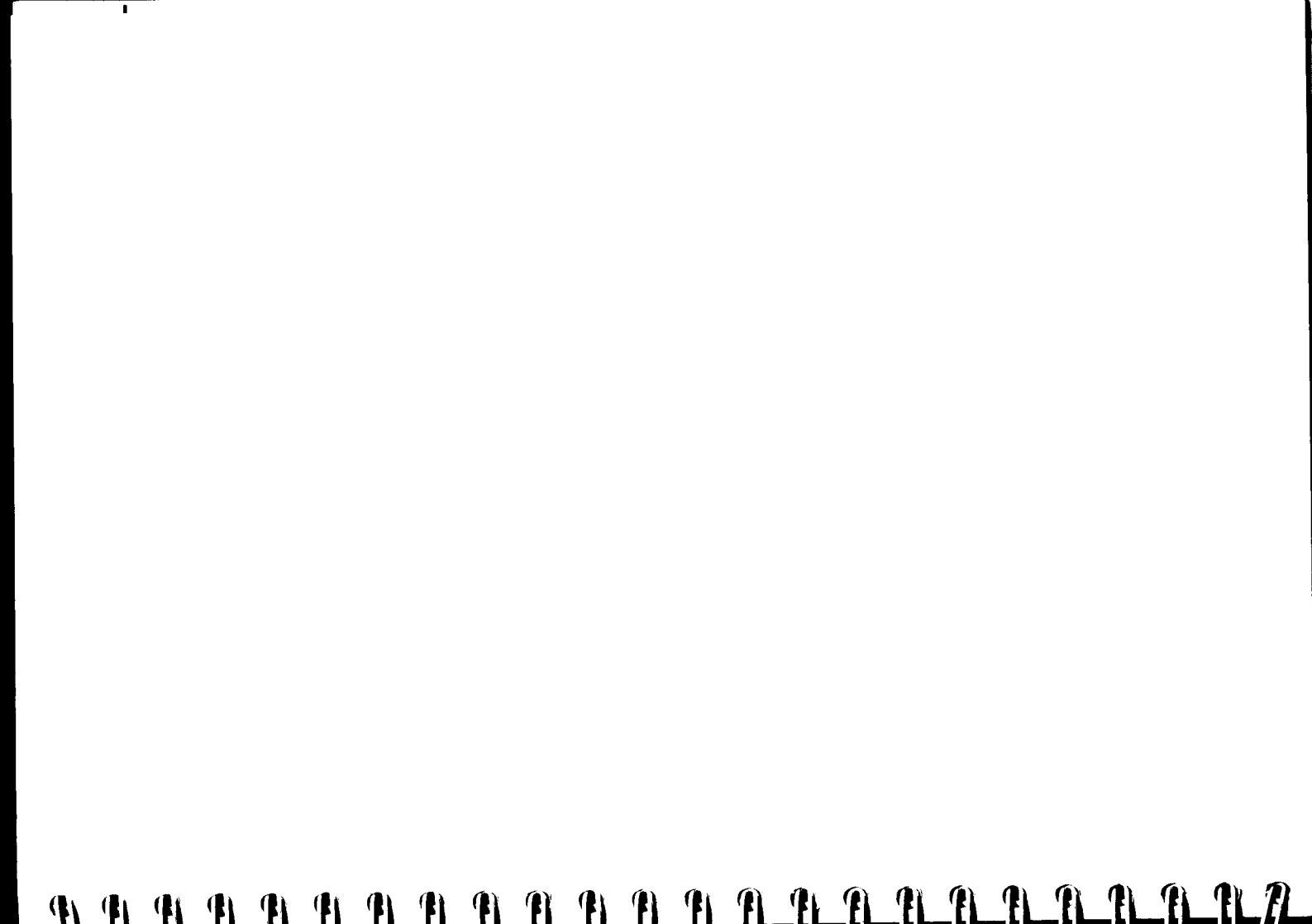
CAMBRIDGE LISP

reference manual

ARM Evaluation System

Acorn OEM Products



Cambridge LISP

Part No 0448,011
Issue No 1.0
15 August 1986

Within this publication the term 'BBC' is used as an abbreviation for 'British Broadcasting Corporation'.

- The manual is provided on an 'as is' basis except for warranties described in the software licence agreement if provided.
- The software and this manual are protected by Trade secret and Copyright laws.

The product described in this manual is subject to continuous developments and improvements. All particulars of the product and its use (including the information in this manual) are given by Acorn Computers in good faith.

There are no warranties implied or expressed including but not limited to implied warranties or merchantability or fitness for purpose and all such warranties are expressly and specifically disclaimed.

In case of difficulty please contact your supplier. Every step is taken to ensure that the quality of software and documentation is as high as possible. However, it should be noted that software cannot be written to be completely free of errors. To help Acorn rectify future versions, suspected deficiencies in software and documentation, unless notified otherwise, should be notified in writing to the following address:

Customer Services Department,
Acorn Computers Limited,
645 Newmarket Road,
Cambridge
CB5 8PD

ISBN 1 85250 006

Published by:
Acorn Computers Limited, Fulbourn Road, Cherry Hinton, Cambridge CB1 4JN, UK

Contents

Part I

Part II

Part I

1. Introduction

This is a guide to Acorn Cambridge LISP running under the Executive on Acorn ARM computers. This section describes the main features of the Acorn Cambridge LISP, and comments on the facilities provided. Please note that this manual is not a tutorial; appendix B contains several references to such texts. Throughout this manual, except where an alternative meaning is obvious, LISP refers to the Acorn ARM implementation of Cambridge LISP.

Cambridge LISP was originally developed to provide support for an ongoing research project in computer algebra. It is intended for running experimental programs, and so it makes a policy of checking for exceptional cases (e.g. `car` or `cdr` of atoms) and tries hard to provide clear and concise diagnostics. The expectation that the system would be used for writing parts of algebra systems has led to the inclusion of an arithmetic package that puts consistency above efficiency: integers can grow to be any size, the normal arithmetic primitives accommodate rational numbers, and there is a well-defined interface between exact and floating point number representations. The system provides a number of character handling facilities; can select and use several input/output streams, and has a built-in LISP prettyprinter.

To a large extent, the system is compatible with a proposal for a LISP standard that was put forward by Professor A.C. Hearn and others of the University of Utah and the Rand Corporation. A short bibliography is provided in appendix B.

For users coming to Cambridge LISP from other dialects of LISP, your attention is drawn to the following points:

(1) function definition is performed with the functions `de` or `df`;

(2) the function associated with an identifier is its value;

(3) the distinct value and function definition cells of other LISP dialects are not supported.

1.1 Installing LISP

Acorn Cambridge LISP for the ARM is distributed on ADFS floppy discs.

1.2 Running LISP

To run LISP, type

```
Lisp -image <image file name>
```

at the ARM prompt. The keyword '-image' must be supplied, followed by the full (or relative) pathname of the directory which contains the image files. On the distributed LISP system, the image directory is '$.Lib.Image' on the ADFS.

If -identify is specified, you will be given an indication of the store in use, then an initial store image is loaded from the directory image. As more complex use is made of LISP, the various store preservation functions can be used to produce customised versions. For example, if the REDUCE system is available and is in the current directory, typing:

```
LISP -image reduce
```

will run REDUCE.

The process of customisation takes the form:

```
LISP -image oldimage -dump newimage
```

Then, when the LISP function `(preserve)` is called, the store image in oldimage is copied to newimage, together with updates made before the call to `(preserve)`

1.3 Start-up options

The options available at the point of starting LISP are:

-from

If present expects a file name to use as the standard input to LISP. The default is the terminal.

-to

If present expects a file name to use as the standard output to LISP. The default is the terminal.

-image

If present expects the name of a directory in which to find the initial store image and fast load modules. The default is $.i.

-dump

If present expects the name of a directory in which to put the store image and fast load modules generated in the run, by use of module and preserve. The default is the image directory.

-leave

Expects a number of bytes (in units of 1024) that LISP will leave for the ARM to use as workspace. This should normally not be needed. The default is 20.

-store

Expects a number of bytes (in units of 1024) that LISP will use for this run. It is useful to give exactly reproducible runs, or to see how well some program would behave if used with a smaller computer than the one you have.

-identify

This option enables a few lines of start-up information to be displayed on entering LISP. This gives the version number, the amount of space used up by LISP, the image size, the date and time the store image was created, and how much store was used.

-help

Displays help information: a brief synopsis of the start-up options.

1.4 Use of space

LISP will attempt to acquire as much space as it can, leaving a little behind for other operating system activities. This behaviour can be changed by use of options as described above. If -identify has been specified, messages produced at the start and finish of each run give some indication of how much store is used and how much was available. If garbage collection becomes too frequent, more store is needed. There is no need to tell LISP how to allocate the store it is given - it has its own flexible scheme so that, for example, neither stack nor freestore can run out while there is some of the other left. Note also that the LISP compiler does not take up much space until it is used, and it can be removed using `excise` when it is finished with.

1.5 An example session with Cambridge LISP

The following example shows the dialogue during a short session with LISP. A few variables to configure the environment are set, a short LISP function is defined and tested, and some function definitions are read in from a file.

```
Lisp -image $.Lib.Image -identify

Acorn Cambridge Lisp entered in about 4030 Kbytes
Store image was made at 09:55:48     on 12-Mar-86
Lisp version - 1.05\1.05\1.05 12-Mar-86     image size = 105716 bytes

Started at 15:33:45 on 14 Jun 86 after 0.01+9.15 secs - 7.7% store used

(setq !*comp nil)
> nil

(de flatten (L)(cond
 ((null L) nil)
 ((atom L)(list L))
 (t(nconc (flatten (car L))
          (flatten (cdr L))))

> flatten

(flatten 'a)

> (a)

(compile '(flatten))
> **128 bytes 170 ms compiling flatten
> (flatten)

(flatten '(a)
> (a)

(flatten '((a)((1 2 3)1((((1)
> (a 1 2 3 1 1)
```

```
> *** End of file detected

> *** END OF RDF
(stop)

> End of Lisp run after 19.50+14.49 secs - 66.1% store used
```

The sign > is not a LISP prompt, but a signal that what follows is an evaluation returned by LISP.

1.6 Finding out what is available

There are three ways of finding out what is available in Cambridge LISP. First, try something and see if it works. Many of the functions provided have the same specifications as those in other LISP dialects as described in various textbooks and reference manuals. In particular, the Standard Lisp is close to this implementation. See the references in appendix B.

The second suggestion for checking what might be available is to look at the object list. LISP keeps the names of all atoms - and hence all functions - that it knows about in a structure known as the object list.

The function `oblist` which does not need any arguments, returns a list of all items held in this structure. It is a sort of index to the collection of available functions.

The third and best method is to consult Part II of this manual. Particular incompatible or especially useful features of the Cambridge system are noted below. See also appendix B for references to other documents which describe similar Cambridge LISP systems, for example, most of the functions provided have essentially the same specification as the versions defined in either the *LISP 1.5 users manual* or the *Stanford LISP reference manual*.

1.7 Compatibility with Acornsoft LISP

Acornsoft LISP (see appendix B) is a small version of LISP for the BBC Microcomputer. You will find that most Acornsoft LISP programs run under Cambridge LISP after modest changes are made.

Acornsoft uses upper case identifiers and accordingly `*lower` should be set to t in Cambridge LISP:

```
(setq !*lower t)
```

Acornsoft uses `defun` to define both `eval/spread` and `noeval/nospread` functions; the distinction being made by the format of the parameters in the definition. You may equate functions by typing:

```
(setq defun de)
```

Lastly, the hyphen '-' in Acornsoft LISP is not defined as a break character. You may wish to edit your source or to use `setsyntax` to redefine this. Using `PRIN` in Acornsoft LISP to tidy up the use of break characters in your program text is advised.

2. Preparing programs

2.1 Special characters

LISP is normally used in an interactive fashion with program material being entered on line. When it is desired to import program material from other LISP systems, or to generate material off line, it is important to remember that many characters have a meaning assigned to them by the read functions of the system.

See `setsyntax` for a description of the initial definitions. `!` used as a prefix causes the character immediately following to be accepted without special interpretation. This is useful, for example, in specifying pathnames which include a dot, for example,

```
(rdf 'lspdir!.tsp)
```

Enclosing a file name in double quotes will also cause the following name to be taken literally, for example,

```
(rdf "lspdir.tsp")
```

If an identifier is desired which includes a hyphen, there are two courses of action:

(a) write it as a double!-barrelled!-word

(b) call `(setsyntax "-" break!-character nil)` then write the double-barrelled-name without the need for the exclamation marks.

2.2 Case

Cambridge LISP is case sensitive and all supplied functions are named in lower case. When handling program material referencing store LISP functions it may be advantageous to set the variable `*lower` to t to enable continued references to the upper case versions of their names:

```
(setq !*lower t)
(SETQ FOO T)          this now equivalent to (setq foo t)
```

2.3 Defining functions

The function `rdf` will read in a source text file and execute the statements found there. The particular functions used to define functions and macros for example, `de` `df` may not prove compatible with LISP source text from all other LISP systems.

The normal way of defining functions will be to use `(de ...)` and `(df ...)`. The format for these is:

```
(de <function name> (arg1 arg2)
   <body>)
```

as in:

```
(de mycons (a b) (cons a b))
```

As well as functions that have their arguments spread out, it is possible to define functions which expect an evaluated list. These are sometimes known as `lexprs`. In Cambridge LISP they are defined, for example, by

```
(de mylfunc l
  (mapcar l (function print)))
```

If the LISP compiler is available in the image directory and the global flag `*comp` is non-nil, `de` automatically invokes the compiler. Note that `de` is a special form, and you do not have to put quote marks in front of its arguments.

Functions which do not evaluate their arguments can be defined using `df` or `dcf`: for details see section 10.2.

2.4 Macros

As well as functions, there are also macros. The body of a macro is evaluated to give a form that is then evaluated. For example:

```
(dm if (u)
  (list 'cons
     (list (cadr u) (caddr u))
     (list 't 'caddr u))))
```

is an approximation to the definition of the `if` conditional.

The functions that define new functions (that is, `de`, `df` and `dm`) will print a warning message when they redefine an existing function or macro.

Note that some other LISP systems use constructions built around the word `fexpr`, to achieve the effect of `df`. `fexpr` is not part of Cambridge LISP.

A bound variable list that is in fact a single (non-nil) atom is treated specially by both `lambda` and `lambdaq`. The variable is bound to the complete list of arguments given to the function, and there is no check or constraint on how many arguments are given. This makes it reasonably easy to define functions like `list` and `plus` which can cope with any number of arguments. An atomic variable list for a `lambdaq` is illegal; the only valid format for the parameter field is a list with a single entry.

2.5 Error recovery

Some errors cause entry into an iterative break-loop, which prompts for a character which will determine a variety of ways of exiting the loop. These are explained in the prompt:

```
Lisp break>
Q to quit, A to Abort, C to Continue, or . <expression>
```

3. The LISP editor

The Cambridge LISP full-screen editor described in this document is a powerful structure editor written entirely in LISP. It may be invoked via two functions: the first of these, `sedit`, edits the s-expression given as its argument. The edited copy is returned. `fedit` edits the definition of a function given the function's name as an argument; the display portion of the editor has been especially tuned for editing function definitions.

As well as edit existing functions, `fedit` can be used to create new ones, specifying the type of the function as an optional second argument, that is,

```
(fedit myfunction fexpr)
```

The editor sets up a template for the function, and the user fills in its definition using the normal editor commands. If `myfunction` already exists, the second argument is ignored, and the editor entered as normal.

On exit from `fedit`, the edited function is compiled if the variable `*comp` is currently set to a non-nil value. The function is also checked to see if it has been changed from an `expr/lexpr` to a `fexpr` (or vice versa), and if so a warning message is printed that unexpected effects might occur on calls to the function from compiled code.

3.1 Editor commands

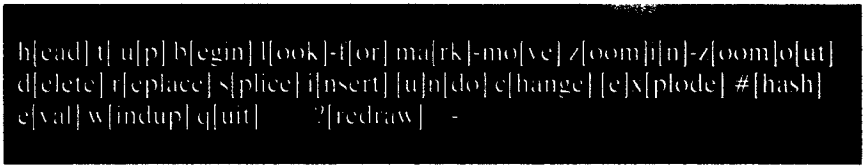
The editor commands are designed around the concept of the 'current s-expression', which is visible on the screen at all times, the first character of which is highlighted by an inverse-video block (the 'edit pointer'). The current s-expression can be any one of the following:

(1) an atom

(2) a LISP list starting with an opening parenthesis

(3) The cdr (tail) of a LISP list; in this case the inverse-video block is over the blank immediately before the car (head) of the current s-expression.

Initially, on entry to the editor, the current s-expression is the whole of the structure being edited and the screen resembles:




```
( lambda(a b)
    (cond
        ((null a) b)
        (t
            (cons
                (car a)
                (append & b) ) ) ) )
```

The three lines at the top of the screen form a menu containing the more important (mostly single character) editor commands; then the structure being edited is displayed (in this case a function definition). The ampersands (&) indicate detail that has had to be suppressed for the structure to fit on the VDU screen.

3.2 Elementary moving

When the arrow keys are pressed, the edit pointer does not move from character to character like a cursor in a text editor, but jumps from one s-expression to the next. The best way to familiarise yourself with the edit pointer's style of movement is to experiment.

In addition to using the arrow keys, there are several commands to move the edit pointer around, and thus make other parts of the structure the current s-expression. They are:

h - Move to the head of the current s-expression.

t - Move to its tail.

u - Move up one level; inverse of head and tail.

b - Move back up to the beginning of the smallest enclosing list.

3.2.1 Find and move

The next four commands perform more complicated location changing, the first two prompting at the bottom of the screen for an s-expression for the command to find.

lf - Look for and move to the next occurrence (in print order) of the user-specified s-expression. The area in which the search takes place starts at the s-expression immediately after the current one, and the search begins at the end of the function, as it appears on the screen.

lk - Look for and move to the next occurrence (in reverse print order) of the user-specified s-expression, the search beginning with the s-expression immediately before the current one.

l - Repeat the last look for command.

ma - Insert a mark at the current edit position. The mark is a new GENSYM ed atom of the form M00<n>.

mo - Move to a previously set up mark.

3.2.2 Structure modification

The following commands perform structure modifying operations:

d - Delete the current s-expression.

r - Replace current s-expression with a user-specified s-expression read from the bottom of the screen. See also section 2.2.4 below headed 'hash variables'.

c - Repeat the last structure modification.

i - Insert a user-specified s-expression at the edit pointer, performing a cons of the user's expression with the current s-expression.

s - Splice in a user-specified list at the edit pointer. If the current s-expression is an atom, it is replaced by the elements in the new list.

n - Undo the last structure modification command. A record is kept of all the modifications made to the structure, and successive undo commands will restore the function to its state prior to editing.

x - Explode the current s-expression so that it can be modified using one of the commands above.

3.2.3 Reformatting the screen

The next three commands change the appearance of the screen:

? - Reinitialise screen, and redisplay (useful if the screen has been messed up for some reason).

zi - Zoom in and display current s-expression in more detail. The command will work only when the edit pointer is not at the top of the screen.

zo - Zoom out; opposite of zoom in. The zoom is not allowed if it would cause the current s-expression itself to be supressed as a detail.

3.2.4 Eval loop and leaving the editor

The final three commands allow the user to enter a read-eval-print loop while still inside the editor, and allow the user to terminate the edit session and exit:

e - Enter a read-eval-print loop; typing 'fin' terminates the loop and causes the editor to be re-entered.

w - Windup and update edited structure.

q - Quit and do not update structure.

3.3 Entering an s-expression to the editor

The 'find', and some of the structure modification commands, require the user to enter an s-expression; in these cases the user is prompted at the bottom of the screen by ?. The s-expression input can cover as many lines as desired, the [delete] key deleting the last character typed (even back across previous lines), and [tab] inserting three spaces. Typing [escape] at any point completely abandons the current command.

3.3.1 Hash Variables

For convenience, in 'cut and paste' operations, the editor sets up the variable #0 to contain the current s-expression, and, if it is a list, #1, #2, ... to contain the values of the top-level elements of it. There is also the command '#' which sets the value of the variable # to be the current s- expression at the time the command was issued. The values of these #- variables are substituted into each s-expression and typed wherever they occur in it. These #-variables are also available in the read-eval-print loop inside the editor invoked by the eval command.

3.3.2 Miscellaneous features

The editor stores the name of the last function it edited in the global variable `**edit-last-function`, and if the function editor is called without being given the name of a function, it re-edits the last one.

The menu of editor commands displayed at the top of the screen can be changed by altering the contents of the global variable `**edit-menu`. The variable must contain a list of strings, each not longer than the width of the screen, each string to go on one line. The position on the screen of the structure being edited is automatically adjusted depending on how much space the menu takes up.

Since there is the facility to enter a supervisor loop within the editor, it is possible (and sometimes very useful) to enter the editor within that loop and thus edit at a second (or even higher) level. To help the user keep track of which level he is in, and the name of the function he is editing at each level, the editor maintains this information in the variable `**edit-level`.

The editor maintains a list of all the functions that have been edited in the current LISP session in the global variable `**edit-functions`. Thus it is easy to keep track of which functions have been changed and so need to be written back out to disc at the end of a session.

3.3.3 Limitations

The editor cannot deal with re-entrant LISP s-expressions. Currently it cannot express vectors or strings adequately for easy editing of their internal constituents.

4. Implementation features

Cambridge LISP is a value cell system. This means that for each identifier in any LISP program there is a single word used to hold the current value of that variable. When variables get bound or unbound, the contents on the value cell will be updated appropriately. This scheme has the advantage of being efficient and lends itself to graceful error recovery. For interpreted code, this mechanism provides what in Cambridge LISP is referred to as `fluid` scope rules (this is known as `special` in some other LISP dialects). The visible manifestations of a value cell LISP implementation are:

(a) A name can only be associated with one value at once. If you try to use a local variable called `car` it will not be possible to get at the built-in function `car` while within the scope of your local variable.

(b) Function definition and `cset` are variants of `set`. If you assign to a name not bound as a local variable, your assigned value will be stored globally.

(c) Functions used as functional arguments should not reference free variables. This rule can be relaxed if you understand the technicalities and possible consequences of not keeping to it.

When LISP is given something to evaluate it has to decide what to do about the function it is given. The Cambridge system works in the following way:

(i) if the 'function part' is a list of the form `(lambda ...)` or `(lambdaq ...)` or if it is the entry-point of a piece of compiled program, LISP processes it directly;

(ii) otherwise LISP replaces the function part by its value and goes back to step (i).

Thus functions get repeatedly evaluated until they make sense. All the LISP built-in functions are variables that have been given initial values that are the entry-points of the corresponding pieces of code. It is an error to try to apply an expression that does not turn into a recognizable function when evaluated enough times - LISP can detect this in most simple cases, but can sometimes go into a loop. It must be stressed that this loop has the same status as any other non-terminating program; this constitutes a user error and not a failure in the LISP system.

Some other systems will only evaluate function parts once, or perhaps twice before demanding that a recognizable form has been reached.

The symbol `lambdaq` is used in Cambridge LISP when a function must avoid evaluating its arguments too early. The use of `lambdaq` is like that of `lambda` except that it inhibits the evaluation of its arguments. Thus a function rather like the built-in `quote` can be redefined by:

```
(setq my!-quote '(lambdaq (a) a))
```

Within the body of a function introduced in this way, `eval` can be called to get arguments explicitly evaluated.

The Cambridge LISP interpreter implements the implied progn feature of many LISP systems, where the function `progn` can be omitted in nearly all circumstances. If a function is given too few arguments, then additional arguments of nil are supplied. If too many arguments are given, then excess arguments are ignored, after they have been evaluated in the case of `eval` functions.

Serious users of LISP will need to invoke the compiler to convert their programs from S-expressions into hard executable machine code. This process normally saves store and results in functions that run much faster. The compilation process however takes some liberties with LISP semantics, and so can not be used indiscriminately. To use the compiler at all, an image directory containing the module `lspcomp` must be available to the LISP system.

If `f1, f2 ...` are functions that have just been defined, a call:

```
(compile '(f1 f2 ...))
```

will replace the definitions of the functions with compiled code that is essentially equivalent. Also functions defined using `de` or `df` can be compiled automatically if the variable `*comp` is set to true.

The compiler has two major semantic differences from the interpreter intended to make compilation more effective:

(a) In compiled code, variables bound either by `lambda` or by `prog` are treated as being local to the function binding them unless they have been specially declared fluid. Thus if use is made of free variables, those variables should be declared using a call

```
(fluid '(v1 v2...))
```

before compilation is attempted.

(b) The compiler freezes some assumptions and knowledge about routines called by the function being compiled. These assumptions can sometimes lead to inconsistencies if the user attempts to redefine functions later. The compiler will not treat calls to user-defined special forms (that is, functions defined using `df` or `dm`) properly unless the special form has been defined before any attempt is made to compile a call to it.

These restrictions arise because the compiler generates open code or special calling sequences for many standard LISP functions: certain function names are treated specially and cause the compiler to generate fixed sequences of orders irrespective of what definition the user thinks should be associated with the name. These include `car`, `cdr`, `cons`, `putv`, `getv`, the integer arithmetic routines: `iplus`, `iminus` and so on, and a few more. A complete list is given in the table below. If one of these is redefined, it will alter the behaviour of interpreted code but will not affect compiled code in any way. In all other cases, redefining a function will cause all references to that name to use the new definition.

Note again that if a variable is to be bound in one function but used in another (or if it is to be treated as a global variable), then before any function mentioning the variable is compiled, a declaration of the following form should be obeyed:

```
(fluid '(var1 var2 ...))
```

The declaration can be removed after compilation by a corresponding call to `unfluid`. note that `fluid` takes the place of declarations known as `special` and `common` in wpagetems. When all user functions have been compiled, a substantial amount of space can be recovered by telling LISP to throw away the compiler. This is done by calling `excise` with argument `lspcomp`.

Functions fixed by the compiler

`apply`	`car`	`cdr`
`cdifference`	`cminus`	`cons`
`cplus`	`ctimes`	`equal`
`flagp`	`gensym`	`get`
`getd`	`getv`	`iadd1`
`idifference`	`ileftshift`	`ilogand2`
`ilogor2`	`ilogxor2`	`iminus`
`iplus2`	`irightshift`	`isub1`
`itimes2`	`ncons`	`putv`
`rplaca`	`rplacd`	`rplacw`
`xcons`		

4.1 Preserve

Particularly when developing a large program, it is useful to be able to dump the state of LISP to a disc file, then pick it up again in a later run. The function used for this is called `preserve`, and `(preserve)` writes a store image to the file with the name lsproot in the dump (or image, if no dump was specified) directory.

After `preserve` has been executed LISP stops, even if the call to `preserve` was embedded deep in some other functions. On restart all information about what was happening when `preserve` was called is lost. `preserve` will write to a member lsproot together with any other members defined by the FASL facility. If image and dump are the same, then the previous lsproot is renamed bakroot before the store is dumped.

Store images can only be loaded at the very start of a LISP run, and on entry to LISP the parameter image will give the directory in which to find the store image which is loaded. Thus:

```
LISP -IMAGE $.OLDIMAGE -DUMP $.NEWIMAGE
 . . .
  (preserve)
```

dumps a store image to the directory $.newimage, and

```
LISP -IMAGE $.NEWIMAGE
 . . .
```

reloads it and continues with the computation. If `preserve` writes out a file successfully, LISP will stop with a return code of at least 200 to signal this fact.

```
(preserve 'initialsupervisor)
```

is a form that can be used to package systems in a secure way. When the image file is reloaded, the user-supplied function `initialsupervisor` will be called rather than the standard LISP supervisor. If `initialsupervisor` is exited, then LISP will stop.

4.2 Load-on-call facility (FASL)

The following functions provide a load-on-call facility in LISP. note that all code is loaded from members of the directory called 'image' (unless the call has designated another directory for that function) and any generated code is written to the same directory, unless a dump has been specified in the call to LISP. The file names lsproot, bakroot, and lsperrs should be avoided, as these are used by the basic system. Various other modules with names beginning with 'lsp' are part of the base system.

(module membername)

Until further notice the compiler will write Fast Load (FASL) data for functions it compiles to the file `membername` in directory 'dump'. These files will be written as binary data. If `membername` is given as nil, or not given, fasl output is switched off and the compiler produces code in store.

(excise membername)

If membername is the name of a faslfile that has been loaded, `(excise membername)` replaces the definitions of all functions in that file with references to their disc versions. This frees the space that was consumed by the compiled code bodies. If `excise` is called with no arguments, it purges all loaded modules.

(preserve)

Write a file lsproot to image (or dump as described above) in a format suitable for LISP to reload it at the start of a subsequent run. If the store image is being written to image, then the previous image is renamed as bakroot. `preserve` will also close the output to a module thereby removing the necessity for a (module nil). After executing `preserve`, LISP stops.

The loading of modules is monitored if the appropriate value is given to verbos: after `(verbos 3)` a message is displayed each time a module is loaded from disc or removed from main memory.

5. Input and output

Input and output in LISP are based on the idea of selectable streams. At the start of a run, the stream designated `-from` (the default is the terminal) is opened and selected for input, and `-to` (default terminal) is opened and selected for output. All streams must be created by `open` before use: `open` returns as its result a LISP object that can be used to refer to a file; although this will often be a LISP atom that names the file, this fact should not be relied on.

5.1 I/O Routines

5.1.1 Open/Close

```
(open filename [input/output])
(close file handle)
```

These open or close a stream. A stream must be opened before it can be selected. The second argument to open specifies whether the stream will be read from or written to. The value returned by `open` is a file handle for use with `close`, `rds`, `wrs`.

5.1.2 wrs/rds

```
(wrs filehandle):[select for writing]
(rds filehandle):[select for reading]
```

`rds` and `wrs` affect all input and output (a possible exception being diagnostics which should always appear on the terminal); in particular, data to be read in, and LISP statements for execution are not kept separate.

5.1.3 Printing

There are four printing styles available in LISP. The first of these is intended to produce output that can be read back into LISP at a later stage, and so strings are printed with " marks around them and any unusual characters in atoms get prefixed with escape marks that is, !.

To use this print style:

`prin`	prints an atom or list (and does nothing else)
`print`	as prin but then ends the print line
`printm`	as print but it attempts to leave a left margin when an expression takes many lines to print.

The next set of routines print in a way that is useful when the program is trying to produce non-LISP-like output. They merely print the characters of atoms and strings without any extra markers.

`princ`	basic print routine
`printc`	as princ followed by call to `terpri`
`printcm`	as printc but leaves a left margin of specified width.

On occasions it is useful to produce circular structures. The previous print styles will go into an infinite loop if they are asked to print such a list. This family however are safe, but more expensive.

`prinl`	basic print for looped structure
`printl`	as prinl terminated by a terpri
`printcl`	as prinl with no escapes

The last style of printing is for the display of LISP programs, and provides a consistent style of indentation.

`superprint`	print with indentation

For explicit control of layout on the page, the following functions are available:

`terpri`	end a record (with a newline)
`eject`	as terpri but prints 'end-of-page' (sends character with code 12, that is, formfeed)
`linelength`	sets the logical width of paper that can be used by print
`ttab`	tab to specified column
`xtab`	tab by a given number of columns

5.2 Reading

The read routines are:

`tyi`	get ascii code of next character
`readch`	get next character
`read-token`	gets next atom, and sets a variable `!*token!-type!*` to a classification code for it
`read`	get next s-expression or atom.

Characters obtained by calls to `readch` can be classified by the predicate functions:

`digit`	is it 0,1,2,3,4,5,6,7,8 or 9?
`liter`	is it A,B,... ,Z,a,b,...,z?
`breakp`	detects blank, comma, brackets and so on. The exact definition depends on effects of previous calls to setsyntax.

Characters can be packed in a buffer, and then assembled into complete atoms:

`clearbuff`	clear the buffer (must be called first)
`pack`	puts characters in the buffer
`mkatom`	convert buffer contents to an atom
`numob`	convert buffer contents to a number
`mkstring`	converts buffer into a string

Notes

`numob` will fail if the buffer contents are anything other than a sensible string of digits, possibly with a leading sign.

`pack` must not be called before `clearbuff` has been used to set the buffer `boffo` to a standard initial state.

`read` either called explicitly by the user or called by the system to read in some more LISP program destroys the buffer contents. Therefore `pack` and so on should only be called from within a nest of routines that both start and finish the atom assembly process.

`explode` takes any argument and returns a list of characters, the characters being those that `prin` would produce if it were handed the list or atom. In particular `explode` converts numbers into characters.

`explodec` is like `explode` but makes a list of the characters `princ` would have produced.

`compress` is an inverse of `explode`.

Part II

6. Functions and variables

In this section, each function is provided with a prototypical header line, and each formal parameter is given a name and suffixed with its permitted type. Lower case tokens are names of classes and upper case tokens are parameter names referred to in the definition. The type of the value returned by the function (if any) is suffixed to the parameter list. If it is not commonly used, the parameter type may be a specific set enclosed in brackets {...}. For example:

```
(putd FNAME:id, TYPE:ftype,
      BODY:{lambda function-pointer}):id
```

`putd` is a function with three parameters. The parameter FNAME is an identifier to be the name of the function being defined. TYPE is the type of the function being defined, and BODY is a `lambda` expression or a function-pointer. `putd` returns the name of the function being defined.

Functions which accept formal parameter lists of arbitrary length have the type class and parameter enclosed in square brackets indicating that zero or more occurrences of that argument are permitted. For example:

```
and([U:any]):extra-boolean
```

is a function which accepts zero or more arguments which may be of any type. The type of the function is specified after the header. An eval type function receives its arguments ready evaluated and a noeval function receives unevaluated arguments. Normally this is dealt with by the system, but the distinction is important when `apply` is being used as the user must ensure that the arguments are already in the correct form.

`spread` type functions have their arguments passed in one-to-one correspondence with their formal parameters.

`nospread` functions receive their arguments as a single list.

6.1 Argument types

note that functions will not necessarily give an error with an argument of a type other than that specified, but the results should not be relied upon.

list
: A list with each member being a dotted pair. that is, `((a.b) (c.d) ...)`

atom
: Any type of number, string, id, vector, function.

boolean
: The set of global variables `t` and `nil`, or their values t and nil.

constant
: All atoms except ids.

extra-boolean
: Any value in the system, all except nil having the interpretation t.

ftype
: The class of definable function types. The ids expr, fexpr, subr, fsubr and macro.

function
: Anything that can be used as a function for example, `lambda` expression, pointer to binary code, id which is defined as a function.

id
: Equivalent to the normal LISP atom, with a property list and value so it can be bound or assigned to. Numbers, vectors and so on are treated specially as they do not need this full mechanism and so cannot be used where an id is specified.

logical
: Integers that can be represented in one word that is, less than 2**24. Arguments of this type can be passed to any function that expects a number or integer but the type of the result will not necessarily be a logical value.

sinteger

Signed integers that can be represented in one word that is, modulus less than 2**24. Arguments of this type can be passed to any function that expects a number or integer but the type of the result will not necessarily be a logical value. They are used extensively by the compiler, and there are a class of functions to handle them.

integer

Signed integers that can be of any size.

n-mod-p

Integers reduced mod p where p is set by `setmod`.

number

All items of type integer, floating, rational.

string

a string of characters enclosed in " ".

6.2 Characters

The character '.' is used in the input notation for lists, and if `a` and `b` are any structures, `(a . b)` represents a dotted-pair with `a` as its `car` and `b` as its `cdr`. To use the atom '.' see the entries under '!' and period.

(Parentheses are used in LISP input to form lists. To use the atom `(` see the entries under `!` and `lpar`.

{ Braces are used as super parentheses. A `}` will close sufficient opening parentheses to reach either a `{` or top level, whichever comes first.

! ! is the default escape character, which causes the following character to be treated as an ordinary letter. This means that characters with special properties, such as `'('` or `'.'`, can be used as part of an identifier. See `setsyntax` (page XX) for how to change the escape character and for a list of characters that have special properties initially.

cr Value is carriage return.

eof `readch` returns a special marker when it reaches the end of a stream. The initial value of `$eof$` is this value, and a program might read:

```
(setq a (readch))
(cond ((eq a $eof$) (go ENDSTREAM)))
```

eol `readch` returns a newline character object when it reads to the end of a line. The initial value of `$eol$` is this atom. `(prin $eol$)` therefore has the effect of `terpri`.

ff Value is a form feed character object.

*echo The variable `*echo` controls echoing of input within `read`.

`*echo`	effect
`nil`	no echo
`pretty`	formatted printing as reading progresses
`t`	character by character echo

The calls to `read` made by the LISP supervisor `(read/eval/printloop)` have `*echo` controlled by `(prarg n)`. The initial value is nil. See `prarg` (section 10.5).

6.3 Specialised variables

Many variables with names beginning with * and & are for internal use and should not be modified. The variables documented below are the ones most likely to be useful to the general user.

`*comp`

Type: Variable

When the variable `*comp` is true, function definitions are compiled. See `de`, `df` and `dm`. The default is `t`.

`*pgen`

Type: Variable

When true the compiler generates an assembly listing. The form of the listing is not compatible with standard assembler, and is only for checking purposes.

`*lower`

Type: Variable

When true, all upper case letters are translated to their lower case equivalent.

`*raise`

Type: Variable As `*lower` but forces characters into upper case.

`*plap`

Type: Variable

The compiler generates an intermediate macro form that is machine independent. When `*plap` is true this form is printed.

6.4 Atoms and values

`t`

The atom `t` is the standard LISP representation of 'true', and most built-in LISP predicates will return either `t` for true or `nil` for false. `t` should not be used as a name for a local or bound variable.

`nil`

`nil` is an identifier that LISP uses in a variety of special ways. It is therefore not possible to use it either as a function name or a variable name. The first special use is that all lists normally terminate with a reference to the atom `nil`, and so `(abc)` is 'really' `(abc . nil)`. The effect of this on the normal programmer is that the test null, as used to see if the end of a list has been reached, can be seen to be equivalent to `(eq xx nil)`. The second special use of nil is as the standard denotation for 'false'. All LISP predicates will return `nil` for false (most will return `t` for true). `nil` is used so often in LISP programs that it has been defined to stand for itself, and so it is possible to write `(cons a nil)` rather than `(cons a (quote nil))`.

`(null` U:any):boolean

Type: eval, spread

Returns `t` if `u` is `nil`.

`(setq` variable:id value:any):any
Type: noeval, nospread

`setq` is the normal assignment operator in LISP. The value of the current binding of `variable` is replaced by the value of VALUE. `variable` must not be `t` or `nil` (or an error occurs).

`(set` EXP:id VALUE:any):any
Type: eval, spread

EXP must be an identifier or a type mismatch error occurs. The effect of set is replacement of the item bound to the identifier by VALUE. If the identifier is not a local variable or has not been declared GLOBAL, it is automatically declared fluid. EXP must not evaluate to t or nil otherwise an error occurs because t or nil cannot be changed.

`(unset` U:id):any
Type: eval, spread

Is equivalent to `(set U indefinite! value)` but returns the old value of the variable.

`(boundp` U:id):boolean
Type: eval, spread

Returns t if U is the name of a variable that has either been bound by prog or as an argument of a function, or has been given a value by `set`.

`csetq`, pts
: For compatibility with older LISP Systems, these are synonyms for `setq` and `set` respectively. `pts` is a synonym for `set`.

`(atom` U:any):boolean
: Type: eval, spread

  Returns t if U is an atom, including any type of constant (see `constantp`). If atom is true, then `car` or `cdr` would be illegal.

`(idp` U:any):boolean
: Type: eval, spread

  Returns t if U is an id (that is, an atom that is not a constant).

`comma`
: Initial value of comma is the atom ','. See description of blank and dollar.

6.5 Dotted pair functions

Dotted pairs are the primitive data type in LISP. They are the product of functions from the `cons` class. The following are fundamental functions for their manipulation and creation:

`(cons U:any V:any):dotted-pair`
Type: eval, spread

Returns a dotted-pair (or cons-cell) which is not `eq` to anything preexisting and has U as its car part and V as its cdr part.

`(consp U:any):boolean`
Type: eval, spread

Check if U is a list created by cons.

`(car U:dotted-pair):any`
Type: eval, spread

```
(car(cons a b))
> a
```

The left part of U is returned. An error occurs if U is not a dotted-pair.

`(cdr U:dotted-pair):any`
Type: eval, spread

```
(cdr(cons a b))
> b
```

The right part of U is returned. An error occurs if U is not a dotted-pair.

`caaaar`

Type: eval, spread

Any name of the form cxxxxr where x represents the characters 'a' or 'd' is treated as a combination of the basic functions `car` and `cdr`. Thus `(caddr U)` is equivalent to `(car (cdr (cdr U)))`. The present implementation allows up to four letters between the 'c' and the 'r', so `caaaar` to `cddddr` are provided for. These are the possible combinations:

car	caar	caaar	caaaar	cdaddr
cdr	cadr	caadr	caaadr	cddaar
	cdar	caddr	caaddr	cddadr
	cddr	cdddr	cadddr	cdddar
		cdaar	cdaaar	cddddr
		cddar	cdaadr	caadar
		cdadr	cdadar	cadadr
		cadar	caddar	cadaar

`(carcheck N:integer)`:integer

Type: eval, spread

Normally, compiled code is produced that is safe, in that it checks to see that all `car` and `cdr` operations are legal. This involves a cost (about 6% of the size of compiled code), and so an option is provided to inhibit this check. `(carcheck n)` directs the compiler to check at level N, where N = 0 means no checking N = 1 requests checking that is safe, but unable to provide very clear diagnostics when something does go wrong (overhead = 4 bytes per access), and N = 2 is both safe and informative. The previous level of checking is returned. `carcheck` also controls the level of checking performed by compiled versions of a few other low-level functions such as `putv` and `getv`. It is strongly recommended that `(carcheck 2)` be used even with programs that are thought to be fully debugged; the overhead is modest and the extra sensitivity substantial. If ultimate performance calls for `(carcheck 0)` this option should be used for just a few of the most time-critical functions.

`(profile` U:integer)

Type: eval, spread

After a call to `profile`, the LISP compiler will generate code that includes statistic gathering orders to order U. The default (U=0) collects no statistics. With U=1 counts are collected at the entrypoint to each routine. With U=2, counts are collected near each conditional branch, and each label in the compiled code. The statistics gathered can be accessed by `readcount` or (more commonly) by `mapstore`.

`(car!-nil!-legal U:boolean)`:boolean

Type: eval, spread

After a call of `(car!-nil!-legal t)` the forms `(car nil)` and `(cdr nil)` (which would both normally result in errors) evaluate to nil. This facility is provided to ease the problems of transferring certain MacLISP and InterLISP code to the Cambridge system.

6.6 Tagged cons cells

`(acons U:any V:any):list`
Type: eval, spread

Cambridge LISP permits the creation of tagged cons-cells and their subsequent identification. This function is like `cons` but produces a different internal tag. This can be checked with the functions `aconsp` or `constype`. Similarly

```
(bcons U:any V:any):list
(ccons U:any V:any):list
(dcons U:any V:any):list
(econs U:any V:any):list
(fcons U:any V:any):list
(gcons U:any V:any):list
(hcons U:any V:any):list
```

`(aconsp U:any):boolean`
Type: eval, spread

Checks to see that U is a cons-cell created by `acons`. Similarly

```
(bconsp U:any):boolean
(cconsp U:any):boolean
(dconsp U:any):boolean
(econsp U:any):boolean
(fconsp U:any):boolean
(gconsp U:any):boolean
(hconsp U:any):boolean
```

For example:

```
(aconsp (bcons 'a 'b)
> nil
```

`(constype U:list):integer`
Type: eval, spread

`constype` returns an integer in the range [0..8] depending on whether U is a node created by `cons, acons, . . . . , hcons`. For example:

```
(constype (econs 'a 'b)
> 5
```

`(changetype L:list T:integer):list`

Type: eval, spread

`changetype` causes the pair L to be of type determined by T. t=0 gives a normal `type`, `t=1` gives an `acons`, . . . , t=8 gives an `hcons`. Values of t outside the range [0..8] give an error.

`(xcons U:any V:any):dotted-pair`

Type: eval, spread

This is the same as See `ncons` and `cons`

`(ncons U:any):dotted-pair`

Type: eval, spread

Is the same as `(cons U nil)`. See `cons`, `xcons`.

6.7 List processing functions

`(list` [U:any]):list
Type: noeval, nospread

A list of the evaluation of each element of U is returned.

```
(progn (setq x 5)
       (list 'the 'value 'of 'x 'is x ))

> (the value of x is 5 )
```

`(list!*` [U:any]):list
Type: macro

A list made up of the arguments given, with the last one used as the final tail of the list. Thus

```
(list!* p q r)
```

has the same effect as

```
(cons p (cons q r))
```

(append U:list V:list):list
Type: eval, spread

Returns a constructed list in which the last element of U is followed by the first element of V. The list U is copied, v is not.

```
(append '(a b c) '(d e f)
> (a b c d e f)
```

`(conc` [U:anylist]):any-list
Type: noeval, nospread

The lists passed to `conc` are concatenated by modifying the structures, so not using up store. `nconc` is similar to `conc` but only allows for two arguments. See also `append`.

```
(setq l1 '(a b c)
(setq l2 '(d e f)
(setq l3 '(g h i)
(conc l1 l2 l3)
> (a b c d e f g h i)
```

l2 now has value (d e f g h i)

(nconc U:list V:list):list
Type: eval, spread

Concatenates V to U without copying U. The last `cdr` of U is modified to point to V.

(copy U:any):any
Type: eval, spread

`copy` takes a list and returns one that has the same gross structure, but which does not share store with the original. The function will fail if the list to be copied has been made cyclic through the use of `rplaca` or `rplacd`. `copy` does not duplicate atoms or vectors: the copying operation is confined to lists as made up using `cons`.

(reverse U:list):list
Type: eval, spread

Returns a copy of the top level of U in reverse order.

```
(reverse '(a b (c d) e))
> (e (c d) b a)
```

(reversewoc U:list):list
Type: eval, spread

`reversewoc` reverses a list without creating a copy, and so is destructive. It can be used to great effect in building lists which naturally are calculated in a left to right fashion where it can replace repeated uses of `append`. See `reverse`.

```
(progn (setq v1 '(a b c d e f)
       (setq v2 (reversewoc v1))
       v1)
> (a)
```

v2 has value (f e d c b a)

`younger` U:list V:list):boolean
Type: eval, spread

Returns t if U and V are both lists and U was created by a `cons` that took place after the `cons` that made V. This provides a cheap, consistent but rather arbitrary order relation on list structures.

`orderp` U:any V:any):boolean
Type: eval, spread

This is a predicate defining a self-consistent order relation between lists. That is if `(orderp a b)` and `(orderp b c)` are both true then `(orderp a c)` as true. If U and V are identifiers this relation reduces to alphabetic order. For more complex structures the details of the ordering should not be relied upon.

6.8 List equality and searching

`(eq` U:any V:any):boolean
Type: eval, spread

Returns t if U points to the same object as V (it tests for equal pointers). `eq` is not a reliable comparison between numeric arguments in general, but is correct for integers with absolute value <2**24. For portability this should not be relied upon.

`(equal` U:any V:any):boolean
Type: eval, spread

Returns t if U and V are the same. Dotted-pairs are compared recursively to the bottom levels of their trees. Vectors must have identical dimensions and equal values in all positions. Strings must have identical characters. Function pointers must have `eq` values. The test `equal` is close in meaning to requiring that the two expressions look alike when printed

`(eqcar` U:any V:any):boolean
Type: eval, spread

This is equivalent to `(eq (car U) V)` except that if U is atomic it returns the answer nil.

`(assoc` U:any V:alist):{dotted-pair nil}
Type: eval, spread

If U occurs as the `car` portion of an element of the alist V, the dotted-pair in which U occurred is returned, else nil is returned.

```
(progn (setq key 2)
       (assoc key '((0 . key0)
                    (1 . key1)
                    (2 . "you got it"}
> "you got it"
```

`(atsoc` U:any V:alist):{dotted pair nil}
Type: eval, spread

`atsoc` is exactly `assoc` except that it uses `eq` to test if a tag has been found instead of `equal` See also `sassoc`.

`(sassoc` U:any V:alist FN:function):any

Returns the same result as `(assoc U V)` if U is present in V, otherwise the evaluation of FN is returned.

`(member` A:any B:list):extra-boolean
Type: eval, spread

Returns nil if A is not a member of list B, otherwise returns the remainder of B whose first element is A. The function `equal` is used to compare list elements.

```
(member 'c '(a b c d e f)
> (c d e f)
```

`(memq` A:any B:list):extra-boolean
Type: eval, spread

Same as `member` but an `eq` check is used for comparison.

`(deleq` U:any V:list):list
Type: eval, spread

As `delete` but uses `eq` rather than `equal` as the test.

`(delete` U:any V:list):list
Type: eval, spread

Returns V with the first top level occurrence of U removed from it.

`(union` U:list V:list);list
Type: eval, spread

Returns a list of all the items from U and V. If some item is in both U and V it will only occur once in the union list. See `append` for list merging/concatenation that does not remove duplicate entries, and `xn` below for list intersection.

`(setdiff` U:list V:list):list
Type: eval, spread

Returns the set difference between two lists; that is those members of U are not members of V using a member test.

`(sort` U:any-list PREDICATE:id`):`any-list
Type: eval, spread

The list U is sorted with respect to the given predicate, for example `(sort '(7 5 9 1 5) 'greaterp)` returns `(9 7 5 5 1)`.

`(sortip` U:any-list PREDICATE:id`):`any-list
Type: eval, spread

As `sort`, but the input list is overridden with the result.

`(sublis` X:alist Y:any`):`any
Type: eval, spread

The value returned is the result of substituting the `cdr` of each element of the alist X for every occurrence of the `car` part of that element in Y.

```
(sublis '((a . A)(b. b)) '( a a bab b))
> (aab ab b)
```

`(subst` U:any V:any W:any`):`any
Type: eval, spread

The value returned is the result of substituting U for all occurrences of V in W.

`(xn` U:list V:list`):`list
Type: eval, spread

Returns the set intersection of the lists U and V, that is, those members of U that are also in V. See also `union`.

`(last` U:list`):`any
Type: eval, spread

Returns the last element of the list U; for instance if U is the list `(a b c d e)`, then E is returned. `last` should not be given an atomic argument. But note:

```
(last '(a b c . e)
        > c
```

`(length` X:any):integer
Type: eval, spread

The top level length of the list X is returned.

```
(length '(1 (2 3) 4)
        > 3
(length '(1 2 .3)
        > 2
```

`(pair` U:list V:list):alist
Type: eval, spread

U and V are lists which must have an identical number of elements. If not, an error occurs. Returned is a list where each element is a dotted-pair, the `car` of the pair being from U, and the `cdr`, the corresponding element from V.

`(pairp` U:any):boolean
Type: eval, spread

Returns t if U is a dotted-pair.

`(neq` U:any V:any):boolean
Type: eval, spread

`neq` is equivalent to `(not (equal U V))`.

6.9 Pointer replacement functions

The following group of functions operate directly on the data structures given as arguments rather than on copies. Accordingly, they do not cause memory to be exhausted, but if used unwisely will damage data and program irreparably.

`(rplaca` U:dotted-pair V:any):dotted-pair
Type: eval, spread

The `car` portion of the dotted-pair U is replaced by V. If dotted-pair U is `(a . b)` then `(v. b)` is returned. An error occurs if U is not a dotted-pair.

```
(setq l '(1 2 3 4)
(prog (ll)
   (cond ((setq ll (member 3 l))(rplaca ll 'a)
         ( t nil)
```

leaves l with value (1 2 a 4)

`(rplacd` U:dotted-pair V:any):dotted-pair
Type: eval, spread

The `cdr` portion of the dotted-pair U is replaced by V. If dotted-pair U is `(a . b)` then `(a . V)` is returned. The type mismatch error occurs if U is not a dotted-pair.

`(rplacw` U:dotted-pair V:dotted-pair):dotted-pair
Type: eval, spread

Equivalent to `rplaca (rplacd U (cdr V)) (car V))` In general the `prinl` and so on, forms of the printing functions should be used to print the results of these functions especially where circular structures may be created.

6.10 List manipulating functions

`(compress` U:id-list`):`{atom}-{vector}
Type: eval, spread

U is a list of single character identifiers which is built into a Standard LISP entity and returned. Numbers, strings, and identifiers with the escape character prefixing special characters are recognized. Identifiers are interned on the `oblist`. If an entity cannot be parsed out of U or characters are left over after parsing, an error occurs.

```
(compress '(A B C)
> ABC
```

`(explode` U:any`):`id-list
Type: eval, spread

Returned is a list of single-character identifiers representing the characters that print as the value of U. The characters that appear in the list are those that would be produced if U were handed to `prin`.

`(explodec` U:any`):`id-list
Type: eval, spread

As `explode` but no escape characters are produced in ids (c.f. `princ`).

`(exploden` U:any`):`integer-list
Type: eval, spread

As `explode` but the list is of the internal codes of the characters rather than the characters.

(explodecn U:any):integer-list
Type: eval, spread

As explodec but the list is of the internal codes of the characters rather than the characters.

```
arg    explode          explodec         explodecn        exploden

123    (!1 !2 !3)       (!1 !2 !3)       (49 50 51)       (49 50 51)
'cat   (c a t)          (c a t)          (99 97 116)      (99 97 116)
"cat"  (!" c a t "!)    (c a t)          (99 97 116)      (34 99 97 116 34)
```

(pack U:any V:any):nil
Type: eval, spread

The function pack converts its argument into a string of characters and places these in the atom assembly buffer boffo. Subsequently the characters placed in boffo can be turned into a real LISP identifier or number through calls to mkatom or numob. boffo must be initialised by a call of clearbuff before pack is used. Note that the standard LISP read and print routines clear boffo. That is, if the result of pack is printed, the buffer is then empty, causing a subsequent mkatom to fail. If pack is given a non-nil second argument, it forces all the characters it packs into lower case.

(packbyte U:any):nil
Type: eval, spread

As pack but acting on internal codes.

(clearbuff):nil

This is a routine with no arguments that clears an internal buffer boffo which is used for constructing atoms. It must be called before an attempt is made to use pack and so on. See pack, numob, mkatom.

(numob):number

If the characters placed in the buffer boffo (by pack and so on.) represent a number, numob will form that number as a proper LISP object. If mkatom had been called instead of numob it would have created an identifier that had the same print format as a number but which had the properties of a variable rather than of a number.

`(mkatom) :id`

Type: eval, spread

If a sequence of characters have been assembled in the buffer boffo (by calls to `clearbuff` and/or `pack`), `mkatom` can be used to form the LISP identifier made out of the characters. `mkatom` consults LISP's internal hash tables and name lists (see `oblist`) and makes certain that identifiers are defined uniquely by their printnames.

`(mkstring) :string`

Creates a LISP string from the characters in boffo.

```
(progn (clearbuff) (pack 123) (pack 456) (numob)    > 123456
(progn (clearbuff) (pack 'abc) (pack 'def) (mkstring) > "abcdef"
(progn (clearbuff) (pack 'abc) (pack 'def) (mkatom)  > abcdef
```

6.11 Creation of symbols

`(gensym)`:id

Type: eval, spread

This creates an identifier which is not interned on the `oblist` and consequently not `eq` to anything else.

```
(eq (gensym) (gensym)
> nil
```

`(gensym1` U:id):id

Type: eval, spread

This generates a symbol in the same way as `gensym` does, but forces the printname of the generated atom to start with the given identifier. See also `symnam`

`(symnam` U:id):id

Type: eval, spread

`symnam` takes one argument which must be an identifier. Until `symnam` is called again, this identifier will be used to provide the initial part of the print representation of atoms created by `gensym`. Note that, for internal reasons, there is a store-use penalty in using more than a few dozen different `symnams`. See also `gensym1`. The value returned is the previous value.

6.12 Flags and property lists

`(flag` U:id-list V:id):nil
Type: eval, spread

U is a list of ids which are to be flagged with V. The effect of `flag` is that `flagp` will have the value t for those ids which were flagged. Both V and all the elements of U must be identifiers or the type mismatch error occurs.

`(flagp` U:any V:any):boolean
Type: eval, spread

This returns t if U has been previously flagged with V, else nil. It returns nil if either U or V is not an id.

`(get` U:any IND:any):any
Type: eval, spread

This returns the property associated with indicator IND from the property list of U. Returns nil if U or IND are not ids. `get` cannot be used to access functions (use `getd` instead).

`(put` U:id IND:id PROP:any):any
Type: eval, spread

The indicator IND with the property PROP is placed on the property list of the id U. If the action of `put` occurs, the value of PROP is returned. If either of U and IND are not ids the type mismatch error will occur and no property will be placed. `put` cannot be used to define functions (use `putd` instead).

`(setplist` U:id PLIST:alist):alist
Type: eval, spread

This replaces the property list of U with PLIST. The function returns the previous property list owned by U.

`(plist` U:id):plist
Type: eval, spread

The function `plist` called with one argument that is an identifier returns the property list of that atom. The format of such a property list is a list of flags (see `flag, flagp`) and dotted pairs of `(name . property)`. (See also `put, get`).

`(remprop` U:any IND:any`)`:any
Type: eval, spread

Removes the property with indicator IND from the property list of U. Returns the removed property or nil if there was no such indicator.

`(remflag` U:id-list V:id`)`:nil
Type: eval, spread

Removes the flag V from the property list of each member of the list U. Both V and all the elements of U must be ids or the type mismatch error will occur. nil is returned.

```
(progn
  (flag '(atm1 atm2) 'myFlag)
  (put 'atm1 'cost 1000)
  (put 'atm2 'price 2000)
  (print (plist 'atm1))
  (print (plist 'atm2)

prints ((cost . 1000) myFlag)
       ((price . 2000) myFlag)
```

`(oblist)`:id-list

Returns a lexicographically ordered list of all the atoms that can be reached by `read`. However it should be Noted that the object list in Cambridge LISP is a collection of balanced trees, so `rplac` operations on the value of `oblist` will have no effect on the object list.

`(remob` U:id`)`:id
Type: eval, spread

If U is present on the `oblist` it is removed. This does not affect U having properties, flags, functions and the like. U is returned.

6.13 Function definitions as values

(putd FNAME:id TYPE:ftype BODY:function):id
Type: eval, spread

Creates a function with name FNAME and definition BODY of type TYPE. This should be one of the symbols `expr` or `fexpr`. If `putd` succeeds, the name of the defined function is returned. The effect of `putd` is that `getd` will return a dotted-pair with the function's type and definition. Likewise the `globalp` predicate will return t when queried with the function name. If function FNAME already exists (and messages are enabled by `(verbose t)`) a warning message will appear:

```
*** FNAME redefined
```

The function defined by `putd` will be compiled before definition (changing `exprs` to `subrs` and `fexprs` to `fsubrs`) if the `*comp` global variable is non-nil.

(getd FNAME:any):{nil dotted-pair}
Type: eval, spread

If FNAME is not the name of a defined function, nil is returned. If FNAME is the name of an `xsubr`, then the dotted-pair `(xsubr . function-pointer)` is returned where the function-pointer is that associated with FNAME. If FNAME is the name of an `xexpr` then the dotted-pair `(xexpr . lambda)` is returned, the lambda expression being the definition of the function. If FNAME is the name of a macro then the dotted pair `(macro . lambda)` is returned with lambda being the body of the macro.

6.14 Vector operations

`(mkvect` UPLIM:integer):vector
Type: eval, spread

Defines and allocates space for a vector with UPLIM + 1 elements accessed as 0...UPLIM. Each element is initialised to nil. An error will occur if UPLIM is less than zero, or if there is not enough space for a vector of this size.

```
(mkvect 4)
    > %< nil,nil,nil,nil,nil %>
```

Note the printing convention used.

`(vectorp` U:any):boolean
Type: eval, spread

Returns t if U is a vector.

`(getv` V:vector INDEX:integer):any
Type: eval, spread

Returns the value stored at position INDEX of the vector V. The Type mismatch error may occur and an error occurs if the INDEX does not lie within `0...(upbv V)` inclusive.

`(putv` V:vector INDEX:integer VALUE:any):any
Type: eval, spread

Stores VALUE into the vector V at position INDEX. VALUE is returned. A type mismatch error may occur, and if INDEX does not lie in `0...upbv(V)` an error occurs.

`(upbv` U:any):integer
Type: eval, spread

Returns the upper limit of U if U is a vector, or 0 if it is not.

```
(prog (V)
  (setq v(mkvect 3))
  (putv v0 "a b c")
  (putv v1 34)
  (putv v2 t)
  (putv v3 29)
  (print V)
  (print (upbv V)
```

prints

```
> %<"a b c",34,t,29 %>
> 3
```

`(stringconcat` U:string V:string):string

Type: eval, spread

Returns the concatenation of the strings U and V.

```
(stringconcat "abc" "def")
        > "abcdef"
```

`(stringp` U:any):boolean

Type: eval, sprcad

Returns t if U is a string.

6.15 The AVL module

The avltree module provides an efficient balanced tree lookup and deletion. It is used in the printing of circular lists (see `printl, prinl, printcl`) and the maintenance of the LISP oblist. The functions of interest to the user are documented below. The trees produced by this module make use of the `acons, bcons,` and so on, functions, and are not general LISP trees.

`(avl-add` KEY:any TREE:avltree ORDER:function):avltree
Type: eval, spread

The KEY is added to the avl balanced tree, using order as the ordering predicate. ORDER must be an eval/spread function of two arguments. This form of adding to the tree uses an equal test. To print the tree in order see `values-in-tree.`

`(avl-delete` KEY:any TREE:avltree ORDER:function):avltree
Type: eval, spread

The KEY is deleted from the avltree.

`(avl-lookup` KEY:any TREE:avltree ORDER:function):boolean
Type: eval, spread

The KEY is looked up on the tree using an equal test.

`(avlq-add` KEY:any TREE:avltree ORDER:function):avltree
Type: eval, spread

The KEY is added to the avlbalanced tree, using ORDER as the ordering predicate. ORDER must be an eval/spread function of two arguments. This form of adding to the tree uses an eq test. To print the tree in order see `values-in-tree.`

`(avlq-delete` KEY:any TREE:qvltree ORDER:function):avltree
Type: eval, spread

The KEY is deleted from the avltree.

`(avlq-lookup` KEY:any TREE:avltree ORDER:function):boolean
Type: eval, spread

The KEY is looked up on the tree using an eq test.

`(values-in-tree` T:avl-tree):list
Type: eval, spread

`values-in-tree` returns the list of value in the avltree in order.

6.16 Arithmetic functions

Acorn Cambridge LISP supports arithmetic operations over four classes of numeric atoms:

small integers in the range -2**24 to +2**24

integers of any size

floating point numbers

rational numbers

It supports the usual operations over these, and additionally can perform modulus arithmetic over the small integers. A convenient naming convention has grown up whereby arithmetic operations are named for example, `add1` and `iadd1`; the `i-prefix` indicating the use of the function on integer arguments. `c-` and `m-prefixes` are likewise used to indicate functions specialised to handle arithmetic modulo n where n is a number set by `setmod`. A number of functions are supplied for type testing and conversion.

`(fix` U:number):integer
Type: eval, spread

Returns an integer which corresponds to the truncated value of U. The result of conversion retains all significant portions of U. If U is an integer it is returned unchanged.

`(fixp` U:any):boolean
Type: eval, spread

Returns t if U is an integer (a fixed number).

`(float` U:number):floating
Type: eval, spread

The floating point number corresponding to the value of the argument U is returned. Some of the least significant digits of an integer may be lost due to the implementaion of floating point numbers. `float` of a floating point number returns the number unchanged. If U is too large to represent in floating point an error occurs.

`(floatp` U:any):boolean
Type: eval, spread

Returns t if U is a floating point number and nil otherwise.

`(digit` U:any):boolean
Type: eval, spread

Returns t if U is a digit, otherwise nil. Note that a digit is a character and not a number. (that is, U=!2 returns t but U=2 returns nil).

`(eqn` U:any V:any):boolean
Type: eval, spread

Returns t if U and V are eq or if U and V are numbers and have the same numeric value after any necessary conversions have been performed. Floating point numbers are `eqn` only if they have, bit for bit, the same internal representation. There is no allowance made for rounding error, and so `eqn` on floating point arguments should be used only when this precise comparison is required.

`(geq` U:number V:number):boolean
Type: macro

Returns t if U >= V.

`(evenp` U:number):boolean
Type: eval, spread

Returns t if U is an even integer.

`(greaterp` U:number V:number):boolean
Type: eval, spread

Returns t if U is strictly greater than V, otherwise returns nil.

`(igreaterp` U:integer V:integer):integer
Type: eval, spread

Similar to `greaterp` but only works for small integers. When appropriate, it may be faster than `greaterp`.

`(ilessp` U:integer V:integer`):`integer
Type: eval, spread

Similar to `lessp` but only suitable for small integers.

`(imax` [U:integer]`):`integer
Type: noeval, nospread

Similar to `max` but only suitable for small integers.

`(imax2` U:integer V:integer`):`integer
Type: eval, spread

Similar to `max2` but only suitable for small integers.

`(imin` [U:integer]`):`integer
Type: noeval, nospread

Similar to `min` but only suitable for small integers.

`(iminusp` U:integer`):`boolean
Type: eval, spread

Similar to `minusp` but only suitable for small integers.

`(imin2` U:integer V:integer`):`integer
Type: eval, spread

Similar to `min2` but only suitable for small integers.

`(izerop` U:integer`):`integer
Type: eval, spread

Similar to `zerop` but will not recognize floating point zero. See `iadd1` (page XX). In fact `(izerop xx) = (eq xx 0)`.

`(lessp` U:number V:number`):`boolean
Type: eval, spread

Returns t if U is strictly less than V, otherwise returns nil.

`(max` [U:number]`):`number
Type: noeval, nospread

Returns the largest of the values in U. If two or more values are the same the first is returned.

`(max2 U:number V:number):number`
Type: eval, spread

Returns the larger of U and V. If U and V are the same value U is returned (U and V might be of different types). This function is used in the expansion of `max`.

`(min [U:number]):number`
Type: noeval, nospread

Returns the smallest of the values in U. If two or more values are the same the first of these is returned.

`(minusp U:number):boolean`
Type: eval, spread

Returns t if U is a negative number, otherwise nil.

`(min2 U:number V:number):number`
Type: eval, spread

Returns the smaller of its arguments. If U and V are the same value, U is returned (U and V might be of different types). This function is used in the expansion of `min`.

`(numberp U:any):boolean`
Type: eval, spread

Returns t if U is a number (integer, rational or floating).

`(onep U:any):boolean`
Type: eval, spread

Returns t if U is the number 1 or 1.0. There is no error if the item is not numeric. The effect is like `(eqn U 1)`.

`(smallp U:number):boolean`
Type: eval, spread

Returns t if U is an integer that can be stored as a single word.

`(zerop U:number):boolean`
Type: eval, spread

Returns t if U is a number and it is either the integer 0 or the floating point number 0.0. See `onep`.

6.17 Basic arithmetic operations

All the routines with names ixxxx where xxxx is the name of an arithmetic operation, are index mode operations. They must only be called with arguments that are integers less than 2**24, and must be called in such a way that the result will satisfy the same constraints. Failure to adhere to these constraints (for example, overflow conditions, bignum inputs,...) may not be detected and may lead to inconsistent behaviour. The routines do not necessarily check their arguments' types or ranges, but will at least never return a value that will not print as a small number. The LISP compiler can turn these routines into reasonably efficient in-line code, which should be much faster than use of the more general arithmetic routines. It must be stressed that only small numbers are valid and this constraint is not checked by the system.

`(abs` U:number):number
Type: eval, spread

Returns the absolute value of its argument.

`(add1` U:number):number

`(iadd1` U:integer):integer
Type: eval, spread

Returns the number U incremented by 1. Equivalent to, but faster than, a call to `(plus U 1)`. See also `sub1`.

`(sub1` U:number):number

`(isub1` U:integer):integer
Type: eval, spread

If U is a number then U-1 is returned. If U is not a number then an error is given. The effect is the same as (difference U 1) but is faster.

`(difference` U:number V:number):number

`(idifference` U:integer V:integer):integer
Type: eval, spread

Returns U - V.

`(minus` U:number`):number`

`(iminus` U:integer`):integer`
Type: eval, spread

Returns - U.

`(plus` [U:number]`):number`

`(iplus` [U:integer]`):integer`
Type: noeval, nospread

Forms the sum of all its arguments.

`(plus2` U:number V:number`):number`

`(iplus2` U:integer V:integer`):integer`
Type: eval, spread

Returns the sum of U and V. This function is used in the expansion of `plus`.

`(times` [U:number]`):number`

`(itimes` [U:integer]`):integer`

Returns the product of all its arguments.

`(itimes2` U:integer V:integer`):integer`

`(times2` U:number V:number`):number`
Type: eval, spread

Returns the product of U and V.

`(quotient` U:number V:number`):number`

`(iquotient` U:integer V:integer`):integer`
Type: eval, spread

The quotient of U divided by V is returned. If U and V are integers the result will be an integer and `(remainder U V)` will be the corresponding remainder. An error occurs if division by zero is attempted.

`(remainder` U:number V:number):number

`(iremainder` U:integer V:integer):integer
Type: eval, spread

If both U and V are integers, the result is the integer remainder of U divided by V. If either parameter is floating point, the result is the difference between U and V * (U/V) all in floating point. The sign of the remainder is always the same as the sign of V. An error occurs if V is zero.

`(divide` U:number V:number):dotted-pair
Type: eval, spread

The dotted-pair `(quotient . remainder)` is returned. The quotient part is computed the same as by `quotient` and the remainder the same as by `remainder`. An error occurs if division by zero is attempted.

`(random)` :integer

Returns a random integer in the range 0 to 2**24-1. The pseudo-random sequence used is initialised to a number based on the time of day LISP was run. The seed can be fixed by an option at load time: "-opt Rnnn" sets the initial seed to nnn.

`(sqrt` U:number):number

`(isqrt` U:integer):integer
Type: eval, spread

Returns the square root of U. If U is an integer that is a perfect square the result will be an integer, otherwise floating point.

`(gcd` U:integer V:integer):integer
Type: eval, spread

The positive integer that is the greatest common divisor of U and V is returned.

6.17.1 Modulo arithmetic functions

The functions supplied for modulo arithmetic are described below. A naming convention exists whereby functions which begin with a c perform arithmetic mod p in the range [0,p-1] ; those functions which begin with an m perform arithmetic mod p yielding results in the range [-p/2,p/2]. The integer p is usually but not always a prime number. It is set by `setmod`.

`(setmod` U:integer):integer
Type: eval, spread

`(setmod p)` sets the modulus for the `cplus` and `mplus` families of modulus arithmetic functions. `(setmod 0)` returns the current modulus without resetting it.

`(cdifference` U:n-mod-p V:n-mod-p):n-mod-p
Type: eval, spread

The result is U - V, with all numbers reduced mod p in the range [0,p-1]. See also `mdifference`.

`(mdifference` U:n-mod-p V:n-mod-p):n-mod-p
Type: eval, spread

Returns U - vmod p in the range [-p/2,p/2]. See also `cdifference` and so on.

`(cminus` U:n-mod-p):n-mod-p
Type: eval, spread

Returns -U mod p.

`(mminus` U:n-mod-p):n-mod-p
Type: eval, spread

Returns -U mod p.

`(cmod` U:integer):n-mod-p

`(mmod` U:integer):n-mod-p
Type: eval, spread

These reduce the integer U mod p in the range [0,p-1] or [-p/2,p/2] respectively.

`(cplus` U:n-mod-p V:n-mod-p):n-mod-p

`(mplus` U:n-mod-p V:n-mod-p):n-mod-p
Type: eval, spread

Return U + V mod p.

`(cquotient` U:n-mod-p V:n-mod-p):n-mod-p

`(mquotient` U:n-mod-p V:n-mod-p):n-mod-p
Type: eval, spread

Return the quotient of U and V mod p.

`(crecip` U:n-mod-p):n-mod-p

`(mrecip` U:n-mod-p):n-mod-p
Type: eval, spread

Return the reciprocal of U mod p.

`(ctimes` U:n-mod-p V:n-mod-p):n-mod-p

`(mtimes` U:n-mod-p V:n-mod-p):n-mod-p
Type: eval, spread

Return U * V mod p.

6.17.2 Rational arithmetic operations

`(numq` U:number):integer
Type: eval, spread

Returns the numerator of the number U. If U is not a rational the value returned is the argument. Giving `numq` a non numeric argument is an error.

`(denq` N:number):integer
Type: eval, spread

If N is a LISP number, its denominator is returned. If N is not rational its denominator is the integer 1. See `numq`.

`(rational` U:number V:number):rational number
Type: eval, spread

Divides U by V, leaving the result as an exact fraction. If either U or V is floating point, it will be converted to rational number form before the division is attempted.

```
(setq pi (rational 22 7)     > (22/7)
(numq pi )                   > 22
(denq pi )                   > 7
(times 4 pi)                 > (88/7)
```

`(rationalp` U:any):boolean
Type: eval, spread

Returns t if U is a rational number, and nil otherwise.

`(recip` U:number):number
Type: eval, spread

`recip` finds the reciprocal of a number by calling `(quotient 1 U)`. In this sense the reciprocal of any integer other than + or -1 will be zero.

6.17.3 Trigonometric calculating functions

(arccos U:number):number
Type: eval, spread

```
(arcsin U:number):number
(atan U:number):number
(cos U:number):number
(cot U:number):number
(sin U:number):number
(tan U:number):number
```

(exp U:number):number
Type: eval, spread

exp calculates the exponential of the argument which must be numeric. The result is a floating point number

(expt U:number V:number):number
Type: eval, spread

Returns U raised to the V power, where V cannot be an integer of unlimited precision. (that is, V can be a floating point number or small integer). A floating point U to an integer power V does not have V changed to a floating number before exponentiation.

(log U:number):number
Type: eval, spread

As exp except that the function is the natural logarithm.

(log10 U:number):number
Type: eval, spread

As log except that the function is logarithm to the base 10.

7. Control structures

Acorn Cambridge LISP supports a wide variety of control structures both for transfer of control at a local level and at a global level. The conditional form is the primitive local operator.

`(cond` [U:cond-form]):any
Type: noeval, nospread

A cond-form is a list of the form (predicate expression ... expression). The predicate of each U is evaluated until a non-nil value is encountered. The sequence of expressions following this predicate are evaluated and the value of the last one becomes the value of `cond`. If all the predicates evaluate to nil, then the value of `cond` is nil, and if no expressions follow a predicate, the value returned if this predicate succeeds is the value of this predicate.

`(select` U:any [V:pair] W:any):any
Type: macro

V is an association list. U is compared for equality with the successive `cars` of V, and when found, `select` returns the evaluation of the `cdr`. If there is no match then W is evaluated, `select` expands into a `cond` function.

`(prog` VARS:id-list [PROGRAM:{id any}]):any
Type: noeval, nospread

VARS is a list of ids which are considered fluid when the `prog` is interpreted, and local when compiled. The `prog` 's variables are allocated space when the `prog` form is invoked, and are deallocated when the `prog` is left. `prog` variables are initialised to nil. The PROGRAM is a set of expressions to be evaluated in order of their appearance in the `prog` function. Identifiers appearing in the top level of the PROGRAM are labels which can be referenced by `go`. The value returned by the `prog` function is determined by a `return` function, or nil if the `prog` "falls through" that is, the flow of execution is not affected by any transfers to labels by `go`.

(go LABEL:id)

Type: noeval, nospread

go alters the normal flow of control within a prog function. The next statement of a prog function to be evaluated is immediately preceded by LABEL. A go may only appear in the following situations:

(1) At the top level of a prog referencing a label which also appears at the top level of the same prog.

(2) As the consequent of a cond item of a cond appearing on the top level of a prog.

(3) As the consequent of a cond item which appears as the consequent of a cond item to any level.

(4) As the last statement of a progn which appears at the top level of a prog or in a progn appearing in the consequent of a cond to any level subject to the restrictions of 2 and 3.

(5) As the last statement of a progn within a progn or as the consequent of a cond to any level subject to the restrictions of 2, 3 and 4.

An error occurs if LABEL does not appear at the top level of the prog in which the go appears or if the go has been placed in a position not defined by the rules. See also casego. go cannot be used for non-local transfers of control. For such facilities see throw.

(return U:any)

Type: eval, spread

Within a prog, return terminates the evaluation of a prog and returns U as the value of the prog. The restrictions on the placement of return are exactly those of go. Improper placement of return results in an error.

```
(de iterativeFactorial (n)
  (prog (x)
      (setq x 1)
     L
      (cond ((zerop n)(return x ))
            ( t (setq x (times x n))
                (setq n (sub1 n)
      (go L)
```

`(casego` U:any [V:(any . label)])
Type: noeval, nospread

A case is a list of the form `(value label)` where both `value` and `label` are atoms. U is evaluated (once) and its value compared in turn against the value in each case. If a match is found, control is transferred to the label, as if a `(go label)` had been obeyed. If none of the values match, the entire `casego` construction is taken to have the value nil, and no transfer of control occurs. The value and label of each case are not evaluated and so must be literal values. `casego` must occur in a context where `go` would be legal.

`(progn` [U:any]):any
Type: noeval, nospread

U is a set of expressions which are executed sequentially. The value returned is the value of the last expression.

`(prog1` [U:any]):any
Type: eval, spread

Evaluates its arguments in order and returns the value of U.

`(prog2` [U:any]):any
Type: eval, spread

`prog2` is like `progn` except that it may only be used to combine two expressions. It is provided for compatibility with other LISP systems.

The `catch` and `throw` functions in Acorn Cambridge LISP provide the ability to transfer control to an enclosing function other than by the normal process of function evaluation and return.

`(catch` TAG:id EXP:any FAIL:any)

Type: noeval, spread

`catch` provides a method of non-local transfer of control. EXP is evaluated; if within this a throw is evaluated with the tag TAG, then `catch` will exit with the value of the throw (or the value of FAIL if given).

`(throw` TAG:id VAL:any)

Type: macro

Used in conjunction with `catch`, this provides a form of non-local control. Control continues from the last catch in the execution path that has the tag TAG, and the catch returns the value VAL.

7.1 Common LISP control structures

The following functions are based on Common LISP functions. Refer to a Common LISP Manual for extra detail.

`(let ((v1 val1)` (v2 val2...)) body1..bodyn)

Type: macro

Equivalent to lamda expressions binding variable1 to value1 and then evaluating the sequence body. `let` performs all the bindings in parallel. Thus

```
(let ((x y)(y x))...)
```

temporarily swops the value of x with the value of y.

`let*`

Type: macro As `let` but performs bindings sequentially.

`(do ((var1 init1 inc1)`(var2 init2 inc2)...)
`(exitcondition resultvalue) body1...)`

Type: macro

`do` binds var2 to init2 and obeys the body until the condition is true. The expression (inc2..) is used to establish new values for var2. `do` updates values in parallel.

`do*`

Type: macro

As `do` but updates variables sequentially.

`(loop body1 .. bodyn)`

Type: macro

The body iterates until a `return` is obeyed. Within a `loop`, the forms

```
(while condn val)
(until condn val)
```

may be used to provoke exits. These are not part of common LISP but are extensions based on Acornsoft LISP.

`(if cond value)`

`(if cond then-value else-value)`

Type: macro

This is a simple conditional that may prove easier to use than cond.

`(when cond body1 ... bodyn)`

`(unless cond body1 ... bodyn)`

Type: macro

Further conditionals, useful when several actions are to be performed, when some conditionals are satisfied.

`(dolist (var init-list result) body1 ...)`

Type: macro

Obey the body with the variable bound to items from the list; then return the specified result.

`(dotimes (var count result)` body1...)

Type: macro

Obey the body with the variable bound to 0,1,..[count - 1].

```
(dolist (x '(0 1 2) 'done) (print (times x x)))
(dotimes (x 3 'done) (print (times x x))
```

have the same effect.

8. Loops

The map functions of LISP provide the capacity for iterative operations over data structures. The functions `mapc`, `mapcar` and `mapcan` apply a given function to successive `cars` of a given list, thereby processing each top level element of the list; the functions `map`, `maplist` and `mapcon` apply the given function to successive `cdrs` of the given list. The functions `maplist` and `mapcar` return copied lists of the results of these multiple applications; `mapcon` and `mapcan` use `replacds` to modify the list of accumulated results.

There are also a collection of similar functions which have arguments in MacLISP order and support mapping over multiple lists. These are: `cl:mapc`, `cl:mapcan`, `cl:mapcar`, `cl:mapcon`, `cl:mapl`, `cl:maplist`.

`(map` X:list FN:function):any
Type: eval, spread

Applies FN to successive `cdr` segments of X, that is, `X`, `(cdr X)`, `(cddr X)` ... The list X is returned.

`(mapc` X:list FN:function):any
Type: eval, spread

FN is applied to successive `car` segments of list X (that is, `(car X)`, `(cadr X)`, `(caddr X)` ...). The list X is returned.

`(mapcan` X:list FN:function):any
Type: eval, spread

A concatenated list of FN applied to successive `car` segments of X is returned. Note that FN must return a value that is a list for `mapcan` to work.

`(mapcar` X:list FN:function):any
Type: eval, spread

A constructed list of FN applied to successive `car` segments of list X is returned.

```
(mapcar '(1 2 3) (lambda (x)(plus x x)
        > (2 4 6)
```

(mapcon X:list FN:function):any

Type: eval, spread

A concatenated list of FN applied to successive `cdr` segments of X is returned. (that is, `X, (cdr X), (cddr X)...)`. Note that FN must return a value that is a list.

(maplist X:list FN:function):any

Type: eval, spread

A constructed list of FN applied to successive `cdr` segments of X is returned.

```
(maplist '(a b c d e f) (lambda (x)(compress x)
> (abcdef bcdef cdef def ef f)
```

9. Logic functions

The functions `and`, `or`, and `not` are commonly used to implement a control structure analogous to some `cond` form. For bit level comparisons see `logand` and `logor`

`(or` [U:any]):extra-boolean
Type: noeval, nospread, Base Type: noeval, nospread

U is any number of expressions which are evaluated in order of their appearance. When one is found to be non-nil, it is returned as the value of `or`. If all are nil, nil is returned.

`(and` [U:any]):extra-boolean
Type: noeval, nospread

`and` evaluates each U until a value of nil is found or the end of the list is encountered. If a non-nil value is the last value, it is returned, otherwise nil is returned.

`(not` U:any):boolean
Type: eval, spread

If U nil, return t else return nil (same as null function).

9.1 Bit-level operations

Acorn Cambridge LISP supports bit level logical operations over integers. These functions are constrained to work on small integers in the range [0,2**24]. Versions of these functions with names prefixed by `i` may compile into in-line code, but do not check their arguments as thoroughly as the more general versions.

`(logand` [U:logical]):logical

`(ilogand` [U:logical]):logical
Type: noeval, nospread

The result returned is the logical AND of all the arguments. Ilogand accepts only quantities with 24-bit values as arguments.

`(logand2 U:logical V:logical):logical`

`(ilogand2 U:logical V:logical):logical`
Type: eval, spread

`logand2` behaves like `logand` except that it expects exactly two arguments. Compiled references to `logand` get converted into sequences of calls to `logand2`.

`(logor [U:logical]):logical`

`(ilogor [U:logical]):logical`
Type: noeval, nospread

`logor` forms the logical (that is, bitwise) OR of a sequence of 24 bit values, and is otherwise similar to `logand`.

`(logor2 U:logical V:logical):logical`

`(ilogor2 U:logical V:logical):logical`
Type: eval, spread

Like `logor`, but expecting exactly two arguments. See `logand2`.

`(logp U:number):boolean`
Type: eval, spread

Returns t if U is an integer in the range 0 to 2**24-1, that is, if the binary representation of U is at most 24 bits long and so U can be used directly in `logand`, `logor` and so on.

`(logxor [U:logical]):logical`

`(ilogxor [U:logical]):logical`
Type: noeval, nospread

As `logand` and `logor`, but forms the bitwise exclusive or (non-equivalence) of its arguments.

`(logxor2 U:logical V:logical):logical`

`(ilogxor2 U:logical V:logical):logical`
Type: eval, spread

Like `logxor` but expecting exactly two arguments.

`(leftshift` U:logical V:integer):logical

Type: eval, spread

The 24-bit value U is shifted left by V places, keeping only the bottom 24 bits of the result. If the second argument is negative, a right shift is indicated. See also `logand`, `logor` and `logxor`.

`(ileftshift` U:integer V:integer):integer

Type: eval, spread

Similar to `leftshift` but will not accept a negative second argument. `irightshift` is provided for right shifts. See `iadd1`.

`(irightshift` U:integer V:integer):integer

Type: eval, spread

Since `ileftshift` can not accept a negative second argument, this routine is provided. It shifts a (small) number right. See `ileftshift`, `iplus`.

10. I/O and file handling

10.1 Files

At any one time, Acorn Cambridge LISP has one file selected for input and one for output. Reading and printing use these two files. Functions are provided to open and to select new streams.

`(open` FILE:any HOW:id):any
Type: eval, spread

Open the file with the name FILE for output if HOW is eq to output, or input if HOW is eq to input. If HOW is APPEND the file is opened for output and left positioned so that new output is written after any previous contents. After calls to `pdsinput` and `pdsoutput`, FILE is treated as the name of a member of the directory specified by these calls. Alternatively, FILE can be a list consisting of the name of the directory and the membername required. If a third argument, of the same form as FILE, is given to `open` the effect is the same as `close` performed on the third argument followed by `open` performed on the first. If the file is opened successfully, a file-handle is returned. This handle should be used to refer to the file when using other I/O routines. An error occurs if HOW is something other than input, output or append, or if the file cannot be opened.

`input, output, append`

flag values, used as the second argument to `open`.

`(close` FILE:any):any
Type: eval, spread

Closes the file with file-handle FILE, releasing store used for buffers and control blocks. FILE can refer to a member of a directory (see `open`). nil is returned. An error occurs if the file cannot be closed. The functions `rds` and `wrs` provide a temporary diversion for input and output streams.

`(rds` FILE:any):any
Type: eval, spread

Input from the currently selected input file is suspended and further input comes from the file with name FILE. If FILE is nil, the standard input device is selected. When end of file is reached on a non-standard input device, the standard input device is reselected. When end of file occurs on the standard input device the Standard LISP reader terminates. `rds` returns the name of the previously selected input file.

`(wrs` FILE:any):any
Type: eval, spread

Output to the currently active output file is suspended and further output is directed to the file with file-handle FILE. The file named must have been opened for output. If FILE is nil, the standard output device is selected. `wrs` returns the file-handle of the previously selected output file.

A default directory for connection is specified by `pdsinput` and `pdsoutput`

`(pdsinput` FILE:any):nil
Type: eval, spread

Causes calls to `open, rds and close` to refer to members of the directory with name FILE. This returns nil.

`(pdsoutput` FILE:any):nil
Type: eval, spread

As `pdsinput but for open, wrs and close.`

10.2 Printing

`(prettyprint` U:any):any
Type: eval, spread

Print the LISP expression U in an indented style.

`(prin` U:any):any
Type: eval, spread

The value of U is printed with any special characters preceded by the escape character. The value of U returned.

`(princ` U:any):any
Type: eval, spread

The value of U is printed with no escape characters. The value of U is returned.

`(princl` U:any):any
Type: eval, spread

As `princ` but ensures that printing starts at the beginning of a line.

`(princs` U:any):any
Type: eval, spread

The same as `princ` except that it prints a newline before U if the line is not at the beginning.

`(prinhex` U:number V:integer):number
Type: eval, spread

The number U is printed in hexadecimal in a field width V.

`(prinl` U:any):any
Type: eval, spread

Like `prin` but treats circular lists correctly.

`(print` U:any`):`any

Type: eval, spread

The value of U is printed, with escape characters, followed by a new line. `print` will fail if given cyclic structures, and there is no guarantee that the output it produces will be acceptable to the `read` function - in particular `gensym` s and binary code print legibly, but not in a way where they can be re-input.

```
(print '!*comp)
prints !*comp
```

`(printc` U:any`):`any

Type: eval, spread

As for `print` but with no escape characters.

```
(printc '!*comp)
prints *comp
```

`(printcm` U:any N:integer`):`any

Type: eval, spread

As for `printc` but leaving a left margin of size non line overflow.

`(printl` U:any`):`any

Type: eval, spread

Prints circular lists without looping for ever. Reference points are labelled in the output with %%Ln: and referred to by %%Ln.

`(printm` U:any N:integer`):`any

Type: eval, spread

As for `print` but leaving a left margin of size N on line overflow.

`(superprinm` U:any N:integer`)`

Type: eval, spread

Same as `superprint` but leaves a left margin of width N.

`(superprint` U:any`):`any

Type: eval, spread

Prints U in an indented format (if it will not all fit on one line) which is intended to make the structure of the list more readily visible. The detailed print style is tuned for the display of LISP programs, and so some words (for example, prog, lambda, quote) are treated specially by `superprint`, forcing it to split lines in standardized places. The value returned is the argument.

`(superprintm` U:any N:integer`)`

Type: eval, spread

Same as `superprint` but leaves a left margin of width N, and terminates with a number of newlines.

`(tyo` U:integer`)`

Type: eval, spread

Prints the character with internal code U.

```
(tyo 65)
```
prints an A

`(bintyo` U:integer`)`

Type: eval, spread

As `tyo`, but sends the character uninterpreted to the VDU driver. This may be required if graphics or full-screen output is to be performed.

`(terpri)`:nil

The current print line is terminated (that is, a new line is started).

`(eject)`:nil

Causes a skip to the top of the next output page if the destination supports carriage controls.

`(linelength` LEN:{integer nil}`)`:integer
Type: eval, spread

If LEN is an integer, the maximum line length to be printed before the `print` functions initiate an automatic terpri is set to the value LEN. The initial linelength is 72 characters. If LEN is nil, the current linelength is returned but is not reset. Values of the line length less than 24 are not permitted.

`(lposn)`:integer

`lposn` always returns zero. It is intended to record the line on the page.

`(outradix` RADIX:integer`)`:nil
Type: eval, spread

Sets the radix that will be used when printing subsequent integer values. Legal arguments are 2,8,10 and 16 (decimal). Note that only small numbers are printed under control of this option - numbers bigger than 2**24 are always printed in decimal.

`(posn)`:integer

Returns the number of characters in the output buffer (ie. position in output line). When the buffer is empty, 0 is returned.

`(ttab` U:integer`)`:nil
Type: eval, spread

Enough spaces are printed to move the next character position in the line to U.

`(xtab U:integer)` :nil
Type: eval, spread

Prints U spaces on the current line.

10.3 The programmable reader

(tyi):integer

Reads one character and returns its internal code.

(tyipeek):integer

Returns the internal code for the next character in the input without reading it. that is, a subsequent call to `tyi` will return this character.

(tyiq):integer

As `tyi` but does not echo what it reads.

(bintyi):integer

As `tyi` but returns character without local editing or interpretation of control characters.

(read):any

Returns the next expression from the file currently selected for input. Valid input forms are: dot-notation, list-notation, numbers, function-pointers, strings, and identifiers with escape characters. Identifiers are interned on the `oblist`. `read` returns eof when the end of the currently selected input file is reached.

(read-token):atom

Reads one symbol and sets the variable *token-type* to one of number, symbol or break-character.

(read-tokenq):atom

As `read-token` but does not cause echo.

(readch):id

Returns the next character from the file currently selected for input. If all the characters in an input record have been read, the id eol is returned. If the file selected for input has all been read, the id eof is returned. Note that the normal LISP escape character conventions and macro expansion do not operate in character by character reading.

`(readchq)`:id

Type: LIspread

As `readch` but does not cause echo.

`(readq)`:any

As `read` but does not cause echo.

`(ascii` CODE:integer):character

Type: eval, spread

Returns the character corresponding to the given internal code for example, (ascii 48) returns the character !0.

`(character` N:integer):integer

Type: macro

`character` gives the character corresponding to the integer N by reading the `character-atom-table`.

`character-atom-table`

A table of characters used by the reader and by `character`. It translates from internal code to ASCII, and allows synonyms.

`fin`

The atom `fin` is used to mark the end of a LISP program, and it is recommended that most files end with the sequence:

```
fin ))))))))))))))))))))))))))))))
```

If `fin` is omitted, the system will stop on end-of-file, but will print a warning message to this effect.

10.4 Syntax

The LISP system read functions are driven by the syntactic properties of the characters encountered. The syntax properties are defined by a read-syntax table. A copy of the existing one can be made by the function `(copy-syntax-table <table>)` and the free variable `read-syntax-table` rebound.

`(setsyntax` U:chars V:property W:value):chars
Type: eval, spread

U specifies a character or characters that are to be given special properties with respect to input. U can be a single-character id, a list of such ids or a string, which is treated as a list of characters. V specifies the property and if W is non-nil this property is set up for each character. If W is nil then the property is cancelled for the given characters. V can take the following values. The value returned is that of U.

escape	enables the character to force any character following it to be treated as a letter.
break-character	causes the character to terminate identifiers.
digit	initially applies to 0.....9, not wise for user to change!
lowercase	initially applies to a.....z, not wise for user to change!
macro	value should be a function, which is called (with no arguments) whenever the character is encountered in the input. The result returned by this function becomes an element of the list being read.
splice	as for macro except a list of items to include in the list being read is expected to be returned from the function. A special case is when the function returns nil, when the macro character plus anything read by the function are ignored by the main reader. (This is how comments are implemented.)

The characters that have special input properties initially are:

ignore	eol, ff, blank, tab
break-character	eol, ff, blank, tab, eof (.){}#$%&=- ~ \[]+;,*:()?/
escape	!
digit	0123456789
may-start-number	+-.
upper case	ABCDEFGHIJKLMNOPQRSTUVWXYZ
letter	abcdefghijklmnopqrstuvwxyz ABCDEFGHIJKLMNOPQRSTUVWXYZ

For example, to rename the characters * and - from the set of break-characters, evaluate `(setsyntax "-*" 'break!-character)`

`*token-type*`
: This variable is set by the tokenizer of the LISP reader to indicate the type of the token read. Possible values are: `break-character`, `result-of-read-macro`, `number`, `symbol` or `escape`.

  The meanings of these are obvious when taken with `setsyntax`.

`(breakp` U:any):boolean
: Type: eval, spread

  `breakp` tests its argument to see if it is a character such as a dot, bracket or blank that would terminate an atom. See also `digit`, `liter`.

`(liter` U:any):boolean
: Type: eval, spread

  Returns t if U is a character of the alphabet, nil otherwise.

`(internalcode` U:id):integer
: Type: eval, spread

  If U is a single character id its ascii code is returned. See `ascii`.

10.4.1 Character level syntax

%
: Comments are by default introduced by `%`, and they last until the end of a line. Since they are implemented by a splice readmacro, the character that introduces comments can be changed (see `setsyntax`).

blank
: The atom `blank` has an initial value that is either the character blank or space. To test if 'ch' is a space, you can either type:

```
(eq ch blank)
or
(eq ch (quote ! )).
```

See entry under ! (page XX) for further explanation of the above.

dollar
: The initial value of dollar is the character '$'.

f
: The initial value of f is nil, and so `f` can be used as a name for 'false'. Unlike some other systems, in Cambridge LISP `f` can be used as a bound variable, and the local binding will override the global value.

lpar
: The initial value of `lpar` is the atom `'(`, a left parenthesis.

period
: The initial value of the atom period is the atom '.'.

rpar
: The initial value of the atom `rpar` is the atom ')', a right parentheses.

tab
: Variable having the value of the character tab.

eqsign
: The initial value of `eqsign` is =.

10.5 Interacting with the LISP supervisor

`(prarg` U:mode`):`mode
Type: eval, spread

mode is one of nil, t, pretty or expanded. After `(prarg nil)`, the LISP supervisor does not echo what it reads and interprets. `(prarg t)` causes the supervisor to print arguments; `(prarg 'pretty)` causes it to superprint them; and `(prarg 'expanded)` causes it to superprint them after expansion of readmacros. See `prval` and `prmsg`. The initial state is no echo. The function returns the previous value.

`(prmsg` U:boolean`):`boolean
Type: eval, spread

If U nil, then the printing of messages by the LISP supervisor is inhibited. The function returns the previous value.

`(prval` U:any`):`integer
Type: eval, spread

`prval` can be used to control the way in which the LISP supervisor prints the values of expressions it processes. After `(prval 0)` it prints nothing. `(prval 1)` or `(prval nil)`, which are the default, use `print` to display the result of a computation; while after `(prval 2)` the function `printc` is used. If U is 3, or pretty, values are superprinted. The function returns the previous value.

10.6 Saving work

`(preserve` U:function)

Type: eval, spread

a LISP core-image can be created by executing `preserve`. The name DUMP refers to a directory. The state of LISP is written out onto the file, in a format suitable for loading as an initial image. After the system has been dumped, LISP stops. Store images are reloaded by providing them to LISP under the directory IMAGE when the system starts up. If a function was specified by U when `preserve` was done, this function is called when LISP starts up again. If none was specified, then the supervisor that was being used when `preserve` was called is used. The image is written to the member LSPROOT.

`(rdf` INFILE:id OUTFILE:id):nil

Type: eval, spread

Reads and executes the LISP code in the given file, with the output going to the other file. If OUTFILE is null, or is omitted (the normal use), then the terminal is used.

`(setreturncode` U:integer):integer

Type: eval, spread

Sets the eventual OS return code. `setreturncode nil` reads the return code currently set up.

`(supervisor)`

`supervisor` is a user entry into the standard LISP loop that reads, echoes and evaluates LISP code. It can be useful for processing data-files that contain executable LISP statements. There is no exit.

`(stop` U:integer)

Type: eval, spread

Exits directly from LISP. `(stop n)` gives a return code of at least n. See `setreturncode` for a more general way of controlling return codes.

11. Evaluating functions

`(eval` U:any):any
Type: eval, spread

U is evaluated as a piece of LISP code with respect to the current collection of variable bindings. `eval` is the function used by the LISP interpreter to evaluate LISP code. `eval` is an inverse of `quote`, hence `(eval 'a)` is equivalent to requesting the value of a.

`(evlis` U any):any
Type: eval, spread

`evlis` returns a list of the evaluation of each element of U.

`(apply` FN:{id function} ARGS:any-list):any
Type: eval, spread

FN must be a function in the form of a code pointer or lambda expression, or else an id which has been defined as a function. ARGS must be a list of arguments in a form ready to be bound to the formal parameters of FN (that is, if FN expects evaluated arguments then they must be already evaluated). The result of evaluating FN with the values given in ARGS bound to its formal parameters is returned. If ARGS contains more items than FN has formal parameters, then the excess items are ignored, and if ARGS has fewer items, the excess formal parameters are set to nil.

```
(progn
   (setq x car)
   (setq y'(( a . b)))
   (apply x y)
> a
```

`(mkquote` U:any):any-list

This is a function of one argument and its definition is equivalent to `(lambda (X) (list 'quote X))`.

`(quote` U:any):any

Type: noeval, nospread

Returns U unevaluated.

`(function` fn:function):function

Type: noeval, nospread

The function `fn` is to be passed to another function. If `fn` is to have side effects, its free variables must be fluid or global. This function is like `quote` (indeed, the interpreter does not distinguish between them), but if `(function (lambda ...))` occurs in code that is being compiled, the lambda expression will be compiled, and indeed may be expanded into in-line code, rather than into a separate `subr`.

`(gts` U:id):any

Type: eval, spread

This returns the current value of the identifier U, or nil if it is unset. `gts` is intended particularly for evaluating non-local variables, where it is a cheap but restricted equivalent to `(eval U)`, except perhaps for its treatment of unset values.

11.1 Declarations and binding

`(fluid` IDLIST:id-list):nil
Type: eval, spread

The ids in IDLIST are declared as fluid type variables. Ids not previously declared are initialised to nil. Variables in IDLIST already declared fluid are ignored. Changing a variable's type from global to fluid is not permissible and results in an error.

`(fluidp` U:any):boolean
Type: eval, spread

If U has been declared fluid (by declaration only), t is returned, otherwise nil is returned.

`(global` IDLIST:id-list):nil
Type: eval, spread

The ids of IDLIST are declared global type variables. If an id has not been declared previously, it is initialised to nil. Variables already declared global are ignored. Changing a variable's type from global to fluid is not permissible and results in an error.

`(globalp` U:any):boolean
Type: eval, spread

If U has been declared global or is the name of a defined function, t is returned, otherwise nil is returned.

`(unfluid` IDLIST:id-list):nil
Type: eval, spread

The variables in IDLIST that have been declared as fluid variables are no longer considered as fluid variables. Others are ignored. This affects only compiled functions, as free variables in interpreted functions are automatically considered fluid.

`(unglobal` U:id):nil
Type: eval, spread

Undoes effect of `global`.

(prog VARS:id-list [PROGRAM:{id any}]):any
Type: noeval, nospread

VARS is a list of ids which are considered fluid when the prog is interpreted, and local when compiled. The prog's variables are allocated space when the prog form is invoked, and are de-allocated when the prog is left. prog variables are initialised to nil. The PROGRAM is a set of expressions to be evaluated in order of their appearance in the prog function. Identifiers appearing in the top level of the PROGRAM are labels which can be referenced by go. The value returned by the prog function is determined by a return function or nil if the prog "falls through". The VARS introduced by prog may have to be declared fluid if it is required to reference a binding made in this prog within a function called from within the prog

11.2 Function definition

(de NAME:id PARAMS:{id id-list} FN:any):id
Type: noeval, nospread

The function FN with formal parameter(s) specified by PARAMS is added to the set of defined functions with the name NAME. Any previous definitions of the function are lost. The function is left unchanged unless the `*comp` variable is t in which case the expression FN is compiled. The name of the defined function is returned.

```
(de structEqual ( x y)
  (cond ((eq x y) t)
        ((atom x) nil)
        ((structEqual (car x)(car y))
            (structEqual (cdr x)(cdr y)
```

(deflist U:dlist IND:id):id-list
Type: eval, spread

A dlist is a list in which each element is a two element list: (ID:id PROP:any). Each id in U has the indicator IND with property PROP placed on its property list by the `put` function. The value of `deflist` is a list of the first elements of each two element list. Like `put`, `deflist` may not be used to define functions.

(defprop U:dlist IND:id):list
Type: eval, spread

Like `deflist`, but tries to compile the properties before placing them on the property list. No error occurs if a property is not compilable.

(df NAME:id PARAM:{id id-list} FN:any):id
Type: noeval, nospread

The function FN with formal parameter(s) specified by PARAM is added to the set of defined functions with the name NAME. Any previous definitions of the function are lost. The function created is of type `fexpr` unless the `*comp` variable is t, in which case the expression FN is compiled and an `fsubr` is created. The name of the defined function is returned.

(dm MNAME:id PARAM:{id id-list} FN:any):id
Type: noeval, nospread

The macro FN with formal parameter(s) specified by PARAM is added to the set of defined functions with the name MNAME. The result of the macro should be an expression to be evaluated. Any previous definitions of the function are overwritten. The function created is of type `macro`, and the name of the macro is returned. If `*comp` is true, then the macro is compiled.

For example, if a macro to enable writing `(push x L)` with the effect of `(setq l (cons x L))` is required:

```
(dm push(LL)
    (list 'car (list 'setq (caddr LL)
                     (list 'cons (cadr LL)(caddr LL)
```

(dcf NAME:id PARAM:{id id-list} FN:any):id
Type: noveal, nospread

Like `df`, `dcf` defines a new `noeval` function. The difference is in how the formal arguments in the definition are matched up with actual arguments in a call. With df a function is defined as if it expected just one argument, and when called that variable has as its value a list of the actual arguments provided. With dcf a `spread` function is defined, and so actual arguments are matched against formals.

Example:

```
(df f1 (a) (print a))
(dfc f2 (a b) (print a)(print b))
(f1 p q)     prints (p q)
(f2 p q)     prints p then prints q.
```

`(dcm` NAME:id PARAM:{id idlist} FN:any):id
Type: noveal, nospread

As `dm`, but the parameter list is matched against the argument list in a macro call (whereas with `dm` the argument to the macro gets bound to the whole macro call). For example,

```
(dm f1 (u) ... (cadr u) ... (caddr u) ...)
```

could be expressed as

```
(dcm f1 (a b) ... a ... b).
```

`(expand` L:list FN:function):list
Type: eval, spread

FN is a defined function of two arguments to be used in the expansion of a macro. `expand` returns a list in the form:

```
(fn L[0] (fn L[1] ... (fn L[n-1] L[n]) ... ))
```

where "n" is the number of elements in L, L[i] is the ith element of L.

`(fntype U:function)`:{(ftype . nargs) atom}
Type: eval, spread

If U is either a piece of binary code, or a lambda expression, the result returned will be a dotted-pair `(type . nargs)` specifying the type and number of arguments that U requires. The possible types are `expr`, `fexpr`, `subr` and `fsubr`, and if `nargs` is given as negative, it means that the function will accept an indefinite number of arguments. If given a non-functional or malformed argument, some atomic value is returned.

`lambda`

`lambda` is a marker atom that identifies a piece of LISP structure as representing a function. The correct syntax for its use is

```
(lambda variables expr1 expr2 ... exprn)
```

where variables is a list of formal arguments that the function needs, and the expressions are the body of the function. See `lambdaq`.

`lambdaq`

`lambdaq` introduces a function that will receive its arguments unevaluated. Except for suppressing argument evaluation, `lambdaq` behaves exactly like `lambda`. The `lambdaq` facility in Cambridge LISP takes the place of `fexpr/fsubr` activity in some other systems.

`macro`

`Macros` are introduced by calls to `dm`, and subsequently calls of the form (name args) will get trapped, and the entire function application passed to the macro definition for processing. See `dm` for details.

`(constantp` U:any):boolean
Type: eval, spread

Returns t if U is a constant (a number, string, function-pointer, or vector).

`(make-constant` NAME:id VALUE:any):id
Type: eval, spread

The identifier NAME is made into a constant with value VALUE. NAME cannot now be bound as an argument to a function.

`(remd` FNAME:id):{nil dotted-pair}
Type: eval, spread

Removes the function named FNAME from the set of defined functions. Returns the `(ftype . function)` dotted-pair or nil as does `getd`. The global/function attribute of FNAME is removed and the name may be used subsequently as a variable.

11.3 Compiler functions

`(codep` U:any):boolean
Type: eval, spread

Returns t if U is a pointer to compiled code.

`(compile` U:id-list):id-list
Type: eval, spread

`compile` takes a list of names of functions and compiles them. See also `carcheck, *pgen, profile`.

Example:

```
(compile '(FUN1 FUN2 FUN3))
```

`(comprop` U:id-list PROPNAME:id):id-list
Type: eval, spread

For each id in U its property with name PROPNAME is compiled. These properties must be lambda expressions.

`(module` U:id):nil
Type: eval, spread

This directs the compiler to put the code that it generates into a module for later use. The code will be written directly to the DUMP directory if present, otherwise it will be written to the IMAGE directory, as well as being kept in store in case it is needed in a bootstrapping process. The module selected by `module` will replace any previous one with the same name. Empty modules are eventually purged from the system. The name nil and any starting with the characters 'LSP' should be avoided. `(endmodule)` or another call to `module` terminates a module.

`(excise NAME:{id id-list})`

Type: eval, spread

LISP has a load-on-call mechanism, and the function `excise` can be used to unload previously loaded modules. If `name` is nil then everything is unloaded, otherwise the named module(s) are unloaded. As a particular case, `excise` can be used to recover the store taken up by the LISP compiler, in that `(excise 'LSPCOMP)` purges the relevant functions. Note that after `excise` has been called, further reference to the excised module will result in it being reloaded.

`(endmodule)`

See `module`.

12. Editor entry points

`(fedit` FN:id):any

Type: noeval, spread

`fedit` enters the structure editor to edit the function defined with the name ID. For more details of the editor see chapter 2. If the editor is entered with no argument, then the last edit is resumed, either from the start if the edit was left via `stop` or `ok`, or at the same place if the last edit was left by `save`.

`(editp` U:id):any

Type: noeval, spread

`editp` enters the structure editor to edit the property list of the identifier U. For more details of the editor see chapter 2 and `fedit`.

`(editv` U:id):any

Type: noeval, spread

`editv` enters the structure editor to edit the value of the identifier U. For more details of the editor see chapter 2 and `fedit`.

13. Error control

`(errorset U:any FLAG:integer):any`

Type: eval, spread

A LISP program can call `eval` to get a fragment of code explicitly evaluated. If this is done, however, errors in the code will cause a complete backtrace of all the functions being executed. `errorset` is a variant of `eval` that overcomes this problem, and allows the user to obey code while keeping control if the code turns out to be faulty. The result returned is the same as `(list (eval U))` if the evaluation works, but if there is an error, the result returned is atomic and is a number identifying the type of error that occurred. See `error` for further details. The value of FLAG determines how much information about the error is reported to the user. A value of zero results in no notification about the error, and values 1 to 5 result in progressively more information about the functions being obeyed and the variables on the stack being printed.

```
(progn
  (setq inputVariable (errorset (read) 0))
  (cond ((numberp inputVariable) (setq inputVariable "error"))
        ( t inputVariable)
```

is a first attempt to cope with errors in input

`*emsg*`

is set by `errors` to the error message produced, and so is useful after `errorset` catches the error.

`(error NUMBER integer MESSAGE any)`

Type: eval, spread

NUMBER and MESSAGE are passed back to a surrounding `errorset` (the Standard LISP reader has an `errorset`). MESSAGE is placed in the global variable `*emsg` and NUMBER becomes the value of the `errorset`. `error` can be called with a single argument which becomes the message, the error number defaulting to zero. Fluid variables and local bindings are unbound to return to the environment of the `errorset`. Global variables are not affected.

`(backgag` U:integer):integer

Type: eval, spread

The amount of information printed after an error can be controlled by the use of `backgag`. This function takes one argument, which sets the level of printing desired. Arguments should be integers in the range 0 to 6:

0 means no notification of errors at all;
1 gives the header message ERROR:... ;
2 in addition wpages the names of functions being obeyed.
Codes 3,4 and 5 give progressively fuller printing of variables found on the stack.

nil is treated as meaning 0, and any argument out of range is treated as 5.

14. Debugging in LISP

14.1 Tracing functions

`(trace U:{id id-list}):{id id-list}`
Type: eval, spread

Sets up tracing for any function whose name appears in the list U or the function U.

`(tracesetq` U:id-list):id-list
Type: eval, spread

After a call to `tracesetq` in interpreted code, the use of `set` or `setq` to update the variables named in U leads to a message being printed. Unlike `trace`, `tracesetq` has one list of traced variables, and to stop tracing a call `(tracesetq nil)` should be used.

`(untrace` U:id-list)
Type: eval, spread

Undoes the effect of `trace` for the variables named in U.

`(tracecount` N:integer):nil
Type: eval, spread

Causes system to suppress next N items of trace output. This is very useful for delayed errors by switching on `trace` before a problem occurs.

`(embed` NAME:id NEWDEF:function`)`

Type: eval, spread

`embed` is used to provide more detailed tracing than is available with `trace`, or to control the behaviour of system routines. The definition of the function NAME is replaced by NEWDEF, where this new definition may contain calls to the current value. The old definition is stored and can be recovered by `unembed`. For example if the global variable GLOB was of interest before and after the function `change`, one could use the following to get the information:

```
(embed 'change(lambda (X)
    (print (list "Value of glob on entry:" GLOB))
    (change X)
   (print (list "changed by change to:" GLOB))))
```

`(unembed` U:id`)`

Type: eval, spread

Undoes effect of `embed`.

14.2 Tracing memory use

`(readcount` U:function V:any):integer
Type: eval, spread

Reads a call-count accumulated in a function compiled with the profile option set. If V is non-nil then the count is reset to 0.

`(setbtr` LEV:integer):integer
Type: eval, spread

`setbtr` sets the level of backtrace information.

0 Totally silent error recovery
1 Give the message only
2 Message and list of function on the stack
3 Like 2 with extended list of functions
4 Like 3 but includes all fluids bound
5 Message, functions, fluids and arguments to compiled functions
6 As 5 with expressions prettyprinted
7 As 6 with the loop printer printl used
8 As 5 with compiler temporaries as well
9 bcplstack printed before style 8.

Values higher than 8 are only useful for system developers. The value returned is the previous level value. Note that `setbtr` works at the lowest level, and as such calls to other functions, especially `errorset` will nullify the effect of this function. In general, users are recommended to use the `backgag` function which changes the backtrace characteristics at a higher, and hence more predictable level.

`(count` N:integer`)`:integer

Type: eval, spread

After `(count n)` has been obeyed, LISP will allow about n `cons` es to occur before causing an error:

'CONS COUNTER OVERFLOW'.

Note that the counting is very approximate, and that generally n should have a value of several thousand. `count` returns as its value the previous value of the `cons` counter. If a count of zero is established, the `conscounter` trap is disabled. `count` is intended for use with `errorset` and makes it possible to limit the amount of computation that a piece of code can perform. See `speak`.

`(speak)`:integer

`speak` returns the current value of the `cons` counter. Note that a value of 0 means that the counter is disabled, and that the number inspected by `speak` is only updated when a garbage collection occurs.

14.3 Timing functions

`(tempus-fugit)`

A call to `tempus-fugit` will result in LISP printing a line of text containing timing and store use figures.

```
(tempus!-fugit)
            prints
tempus-fugit after 3.21+41.11secs-40.9% store used
```

`(time)`:integer

Returns the elapsed time (in milliseconds) used so far this run, excluding overheads (see `gctime`).

`(timeofday)`:string

Returns a string giving time of day.

```
(timeofday)
        >  "20:16:36"
```

`(date)`:string

Type: eval, spread

This returns a string giving the current date.

15. Miscellaneous functions

`(mapstore` U:boolean)

Type: eval, spread

`mapstore` prints details of all compiled functions present in the LISP heap. If any of these were compiled with the statistics option (see `profile`), the counts will be displayed and reset to zero. `(mapstore t)` prints a similar map of the core LISP system for use by system programmers.

`(reclaim)`:nil

A user call to the function `reclaim` forces LISP to garbage-collect. A side effect of garbage collection may (see `verbos`) be the printing of some store-use statistics.

`(gcdaemon)`

Type: User provided function

If a function `gcdaemon` is defined by the user, it will get called at the end of each garbage collection if it is compiled and not traced. `gcdaemon` will be handed one argument, which will be the serial number of the garbage collection just completed. The `gcdaemon` facility will be inhibited within execution of itself, so garbage collections triggered by work done within `gcdaemon` will not normally lead to re-entry to the function. Erroneous exits from the `gcdaemon` function will lead to the function's definition being removed, and so after the deliberate creation of such an error state `gcdaemon` should be redefined.

`(gctime)`:integer

Type: eval, spread

The value returned by `gctime` is the amount of time (in milliseconds) consumed by 'overheads' since the start of the current LISP run. For these purposes, 'overheads' include initial loading of LISP, the dynamic loading of modules and garbage collection.

`(verbos` N:integer):integer

Type: eval, spread

Sets garbage message level to N. N = 0 for no messages, N = 1 for garbage collection, N > 1 for commentary on FASL activity. The initial setting is N = 0. The value returned is the previous value.

15.1 Graphics functions

Acorn Cambridge LISP provides a set of graphics routines. In order to use them, a graphics screen mode must be selected by calling `(mode n)` with n = 0, 1, or 2. Mode 0 provides 640 * 256 resolution in monochrome, mode 1 is 320 * 256 with 4 colours, and mode 2 is 160 * 256 with 16 colours. The co-ordinate system for the screen can be reset by `(scale h)`, but by default the screen has height 1024. After a call to `(scale h)`, the top of the screen has y co-ordinate h. The width of the screen is always 5/4 times its height. `(cls)` clears the screen, and (home) moves a notional graphics cursor to the centre of the screen. Two styles of graphics are supported:

(1) simple cartesian graphics

```
(moveto x y), (drawto x y)
```

(2) turtle graphics

```
(turn n), (turnto n)
(move l), (draw l)
```

If a closed convex figure is drawn on the screen between calls `(fill t)` and `(fill nil)` the area will be filled in. `(circle r)` and `(circleat x r y)` draw circles, and with `(fill t)` set, they draw filled in circles.

The effect of `ink` depends upon the screen mode; small arguments will lead to solid colours, and larger values will give a variety of shaded effects.

(circle r)- draw circle at current position

(circleat x y r)- draw circle at position x,y

(fill <flag>)- set/clear area - fill mode

(ink n)- establish colour

(mode n)- set screen mode

(move l)- Turtle graphics

(draw l)- Turtle graphics

(drawto x y)- Cartesian graphics

(moveto x y)- Cartesian graphics

(cls)- clear screen

(home)- go to mid-screen

(scale h)- set logical screen height

(paper n)- establish colour

(turnto n)- turns through a specified angle:

(turnto 0)- points to 12 o' clock, and positive angles turn clockwise.

16. Appendix A

16.1 Error Messages

0	User call to error function
1-5	Bad argument for plus
7	Bad argument for a division function
8	Bad argument for minus
9	Malformed number in buffer detected by numob
10	Bad argument for evenp
11	Bad argument for shift function
12-13	Bad argument for logand
14-15	Bad argument for logor
16-17	Bad argument for logxor
18	Argument for remob not an identifier
19-21	Bad argument for expt
22-23	Bad argument for greaterp or lessp
24	Attempt to take car of an atom
25	Attempt to take cdr of an atom
26	Rplaca given atomic first argument
27	Rplacd given atomic first argument
28	Orderp can not process gensyms
29	Bad argument for gts
30-31	Bad syntax for quote function
32	Bad argument for unset
33-34	Bad syntax in cond expression
35	Bad argument for plist
36	Second argument for open is input, output or append
37	Bad first argument for open
38	Mkatom failed-atom assembly buffer not set up
39	Numob failed-atom assembly buffer not set up
40	Atom assembly buffer empty
41	Pack failed-atom assembly buffer not set up
42	Bad argument for pack
43	Unset variable
44	Illegal object used as a function
45	Undefined function
46	Circular definition of function

47	Unset variable in macro-expansion
48	Funargs not implemented
49	Bad syntax in lambda expression
50	Illegal call to codel function
51	Illegal call to fcode function
52	Illegal call to lambdaq function
53	Too many arguments in lambda expression
54	Too many arguments for function
55	Illegal call to (lambda x ...) function
56	Illegal call to a macro
57-58	Illegal item in list of bound variables
59	Illegal item in list of prog variables
60	Return not directly in a prog
61	Attempt to divide by 0.0
62	Bad argument for fix
63	Argument for fix > 10**9
64-66	Bad format for define
67	Bad argument for set or setq
68	Attempt to set the value of nil
69-71	Bad syntax for setq
73-74	Bad format for deflist
75	Bad format in deflist/fexpr
76	Bad argument for put
77	Bad argument for flag
85	Bad argument for remflag
86	Bad argument for remprop
87	Bad argument for prop
89	Not enough store for vector request
90	Casego not directly in a prog
91	Go not directly in a prog
92-96	Bad argument for times
97	Atom too long (limit is 253 chars)
98	Bad syntax in number
99-100	Bad argument for xtab
101-102	Bad argument for ttab
108	Illegal multiple assignment
109	Bad argument for linelength
110-111	Bad syntax for prog
112	Bad syntax for go
113	Label not found

114	Attempt to divide by zero
115	Unable to convert fp number to rational form
129	Store jam
131	Bad argument for gctrap
132	Not enough store to load basic LISP system
133	Failure in LISP supervisor
134	Bad argument for tobig
135	Bad argument for torat
136	Numeric argument expected
138	Argument for prin1 should be atomic
139	Error detected by operating system
140-142	Attempt to divide by zero
143	Bad syntax for define
144	Bad syntax for deflist
145-147	Error in mkvect
148-150	Error in access to vector
151-153	Error in attempt to update vector element
154	Open failed-file does not exist
155	Open failed-file already in use
156	Bad argument for preserve
157	Preserve failed-file not found
158	Preserve failed-file already opened
159	Bad argument for digch
160	Non-atomic arg to chdig
161-162	Argument for chdig not a digit
163	Bad argument for trace
164	Bad argument for untrace
165	End of file detected by read
166	Not an atom for orderp
168	Output radix must be 2,8,10 or 16
169	Bad argument for gcd
173	Illegal car access in compiled code
174	Illegal cdr access in compiled code
175	Illegal rplaca in compiled code
176	Illegal rplacd in compiled code
177	Rplacw read access illegal
178	Rplacw write access illegal
179	Bad argument for count
180	Function type assumptions wrong in compiled code
181	Bad use of car, cdr or rplaca/d in compiled code

182	Bad argument to modular arithmetic routine
183	Bad argument for arcsin/arccos
184	Bad argument for atan
185	Bad argument for exp
186	Bad argument for log/log10
187	Bad argument for expt (base=0.0)
188	Bad argument for sin/cos
189	Negative argument for sqrt
190	Bad argument for tan/cot
191	Bad argument for tan/cot
192	Bad argument for abs
196	Boffo overflowed in pack
197	Bad use of 'function'
198	Bad function name for define
199	Maximum length of integer exceeded
201	Bad argument for (integer) sqrt
202	Negative argument for (integer) sqrt
203	Exponent too large in floating point number
206	Bad argument for bps
208	Type code bad in bps
210	Overflow of quotecell region
211	Unable to open dumpfile
213	Type code bad for getbps
214	Attempt to open sysin for output
215	Attempt to open sysprint for input
216	Close failed on file
217	Lost file in close
218	Bad syntax in use of de, df, dm, dcf or dcm
219-220	Conflict between flag and indicator name
225	Module already loaded
226	Module not found
227	Loading module did not load required function
228	Bad syntax in call to fasl
229	Module empty or irrelevant
230	Format error in module
231	Bad argument for dumpfile
232	Dumping inhibited by return code
233	Failed to write up core image file
234	Bad argument for setreturncode
235	Bad member name for faslcopy

236	Member not found for faslcopy
237	Faslcopy unable to open output file
242	File already open as a sequential dataset
243	File already open as a partitioned dataset
244	Attempt to open file for both reading and writing
245	Attempt to read and write same pds member
246	Lost file in wrs
247	Lost pds on wrs
248	Bad argument for wrs
249	Lost file in rds
250	Lost pds in rds
251	Bad argument for rds
252	Fast loading failed-system may be in inconsistent state
253	Function definition not recovered from module
254	Type code bad in excise
255	Bad member in image file found by faslcopy
256	Bad argument for module
257	Module already in use
258	Unable to open module output file
265	Cons counter overflow

17. Appendix B

17.1 Bibliography

A good introductory text for Lisp programming:

LISP, AC Norman and G Cattell, Acornsoft Ltd 1983.

The following texts explore many of the areas where Lisp is found to be the most convenient programming tool.

Artificial Intelligence Programming, E Charniak C Riesbeck
D McDermott, Lawrence Erlbaum Associates 1980.

LISP, P Winston and B K Horn, 2nd edition Addison-Wesley 1984.

LISP 1.5 users manual
or the
Stanford Lisp reference manual.

This publication describes a version of Lisp which is fairly close to Cambridge Lisp:

ACM SIGPLAN Notices Vol. 14 No. 10 Oct 1979

The following book describes an important new dialect of Lisp:

Common Lisp, the Language, G. Steele, Digital Press, 1984


Acorn
The choice of experience.