{stream}$ *foo* [*parenthesis*$_{\boxed{\texttt{T}}}$ [*noop*]])
($_f$**pprint-tabular** $\widetilde{stream}$ *foo* [*parenthesis*$_{\boxed{\texttt{T}}}$ [*noop* [$n_{\boxed{16}}$]]])
($_f$**pprint-linear** $\widetilde{stream}$ *foo* [*parenthesis*$_{\boxed{\texttt{T}}}$ [*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 $_f$**format** directive ~//.

($_m$**pprint-logical-block** ($\widetilde{stream}$ *list* $\left\{\left\{\begin{array}{l|l}\textbf{:prefix} & string\\ \textbf{:per-line-prefix} & string\end{array}\right\}\left\{\begin{array}{l|l}\textbf{:suffix} & string_{\boxed{\texttt{""}}}\end{array}\right\}\right\}$)
(**declare** $\widehat{decl}^*$)* $form^{\boxed{\texttt{P}}*}$)

▷ Evaluate *form*s, 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 $_f$**write**. Return NIL.

($_m$**pprint-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*.

($_f$**pprint-tab** $\left\{\begin{array}{l}\textbf{:line}\\ \textbf{:line-relative}\\ \textbf{:section}\\ \textbf{:section-relative}\end{array}\right\}$ c i [$\widetilde{stream}_{\boxed{{}_v\textbf{*standard-output*}}}$])

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

($_f$**pprint-indent** $\left\{\begin{array}{l}\textbf{:block}\\ \textbf{:current}\end{array}\right\}$ n [$\widetilde{stream}_{\boxed{{}_v\textbf{*standard-output*}}}$])

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

($_m$**pprint-exit-if-list-exhausted**)

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

($_f$**pprint-newline** $\left\{\begin{array}{l}\textbf{:linear}\\ \textbf{:fill}\\ \textbf{:miser}\\ \textbf{:mandatory}\end{array}\right\}$ [$\widetilde{stream}_{\boxed{{}_v\textbf{*standard-output*}}}$])

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

$_v$***print-array*** ▷ If T, print arrays $_f$**read**ably.

$_v$***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 $_f$**read**ably 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*[0] [*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** $\widehat{\textit{control}}$)
▷ Return function of *stream* and *arg** applying $_f$**format** to *stream*, *control*, and *arg** returning NIL or any excess *arg*s.

($_f$**format** {T|NIL|*out-string*|*out-stream*} *control arg**)
▷ Output string *control* which may contain ~ directives possibly taking some *arg*s. 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*[0]] [,[*col-inc*[1]] [,[*min-pad*[0]] [,'*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-char*s on the left rather than on the right.

~ [*radix*$_{10}$] [,[*width*] [,['*pad-char*$_{\sqcup}$] [,['*comma-char*$_{,}$] [,*comma-interval*$_{3}$]]]] [:] [@] **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*$_{\sqcup}$] [,['*comma-char*$_{,}$] [,*comma-interval*$_{3}$]]] [:] [@] {**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*$_{0}$] [,['*overflow-char*] [,'*pad-char*$_{\sqcup}$]]]] [@] **F**
▷ **Fixed-Format Floating-Point.** With **@**, always prepend a sign.

~ [*width*] [,[*dec-digits*] [,[*exp-digits*] [,[*scale-factor*$_{1}$] [,['*overflow-char*] [,['*pad-char*$_{\sqcup}$] [,'*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*$_{2}$] [,[*int-digits*$_{1}$] [,[*width*$_{0}$] [,'*pad-char*$_{\sqcup}$]]] [:] [@] **$**
▷ **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 **eql** `1` print nothing, otherwise print `s`; do the same for the previous argument; if argument **eql** `1` print `y`, otherwise print `ies`; do the same for the previous argument, respectively.

~ [n_{1}] **%** ▷ **Newline.** Print n newlines.

~ [n_{1}] **&**
▷ **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_{1}] **|** ▷ **Page.** Print n page separators.

~ [n_{1}] **~** ▷ **Tilde.** Print n tildes.

~ [*min-col*$_{0}$] [,[*col-inc*$_{1}$] [,[*min-pad*$_{0}$] [,'*pad-char*$_{\sqcup}$]]] [:] [@] **<** [*nl-text* **~**[*spare*$_{0}$ [,*width*]]**:;**] {*text* **~;**}* *text* **~>**
▷ **Justification.** Justify text produced by *text*s 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.

~ [:] [@] < {[*prefix*"" ~;]|[*per-line-prefix* ~@;]} *body* [~; *suffix*"" ~:] ~: [@] >
▷ **Logical Block.** Act like **pprint-logical-block** using *body* as *f***format** control string on the elements of the list argument or, with @, on the remaining arguments, which are extracted by **pprint-pop**. With :, *prefix* and *suffix* default to (and). When closed by ~@:>, spaces in *body* are replaced with conditional newlines.

{~ [*n*0] i|~ [*n*0] :i}
▷ **Indent.** Set indentation to *n* relative to leftmost/to current position.

~ [*c*1] [,*i*1] [:] [@] 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 @, move to column number c_0+c+ki where c_0 is the current position.

{~ [*m*1] *|~ [*m*1] :*|~ [*n*0] @*}
▷ **Go-To.** Jump *m* arguments forward, or backward, or to argument *n*.

~ [*limit*] [:] [@] { *text* ~}
▷ **Iteration.** Use *text* repeatedly, up to *limit*, as control string for the elements of the list argument or (with @) for the remaining arguments. With : or @:, 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*] [:] [@] [[{*text* ~;}* *text*] [~:; *default*] ~]
▷ **Conditional Expression.** Use the zero-indexed argumenth (or *i*th if given) *text* as a *f***format** control subclause. With :, use the first *text* if the argument value is `NIL`, or the second *text* if it is `T`. With @, do nothing for an argument value of `NIL`. Use the only *text* and leave the argument to be read again if it is `T`.

{~?|~@?}
▷ **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*}*] [:] [@] /[*package* [:]:cl-user:]*function*/
▷ **Call Function.** Call all-uppercase *package*::*function* with the arguments stream, format-argument, colon-p, at-sign-p and *prefix*es for printing format-argument.

~ [:] [@] W
▷ **Write.** Print argument of any type obeying every printer control variable. With :, pretty-print. With @, 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

(ƒ**open** *path* { **:direction** { **:input** | **:output** | **:io** | **:probe** } [**:input**] | **:element-type** { *type* | **:default** } [**character**] | **:if-exists** { **:new-version** | **:error** | **:rename** | **:rename-and-delete** | **:overwrite** | **:append** | **:supersede** | NIL } [**:new-version** if *path* specifies **:newest**; NIL otherwise] | **:if-does-not-exist** { **:error** | **:create** | NIL } [NIL for **:direction :probe**; {**:create**|**:error**} otherwise] | **:external-format** *format* [**:default**] })

▷ Open **file-stream** to *path*.

(ƒ**make-concatenated-stream** *input-stream**)
(ƒ**make-broadcast-stream** *output-stream**)
(ƒ**make-two-way-stream** *input-stream-part output-stream-part*)
(ƒ**make-echo-stream** *from-input-stream to-output-stream*)
(ƒ**make-synonym-stream** *variable-bound-to-stream*)

▷ Return stream of indicated type.

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

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

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

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

(ƒ**concatenated-stream-streams** *concatenated-stream*)
(ƒ**broadcast-stream-streams** *broadcast-stream*)

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

(ƒ**two-way-stream-input-stream** *two-way-stream*)
(ƒ**two-way-stream-output-stream** *two-way-stream*)
(ƒ**echo-stream-input-stream** *echo-stream*)
(ƒ**echo-stream-output-stream** *echo-stream*)

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

(ƒ**synonym-stream-symbol** *synonym-stream*)

▷ Return symbol of *synonym-stream*.

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

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

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

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

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

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

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

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

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

▷ Clear input from *stream*, return NIL.

({ ƒ**clear-output** | ƒ**force-output** | ƒ**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** $\widetilde{stream}$ [**:abort** $bool_{\texttt{NIL}}$])
▷ 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** $\widehat{decl}^*$)* $form^{P*}$)
▷ Use $_f$**open** with *open-arg*s to temporarily create *stream* to *path*; return values of *form*s.

($_m$**with-open-stream** (*foo* $\widetilde{stream}$) (**declare** $\widehat{decl}^*$)* $form^{P*}$)
▷ Evaluate *form*s with *foo* locally bound to *stream*. Return values of *form*s.

($_m$**with-input-from-string** (*foo string* { **:index** $\widetilde{index}$ | **:start** $start_{0}$ | **:end** $end_{\texttt{NIL}}$ }) (**declare** $\widehat{decl}^*$)* $form^{P*}$)
▷ Evaluate *form*s with *foo* locally bound to input **string-stream** from *string*. Return values of *form*s; store next reading position into *index*.

($_m$**with-output-to-string** (*foo* [$\widetilde{string}_{\texttt{NIL}}$ [**:element-type** $type_{\textbf{character}}$]])
(**declare** $\widehat{decl}^*$)* $form^{P*}$)
▷ Evaluate *form*s with *foo* locally bound to an output **string-stream**. Append output to *string* and return values of *form*s if *string* is given. Return string containing output otherwise.

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

$_v$***terminal-io*** ▷ Bidirectional stream to user terminal.

$_v$***standard-input***
$_v$***standard-output***
$_v$***error-output***
▷ Standard input stream, standard output stream, or standard error output stream, respectively.

$_v$***debug-io***
$_v$***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** | **:relative** } { *directory* | **: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*$_{\text{host from }\,_v\textbf{*default-pathname-defaults*}}$
:case {**:local**|**:common**}$_{\textbf{:local}}$ })
▷ 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** }$_{\textbf{:local}}$])
($_f$**pathname-version** *path-or-stream*)
▷ Return pathname component.

(*f* **parse-namestring** *foo* [*host* [*default-pathname*$_{v}$ ***default-pathname-defaults***
{ | **:start** *start*$_{0}$ | **:end** *end*$_{\texttt{NIL}}$ | **:junk-allowed** *bool*$_{\texttt{NIL}}$ | }]])
▷ Return pathname converted from string, pathname, or stream *foo*; and position$_{2}$ where parsing stopped.

(*f* **merge-pathnames** *path-or-stream*
[*default-path-or-stream*$_{v}$ ***default-pathname-defaults***
[*default-version*$_{\texttt{:newest}}$]])
▷ 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*|*}$^{+}$|LISP}[.{*version*|*|newest|NEWEST}]]".

(*f* **logical-pathname-translations** *logical-host*)
▷ List of (*from-wildcard to-wildcard*) translations for *logical-host*. **setf**able.

(*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$_{2}$, and new physical file name$_{3}$.

(*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 22.

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-symbol*s, symbols from *used-package*s, *imported-symbol*s, and *shd-symbol*s. Add *shd-symbol*s 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.

(*f*import / *f*shadowing-import *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.

(*f*shadow *symbols* [*package*$_{v*package*}$])
▷ Make *symbols* of *package* shadow any otherwise accessible, equally named symbols from other packages. Return T.

(*f*package-shadowing-symbols *package*)
▷ List of symbols of *package* that shadow any otherwise accessible, equally named symbols from other packages.

(*f*export *symbols* [*package*$_{v*package*}$])
▷ Make *symbols* external to *package*. Return T.

(*f*unexport *symbols* [*package*$_{v*package*}$])
▷ Revert *symbols* to internal status. Return T.

(*m*do-symbols / *m*do-external-symbols / *m*do-all-symbols (*var* [*result*$_{NIL}$]) (*var* [*package*$_{v*package*}$ [*result*$_{NIL}$]]))
(**declare** *decl**)* { *tag* | *form* }*)
▷ Evaluate *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 *s*block named NIL.

(*m*with-package-iterator (*foo packages* [**:internal**|**:external**|**:inherited**])
(**declare** *decl**)* *form*^{P}*)
▷ Return values of *form*s. In *form*s, 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.

(*f*require *module* [*paths*$_{NIL}$])
▷ If not in *v**modules*, try *paths* to load *module* from. Signal **error** if unsuccessful. Deprecated.

(*f*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*).

(*f*make-symbol *name*)
▷ Make fresh, uninterned symbol *name*.

(*f*gensym [*s*G])
▷ Return fresh, uninterned symbol #:*sn* with *n* from *v**gensym-counter*. Increment *v**gensym-counter*.

(*f*gentemp [*prefix*T [*package*v*package*]])
▷ Intern fresh symbol in package. Deprecated.

(*f*copy-symbol *symbol* [*props*NIL])
▷ Return uninterned copy of *symbol*. If *props* is T, give copy the same value, function and property list.

(*f*symbol-name *symbol*)
(*f*symbol-package *symbol*)
(*f*symbol-plist *symbol*)
(*f*symbol-value *symbol*)
(*f*symbol-function *symbol*)
▷ Name, package, property list, value, or function, respectively, of *symbol*. setfable.

(*g*documentation | (setf *g*documentation) *new-doc*) *foo* 'variable|'function|'compiler-macro|'method-combination|'structure|'type|'setf|T)
▷ Get/set documentation string of *foo* of given type.

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

*c*nil|*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*special-operator-p *foo*) ▷ T if *foo* is a special operator.

(*f*compiled-function-p *foo*) ▷ T if *foo* is of type compiled-function.

15.2 Compilation

(*f*compile NIL *definition* | *name* | (setf *name*) [*definition*])
▷ Return compiled function or replace *name*'s function definition with the compiled function. Return T/2 in case of warnings or errors, and T/3 in case of warnings or errors excluding style-warnings.

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

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

(*f*__compile-file-pathname__ *file* [__:output-file__ *path*] [*other-keyargs*])

▷ Pathname *f*__compile-file__ writes to if invoked with the same arguments.

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

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

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

▷ Input file used by *f*__compile-file__/by *f*__load__.

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

▷ Defaults used by *f*__compile-file__/by *f*__load__.

(*s*__eval-when__ ($\left\{\begin{array}{l}\{\text{:compile-toplevel}\,|\,\text{compile}\}\\ \{\text{:load-toplevel}\,|\,\text{load}\}\\ \{\text{:execute}\,|\,\text{eval}\}\end{array}\right\}$) *form*^{P}*)

▷ Return values of *form*s 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 *form*s are not evaluated. (__compile__, __load__ and __eval__ deprecated.)

(*s*__locally__ (__declare__ $\widehat{\textit{decl}^*}$)* *form*^{P}*)

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

(*m*__with-compilation-unit__ ([__:override__ *bool*$_{\text{NIL}}$]) *form*^{P}*)

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

(*s*__load-time-value__ *form* [$\widehat{\textit{read-only}_{\text{NIL}}}$])

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

(*s*__quote__ $\widehat{\textit{foo}}$) ▷ 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 initialization of the object.

(*f*__make-load-form-saving-slots__ *foo* $\left\{\begin{array}{l}\text{:slot-names } \textit{slots}_{\text{all local slots}}\\ \text{:environment } \textit{environment}\end{array}\right\}$)

▷ 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__ $\left\{\begin{array}{l}\textit{name}\\ (\text{setf } \textit{name})\end{array}\right\}$ [*environment*])

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

(*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*$_{\texttt{NIL}}$])
▷ Print interned symbols containing *string*.

($_f$**apropos-list** *string* [*package*$_{\texttt{NIL}}$])
▷ 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*$_{\texttt{NIL}}$]) ▷ Invoke editor if possible.

($\left\{\begin{matrix}{}_f\textbf{macroexpand-1}\\ {}_f\textbf{macroexpand}\end{matrix}\right\}$ *form* [*environment*$_{\texttt{NIL}}$])
▷ Return macro expansion, once or entirely, respectively, of *form* and $\frac{\texttt{T}}{2}$ if *form* was a macro form. Return *form* and $\frac{\texttt{NIL}}{2}$ otherwise.

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

($_m$**trace** $\left\{\begin{matrix}\textit{function}\\ (\textbf{setf}\ \textit{function})\end{matrix}\right\}^*$)
▷ Cause *function*s to be traced. With no arguments, return list of traced functions.

($_m$**untrace** $\left\{\begin{matrix}\textit{function}\\ (\textbf{setf}\ \textit{function})\end{matrix}\right\}^*$)
▷ Stop *function*s, or each currently traced function, from being traced.

$_v$***trace-output***
▷ Output stream $_m$**trace** and $_m$**time** send their output to.

($_m$**step** *form*)
▷ Step through evaluation of *form*. Return values of *form*.

($_f$**break** [*control arg**])
▷ Jump directly into debugger; return NIL. See page 38, $_f$**format**, for *control* and *arg*s.

($_m$**time** *form*)
▷ Evaluate *form*s and print timing information to $_v$***trace-output***. Return values of *form*.

($_f$**inspect** *foo*) ▷ Interactively give information about *foo*.

($_f$**describe** *foo* [$\widetilde{\textit{stream}}_{v\textbf{*standard-output*}}$])
▷ Send information about *foo* to *stream*.

($_g$**describe-object** *foo* [$\widetilde{\textit{stream}}$])
▷ Send information about *foo* to *stream*. Called by $_f$**describe**.

($_f$**disassemble** *function*)
▷ Send disassembled representation of *function* to $_v$***standard-output***. Return NIL.

($_f$**room** [{NIL|**:default**|T}$_{\textbf{:default}}$])
▷ Print information about internal storage management to ***standard-output***.

15.4 Declarations

(*f*proclaim *decl*)
(*m*declaim $\widehat{decl^*}$)
▷ 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 *foo*s names of declarations.

(dynamic-extent *variable** (function *function*)*)
▷ Declare lifetime of *variable*s and/or *function*s to end when control leaves enclosing block.

([type] *type variable**)
(ftype *type function**)
▷ Declare *variable*s or *function*s to be of *type*.

({ignorable / ignore} {*var* / (function *function*)}*)
▷ Suppress warnings about used/unused bindings.

(inline *function**)
(notinline *function**)
▷ Tell compiler to integrate/not to integrate, respectively, called *function*s into the calling routine.

(optimize { compilation-speed | (compilation-speed $n_{[3]}$) / debug | (debug $n_{[3]}$) / safety | (safety $n_{[3]}$) / space | (space $n_{[3]}$) / speed | (speed $n_{[3]}$) })
▷ Tell compiler how to optimize. $n = 0$ means unimportant, $n = 1$ is neutral, $n = 3$ means important.

(special *var**) ▷ Declare *var*s 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*$_{[\text{curr}]}$])
(*f*get-universal-time)
▷ Seconds from 1900-01-01, 00:00, ignoring leap seconds.

(*f*decode-universal-time *universal-time* [*time-zone*$_{[\text{current}]}$])
(*f*get-decoded-time)
▷ Return second$_{1}$, minute$_{2}$, hour$_{3}$, date$_{4}$, month$_{5}$, year$_{6}$, day$_{7}$, daylight-p$_{8}$, and zone$_{9}$.

(*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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