The **TANGLE processor**

*(Version 4.6)*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>The character set</td>
<td>11</td>
</tr>
<tr>
<td>Input and output</td>
<td>19</td>
</tr>
<tr>
<td>Reporting errors to the user</td>
<td>29</td>
</tr>
<tr>
<td>Data structures</td>
<td>37</td>
</tr>
<tr>
<td>Searching for identifiers</td>
<td>50</td>
</tr>
<tr>
<td>Searching for module names</td>
<td>65</td>
</tr>
<tr>
<td>Tokens</td>
<td>70</td>
</tr>
<tr>
<td>Stacks for output</td>
<td>77</td>
</tr>
<tr>
<td>Producing the output</td>
<td>94</td>
</tr>
<tr>
<td>The big output switch</td>
<td>112</td>
</tr>
<tr>
<td>Introduction to the input phase</td>
<td>123</td>
</tr>
<tr>
<td>Inputting the next token</td>
<td>143</td>
</tr>
<tr>
<td>Scanning a numeric definition</td>
<td>156</td>
</tr>
<tr>
<td>Scanning a macro definition</td>
<td>163</td>
</tr>
<tr>
<td>Scanning a module</td>
<td>171</td>
</tr>
<tr>
<td>Debugging</td>
<td>179</td>
</tr>
<tr>
<td>The main program</td>
<td>182</td>
</tr>
<tr>
<td>System-dependent changes</td>
<td>188</td>
</tr>
<tr>
<td>Index</td>
<td>200</td>
</tr>
</tbody>
</table>
Introduction. This program converts a WEB file to a Pascal file. It was written by D. E. Knuth in September, 1981; a somewhat similar SAIL program had been developed in March, 1979. Since this program describes itself, a bootstrapping process involving hand-translation had to be used to get started.

For large WEB files one should have a large memory, since TANGLE keeps all the Pascal text in memory (in an abbreviated form). The program uses a few features of the local Pascal compiler that may need to be changed in other installations:

1) Case statements have a default.
2) Input-output routines may need to be adapted for use with a particular character set and/or for printing messages on the user’s terminal.

These features are also present in the Pascal version of \TeX, where they are used in a similar (but more complex) way. System-dependent portions of TANGLE can be identified by looking at the entries for ‘system dependencies’ in the index below.

The “banner line” defined here should be changed whenever TANGLE is modified.

\begin{verbatim}
define my_name ≡ `tangle`
define banner ≡ `This is TANGLE, Version 4.6`
\end{verbatim}

The program begins with a fairly normal header, made up of pieces that will mostly be filled in later. The WEB input comes from files web file and change file, the Pascal output goes to file Pascal file, and the string pool output goes to file pool.

If it is necessary to abort the job because of a fatal error, the program calls the ‘jump out’ procedure.

\begin{verbatim}
program TANGLE(web_file, change_file, Pascal_file, pool);
const ⟨Constants in the outer block 8*⟩
type ⟨Types in the outer block 11⟩
var ⟨Globals in the outer block 9⟩
  ⟨Error handling procedures 30⟩
  ⟨Define parse_arguments 188*⟩
procedure initialize;
  var ⟨Local variables for initialization 16⟩
    begin kpse_set_program_name(argv[0], my_name); parse_arguments; ⟨Set initial values 10⟩
    end;
\end{verbatim}

The following parameters are set big enough to handle \TeX, so they should be sufficient for most applications of TANGLE.

\begin{verbatim}
( Constants in the outer block 8* ) ≡
  buf_size = 1000;  { maximum length of input line }
  max_bytes = 65535;  { 1/ww times the number of bytes in identifiers, strings, and module names; must be less than 65536 }
  max_toks = 65535;
    { 1/zz times the number of bytes in compressed Pascal code; must be less than 65536 }
  max_names = 10239;  { number of identifiers, strings, module names; must be less than 10240 }
  max_texts = 10239;  { number of replacement texts, must be less than 10240 }
  hash_size = 353;  { should be prime }
  longest_name = 400;  { module names shouldn’t be longer than this }
  line_length = 72;  { lines of Pascal output have at most this many characters }
  out_buf_size = 144;  { length of output buffer, should be twice line_length }
  stack_size = 100;  { number of simultaneous levels of macro expansion }
  max_id_length = 50;  { long identifiers are chopped to this length, which must not exceed line_length }
  def_unambig_length = 32;  { identifiers must be unique if chopped to this length }
\end{verbatim}

This code is used in section 2*.
The original Pascal compiler was designed in the late 60s, when six-bit character sets were common, so it did not make provision for lowercase letters. Nowadays, of course, we need to deal with both capital and small letters in a convenient way, so WEB assumes that it is being used with a Pascal whose character set contains at least the characters of standard ASCII as listed above. Some Pascal compilers use the original name char for the data type associated with the characters in text files, while other Pascals consider char to be a 64-element subrange of a larger data type that has some other name.

In order to accommodate this difference, we shall use the name text_char to stand for the data type of the characters in the input and output files. We shall also assume that text_char consists of the elements chr(first_text_char) through chr(last_text_char), inclusive. The following definitions should be adjusted if necessary.

\begin{verbatim}
define text_char ≡ ASCII_code { the data type of characters in text files }
define first_text_char = 0 { ordinal number of the smallest element of text_char }
define last_text_char = 255 { ordinal number of the largest element of text_char }
\end{verbatim}

(Types in the outer block 11) +≡

\begin{verbatim}
text_file = packed file of text_char;
\end{verbatim}

Here now is the system-dependent part of the character set. If WEB is being implemented on a garden-variety Pascal for which only standard ASCII codes will appear in the input and output files, you don’t need to make any changes here. But if you have, for example, an extended character set like the one in Appendix C of The \TeXbook, the first line of code in this module should be changed to

\begin{verbatim}
for i ← 1 to '37 do xchr[i] ← chr(i);
\end{verbatim}

WEB’s character set is essentially identical to \TeX’s, even with respect to characters less than '40.

Changes to the present module will make WEB more friendly on computers that have an extended character set, so that one can type things like ≠ instead of <>.

(Changes to WEB will cause the following to be changed from the present file TANGLE.WEB to something like)

\begin{verbatim}
for i ← 1 to '37 do xchr[i] ← chr(i);
for i ← '200 to '377 do xchr[i] ← chr(i);
\end{verbatim}

Changes to the present module will make WEB more friendly on computers that have an extended character set, so that one can type things like ≠ instead of <>.

(Changes to WEB will cause the following to be changed from the present file TANGLE.WEB to something like)

\begin{verbatim}
for i ← 1 to '37 do xchr[i] ← chr(i);
for i ← '200 to '377 do xchr[i] ← chr(i);
\end{verbatim}
Terminal output is done by writing on file \texttt{term\_out}, which is assumed to consist of characters of type \texttt{text\_char}:

\begin{verbatim}
define term\_out \equiv stdout
define print(\#) \equiv write(term\_out,\#) \{\text{'print' means write on the terminal}\}
define print\_ln(\#) \equiv write\_ln(term\_out,\#) \{\text{'print' and then start new line}\}
define new\_line \equiv write\_ln(term\_out) \{\text{start new line}\}
define print\_nl(\#) \equiv \{\text{print information starting on a new line}\}
begin new\_line; print(\#);
end
\end{verbatim}

Different systems have different ways of specifying that the output on a certain file will appear on the user’s terminal.
\begin{verbatim}
\langle\text{Set initial values}\ 10\rangle +\equiv
\{\text{Nothing need be done for C.}\}
\end{verbatim}

The \textit{update\_terminal} procedure is called when we want to make sure that everything we have output to the terminal so far has actually left the computer’s internal buffers and been sent.
\begin{verbatim}
define update\_terminal \equiv fflush(term\_out) \{\text{empty the terminal output buffer}\}
\end{verbatim}

The following code opens the input files. Since these files were listed in the program header, we assume that the Pascal runtime system has already checked that suitable file names have been given; therefore no additional error checking needs to be done.
\begin{verbatim}
procedure open\_input; \{\text{prepare to read web\_file and change\_file}\}
begin web\_file \leftarrow kpse\_open\_file\(web\_name, kpse\_web\_format\);
if chg\_name then change\_file \leftarrow kpse\_open\_file\(chg\_name, kpse\_web\_format\);
end;
\end{verbatim}

The following code opens \texttt{Pascal\_file} and \texttt{pool}. Since these files were listed in the program header, we assume that the Pascal runtime system has checked that suitable external file names have been given.
\begin{verbatim}
\langle\text{Set initial values}\ 10\rangle +\equiv
rewrite(Pascal\_file, pascal\_name);
\end{verbatim}
The \textit{input\_ln} procedure brings the next line of input from the specified file into the \textit{buffer} array and returns the value \textit{true}, unless the file has already been entirely read, in which case it returns \textit{false}. The conventions of \TeX are followed; i.e., \textit{ASCII\_code} numbers representing the next line of the file are input into \textit{buffer}[0], \textit{buffer}[1], \ldots, \textit{buffer}[\textit{limit} − 1]; trailing blanks are ignored; and the global variable \textit{limit} is set to the length of the line. The value of \textit{limit} must be strictly less than \textit{buf\_size}.

We assume that none of the \textit{ASCII\_code} values of \textit{buffer}[\textit{j}] for \(0 \leq \textit{j} < \textit{limit}\) is equal to 0, \texttt{'177}, \texttt{line\_feed}, \texttt{form\_feed}, or \texttt{carriage\_return}.

\begin{verbatim}
function input\_ln(var f : text\_file): boolean;  \{ inputs a line or returns false \}
var final\_limit: 0 .. buf\_size;  \{ limit without trailing blanks \}
begin limit ← 0; final\_limit ← 0;
if eof(f) then input\_ln ← false
else begin while ¬eoln(f) do
  begin buffer[limit] ← xord(getc(f)); incr(limit);
  if buffer[limit − 1] ≠ "\n" then final\_limit ← limit;
  if limit = buf\_size then
    begin while ¬eoln(f) do vgetc(f);
    decr(limit);  \{ keep buffer[buf\_size] empty \}
    if final\_limit > limit then final\_limit ← limit;
    print\_nl(´\nInput\_line\_too\_long´); loc ← 0; error;
  end;
  end;
read\_ln(f); limit ← final\_limit; input\_ln ← true;
end;
end;
\end{verbatim}
34* The \texttt{jump\_out} procedure just cuts across all active procedure levels and jumps out of the program.

\begin{verbatim}
define \texttt{jump\_out} \equiv uexit(1)
define \texttt{fatal\_error}(#) \equiv
   begin new\_line; write(stderr,#); error; mark\_fatal; jump\_out;
   end
\end{verbatim}
TANGLE has been designed to avoid the need for indices that are more than sixteen bits wide, so that it can be used on most computers. But there are programs that need more than 65536 tokens, and some programs even need more than 65536 bytes; \TeX{} is one of these. To get around this problem, a slight complication has been added to the data structures: \texttt{byte\_mem} and \texttt{tok\_mem} are two-dimensional arrays, whose first index is either 0 or 1 or 2. (For generality, the first index is actually allowed to run between 0 and \texttt{ww} – 1 in \texttt{byte\_mem}, or between 0 and \texttt{zz} – 1 in \texttt{tok\_mem}, where \texttt{ww} and \texttt{zz} are set to 2 and 3; the program will work for any positive values of \texttt{ww} and \texttt{zz}, and it can be simplified in obvious ways if \texttt{ww} = 1 or \texttt{zz} = 1.)

\begin{verbatim}
define \texttt{ww} = 3  \{ we multiply the byte capacity by approximately this amount \}
define \texttt{zz} = 5  \{ we multiply the token capacity by approximately this amount \}
\end{verbatim}

\begin{verbatim}
(byte\_mem: packed array [0..\texttt{ww} – 1, 0..\texttt{max\_bytes}] of ASCII\_code; \{ characters of names \})
(tok\_mem: packed array [0..\texttt{zz} – 1, 0..\texttt{max\_toks}] of eight\_bits; \{ tokens \})
(byte\_start: array [0..\texttt{max\_names}] of sixteen\_bits; \{ directory into byte\_mem \})
(tok\_start: array [0..\texttt{max\_texts}] of sixteen\_bits; \{ directory into tok\_mem \})
(link: array [0..\texttt{max\_names}] of sixteen\_bits; \{ hash table or tree links \})
(ilk: array [0..\texttt{max\_names}] of sixteen\_bits; \{ type codes or tree links \})
(equiv: array [0..\texttt{max\_names}] of integer; \{ info corresponding to names \})
(text\_link: array [0..\texttt{max\_texts}] of sixteen\_bits; \{ relates replacement texts \})
\end{verbatim}

Four types of identifiers are distinguished by their \texttt{ilk}:

\begin{itemize}
  \item \textit{normal} identifiers will appear in the Pascal program as ordinary identifiers since they have not been defined to be macros; the corresponding value in the \texttt{equiv} array for such identifiers is a link in a secondary hash table that is used to check whether any two of them agree in their first unambig\_length characters after underline symbols are removed and lowercase letters are changed to uppercase.
  \item \textit{numeric} identifiers have been defined to be numeric macros; their \texttt{equiv} value contains the corresponding numeric value plus $2^{30}$. Strings are treated as numeric macros.
  \item \textit{simple} identifiers have been defined to be simple macros; their \texttt{equiv} value points to the corresponding replacement text.
  \item \textit{parametric} and \textit{parametric2} identifiers have been defined to be parametric macros; like simple identifiers, their \texttt{equiv} value points to the replacement text.
\end{itemize}

\begin{verbatim}
define \texttt{normal} = 0  \{ ordinary identifiers have \texttt{normal} ilk \}
define \texttt{numeric} = 1  \{ numeric macros and strings have \texttt{numeric} ilk \}
define \texttt{simple} = 2  \{ simple macros have \texttt{simple} ilk \}
define \texttt{parametric} = 3  \{ parametric macros have \texttt{parametric} ilk \}
define \texttt{parametric2} = 4  \{ second type of parametric macros have this ilk \}
\end{verbatim}
### Searching for Identifiers

The hash table described above is updated by the `id_lookup` procedure, which finds a given identifier and returns a pointer to its index in `byte_start`. If the identifier was not already present, it is inserted with a given `ilk` code; and an error message is printed if the identifier is being doubly defined.

Because of the way TANGLE’s scanning mechanism works, it is most convenient to let `id_lookup` search for an identifier that is present in the `buffer` array. Two other global variables specify its position in the buffer: the first character is `buffer[id_first]`, and the last is `buffer[id_loc - 1]`. Furthermore, if the identifier is really a string, the global variable `double_chars` tells how many of the characters in the buffer appear twice (namely `@` and `"`), since this additional information makes it easy to calculate the true length of the string. The final double-quote of the string is not included in its “identifier,” but the first one is, so the string length is `id_loc - id_first - double_chars - 1`.

We have mentioned that normal identifiers belong to two hash tables, one for their true names as they appear in the WEB file and the other when they have been reduced to their first unambig_length characters. The hash tables are kept by the method of simple chaining, where the heads of the individual lists appear in the hash and `chop_hash` arrays. If `h` is a hash code, the primary hash table list starts at `hash[h]` and proceeds through link pointers; the secondary hash table list starts at `chop_hash[h]` and proceeds through equiv pointers. Of course, the same identifier will probably have two different values of `h`.

The `id_lookup` procedure uses an auxiliary array called `chopped_id` to contain up to unambig_length characters of the current identifier, if it is necessary to compute the secondary hash code. (This array could be declared local to `id_lookup`, but in general we are making all array declarations global in this program, because some compilers and some machine architectures make dynamic array allocation inefficient.)

```plaintext
(Global in the outer block 9) +≡

id_first: 0 .. buf_size; { where the current identifier begins in the buffer }
id_loc: 0 .. buf_size; { just after the current identifier in the buffer }
double_chars: 0 .. buf_size; { correction to length in case of strings }

hash, chop_hash: array [0 .. hash_size] of sixteen_bits; { heads of hash lists }
chopped_id: array [0 .. max_id_length] of ASCII_code; { chopped identifier }
```

### §53

Here now is the main procedure for finding identifiers (and strings). The parameter `t` is set to normal except when the identifier is a macro name that is just being defined; in the latter case, `t` will be numeric, simple, parametric, or parametric2.

```plaintext
function id_lookup(t : eight_bits): name_pointer; { finds current identifier }

label found, not_found;

var c: eight_bits; { byte being chopped }
i: 0 .. buf_size; { index into buffer }
h: 0 .. hash_size; { hash code }
k: 0 .. max_bytes; { index into byte_mem }
w: 0 .. ww - 1; { segment of byte_mem }
l: 0 .. buf_size; { length of the given identifier }
p,q: name_pointer; { where the identifier is being sought }
s: 0 .. max_id_length; { index into chopped_id }

begin l ← id_loc - id_first; { compute the length }

(Compute the hash code h 54);
(Compute the name location p 55);

if (p = name_ptr) ∨ (t ≠ normal) then { Update the tables and check for possible errors 57};
id_lookup ← p;

end;
```
The following routine, which is called into play when it is necessary to look at the secondary hash table, computes the same hash function as before (but on the chopped data), and places a zero after the chopped identifier in \texttt{chopped.id} to serve as a convenient sentinel.

\[
\text{Compute the secondary hash code } h \text{ and put the first characters into the auxiliary array } \texttt{chopped.id.}
\]

\[
\begin{align*}
\text{begin } i &\leftarrow \texttt{id.first}; s \leftarrow 0; h \leftarrow 0; \\
\text{while } (i < \texttt{id.loc}) \land (s < \texttt{unambig.length}) \text{ do} & \\
\text{begin if } (\texttt{buffer}[i] \neq \texttt{"\_\"}) \lor (\texttt{allow_underlines} \land \neg \texttt{strict.mode}) \text{ then} & \\
\text{begin if } (\texttt{strict.mode} \lor \texttt{force.uppercase}) \land (\texttt{buffer}[i] \geq \texttt{"a\"}) \text{ then } \texttt{chopped.id}[s] \leftarrow \texttt{buffer}[i] - \texttt{\'40} & \\
\text{else if } (\neg \texttt{strict.mode} \land \texttt{force.lowercase}) \land (\texttt{buffer}[i] \geq \texttt{"A\"}) \land (\texttt{buffer}[i] \leq \texttt{"Z\"}) \text{ then} & \\
\text{chopped.id}[s] \leftarrow \texttt{buffer}[i]; & \\
h &\leftarrow (h + h + \texttt{chopped.id}[s]) \mod \texttt{hash.size}; \texttt{incr}(s); & \\
\text{end}; & \\
\text{incr}(i); & \\
\text{end}; & \\
\texttt{chopped.id}[s] \leftarrow 0; & \\
\end{align*}
\]

This code is used in section 57.

\[\text{(Check if } q \text{ conflicts with } p \text{.)}\]

\[
\begin{align*}
\text{begin } k &\leftarrow \texttt{byte.start}[q]; s \leftarrow 0; w \leftarrow q \mod \texttt{ww}; \\
\text{while } (k < \texttt{byte.start}[q + \texttt{ww}]) \land (s < \texttt{unambig.length}) \text{ do} & \\
\text{begin c }\leftarrow \texttt{byte.mem}[w, k]; & \\
\text{if c }\neq \texttt{\_\_} \lor (\texttt{allow_underlines} \land \neg \texttt{strict.mode}) \text{ then} & \\
\text{begin if } (\texttt{strict.mode} \lor \texttt{force.uppercase}) \land (c \geq \texttt{\"a\"}) \text{ then } c \leftarrow c - \texttt{\'40} & \\
\text{else if } (\neg \texttt{strict.mode} \land \texttt{force.lowercase}) \land (c \geq \texttt{\"A\"}) \land (c \leq \texttt{\"Z\"}) \text{ then} & \\
c \leftarrow c + \texttt{\'40}; & \\
\text{if } \texttt{chopped.id}[s] \neq c \text{ then } \texttt{goto not.found}; & \\
\texttt{incr}(s); & \\
\text{end}; & \\
\text{incr}(k); & \\
\end{align*}
\]

\[
\text{if } (k = \texttt{byte.start}[q + \texttt{ww}]) \land (\texttt{chopped.id}[s] \neq 0) \text{ then } \texttt{goto not.found}; \\
\text{print.nl}(\texttt{\"Identifier.conflict with\")}; \\
\text{for } k \leftarrow \texttt{byte.start}[q] \text{ to } \texttt{byte.start}[q + \texttt{ww}] - 1 \text{ do } \texttt{print}(\texttt{chr}[\texttt{byte.mem}[w, k]]); \\
\text{error}; q \leftarrow 0; \{ \text{only one conflict will be printed, since equiv[0] = 0} \}
\]

\texttt{not.found: end}

This code is used in section 62.
We compute the string pool check sum by working modulo a prime number that is large but not so large that overflow might occur.

\[
\text{define check\_sum\_prime } \equiv 37777777667 \quad \{ 2^{29} - 73 \}
\]

(Define and output a new string of the pool \( \text{64*} \) \( \equiv \)

\[
\begin{align*}
\text{begin } & \text{ilk}[p] \leftarrow \text{numeric}; \quad \{ \text{strings are like numeric macros} \} \\
\text{if } & l - \text{double\_chars} = 2 \text{ then} \quad \{ \text{this string is for a single character} \} \\
& \text{equiv}[p] \leftarrow \text{buffer}[\text{id\_first} + 1] + \text{10000000000} \\
\text{else begin} \quad \{ \text{Avoid creating empty pool files.} \} \\
& \text{if } \text{string\_ptr} = 256 \text{ then} \quad \{ \text{Change } \text{.web} \text{ to } \text{.pool} \text{ and use the current directory.} \} \\
& \quad \text{pool\_name } \leftarrow \text{basename\_change\_suffix(web\_name, } \text{.web}, \text{.pool}); \quad \text{rewritebin(pool, pool\_name);} \\
& \quad \text{end;} \\
& \quad \text{equiv}[p] \leftarrow \text{string\_ptr} + \text{10000000000}; \quad l \leftarrow l - \text{double\_chars} - 1; \\
& \text{if } l > 99 \text{ then err\_print(} \text{!Preprocessed\_string\_is\_too\_long}); \\
& \quad \text{incr(string\_ptr);} \quad \text{write(pool, xchr[}^{0} + l \text{ div 10}], xchr[}^{0} + l \text{ mod 10]);} \quad \{ \text{output the length} \} \\
& \quad \text{pool\_check\_sum } \leftarrow \text{pool\_check\_sum } + \text{pool\_check\_sum } + l; \\
& \text{while pool\_check\_sum } > \text{check\_sum\_prime} \text{ do pool\_check\_sum } \leftarrow \text{pool\_check\_sum } - \text{check\_sum\_prime}; \\
& \quad i \leftarrow \text{id\_first } + 1; \\
& \text{while } i < \text{id\_loc} \text{ do} \quad \{ \text{output characters of string} \} \\
& \quad \text{pool\_check\_sum } \leftarrow \text{pool\_check\_sum } + \text{pool\_check\_sum } + \text{buffer}[i]; \\
& \quad \text{while pool\_check\_sum } > \text{check\_sum\_prime} \text{ do pool\_check\_sum } \leftarrow \text{pool\_check\_sum } - \text{check\_sum\_prime}; \\
& \quad \text{if } (\text{buffer}[i] = \text{"""}) \lor (\text{buffer}[i] = \text{"@"}) \text{ then } i \leftarrow i + 2 \quad \{ \text{omit second appearance of doubled character} \} \\
& \quad \text{else incr}(i); \\
& \text{write\_ln(pool);} \\
& \text{end;} \\
& \text{end;} \\
\end{align*}
\]

This code is used in section \( \text{61} \).
§65 TANGLE changes for C

SEARCHING FOR MODULE NAMES

85* When we come to the end of a replacement text, the pop_level subroutine does the right thing: It either moves to the continuation of this replacement text or returns the state to the most recently stacked level. Part of this subroutine, which updates the parameter stack, will be given later when we study the parameter stack in more detail.

procedure pop_level; { do this when cur_byte reaches cur_end }
  label exit;
  begin if text_link[cur_repl] = 0 then { end of macro expansion }
      begin if (ilk[cur_name] = parametric) ∨ (ilk[cur_name] = parametric2) then 
        { Remove a parameter from the parameter stack 91 };
      end
  else if text_link[cur_repl] < module_flag then { link to a continuation }
      begin cur_repl ← text_link[cur_repl]; { we will stay on the same level }
        zo ← cur_repl mod zz; cur_byte ← tok_start[cur_repl]; cur_end ← tok_start[cur_repl + zz]; return;
      end;
      decr(stack_ptr); { we will go down to the previous level }
      if stack_ptr > 0 then 
        begin cur_state ← stack[stack_ptr]; zo ← cur_repl mod zz;
        end;
      exit: end;

89* ( Expand macro a and goto found, or goto restart if no output found 89*) ≡
  begin case ilk[a] of
    normal: begin cur_val ← a; a ← identifier;
      end;
    numeric: begin cur_val ← equiv[a] − ’10000000000; a ← number;
      end;
    simple: begin push_level(a); goto restart;
      end;
    parametric, parametric2: begin { Put a parameter on the parameter stack, or goto restart if error 
      occurs 90* };
      push_level(a); goto restart;
      end;
    othercases confusion(’output ’)
    endcases;
  goto found;
  end
This code is used in section 87.
We come now to the interesting part, the job of putting a parameter on the parameter stack. First we pop the stack if necessary until getting to a level that hasn’t ended. Then the next character must be a ‘(’; and since parentheses are balanced on each level, the entire parameter must be present, so we can copy it without difficulty.

( Put a parameter on the parameter stack, or goto restart if error occurs 90* ) ≡

while (cur_byte = cur_end) ∧ (stack_ptr > 0) do pop_level;
if ( (stack_ptr = 0) ∨ ((ilk[a] = parametric) ∧ (tok_mem[zo, cur_byte] ≠ "") ) then
begin print_nl("!` No parameter given for `!"); print_id(a); error; goto restart;
end;
(Copy the parameter into tok_mem 93*);
equiv[ name_ptr ] ← text_ptr; ilk[ name_ptr ] ← simple; w ← name_ptr mod ww; k ← byte_ptr[w];
debugeq if k = max_bytes then overflow("byte_memory");
byte_mem[w,k] ← "; incr(k); byte_ptr[w] ← k;
gudeq { this code has set the parameter identifier for debugging printouts }
if name_ptr > max_names − ww then overflow("name");
byte_start[name_ptr + ww] ← k; incr(name_ptr);
if text_ptr > max_texts − zz then overflow("text");
text_link[text_ptr] ← 0; tok_start[text_ptr + zz] ← tok_ptr[z]; incr(text_ptr); z ← text_ptr mod zz

This code is used in section 89*. 
Similarly, a `param` token encountered as we copy a parameter is converted into a simple macro call for `name_ptr−1`. Some care is needed to handle cases like `macro(#; print(´#´))`; the # token will have been changed to `param` outside of strings, but we still must distinguish ‘real’ parentheses from those in strings.

```plaintext
define app_repl(#) ≡
    begin if tok_ptr[z] = max_toks then overflow(´token´);
        tok_mem[z, tok_ptr[z]] ← #; incr(tok_ptr[z]);
    end

⟨Copy the parameter into tok_mem⟩ ≡
    bal ← 1; incr(cur_byte); { skip the opening ‘(’ or ‘[’ }
    loop begin b ← tok_mem[zo, cur_byte]; incr(cur_byte);
        if b = param then store_two_bytes(name_ptr + 77777)
        else begin if b ≥ 200 then
            begin app_repl(b); b ← tok_mem[zo, cur_byte]; incr(cur_byte);
            end
        else case b of
            "(": if ilk[a] = parametric then incr(bal);
            ")": if ilk[a] = parametric then
                begin decr(bal);
                    if bal = 0 then goto done;
                end;
            "[": if ilk[a] = parametric2 then incr(bal);
            "]": if ilk[a] = parametric2 then
                begin decr(bal);
                    if bal = 0 then goto done;
                end;
            """: repeat app_repl(b); b ← tok_mem[zo, cur_byte]; incr(cur_byte);
                until b = ""; { copy string, don’t change bal }
            othercases do nothing
        endcases;
    app_repl(b);
end;
end

done:
```

This code is used in section 90*.
(Contribution is * or / or DIV or MOD 105*) ≡
((t = misc) ∧ ((v = "*") ∨ (v = "/"))))

This code is used in section 104.

(If previous output was DIV or MOD, goto bad_case 110*) ≡
if ((out_ptr = break_ptr + 3) ∨ ((out_ptr = break_ptr + 4) ∧ (out_buf[break_ptr] = "."))) then
if (((out_buf[out_ptr - 3] = "D") ∧ (out_buf[out_ptr - 2] = "I") ∧ (out_buf[out_ptr - 1] = "V")) ∨
((out_buf[out_ptr - 3] = "d") ∧ (out_buf[out_ptr - 2] = "i") ∧ (out_buf[out_ptr - 1] = "v")) ∨
((out_buf[out_ptr - 3] = "M") ∧ (out_buf[out_ptr - 2] = "0") ∧ (out_buf[out_ptr - 1] = "D")) ∨
((out_buf[out_ptr - 3] = "m") ∧ (out_buf[out_ptr - 2] = "o") ∧ (out_buf[out_ptr - 1] = "d")) then
goto bad_case

This code is used in section 107.
114* (Cases like <> and := 114*)

\[
\begin{align*}
\text{and_sign:} & \quad \text{begin} \ out contrib[1] \leftarrow "a"; \ out contrib[2] \leftarrow "n"; \ out contrib[3] \leftarrow "d"; \ send out(\text{ident}, 3); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{not_sign:} & \quad \text{begin} \ out contrib[1] \leftarrow "n"; \ out contrib[2] \leftarrow "o"; \ out contrib[3] \leftarrow "t"; \ send out(\text{ident}, 3); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{set_element_sign:} & \quad \text{begin} \ out contrib[1] \leftarrow "i"; \ out contrib[2] \leftarrow "n"; \ send out(\text{ident}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{or_sign:} & \quad \text{begin} \ out contrib[1] \leftarrow "o"; \ out contrib[2] \leftarrow "r"; \ send out(\text{ident}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{left_arrow:} & \quad \text{begin} \ out contrib[1] \leftarrow ";"; \ out contrib[2] \leftarrow "="; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{not_equal:} & \quad \text{begin} \ out contrib[1] \leftarrow ";"; \ out contrib[2] \leftarrow ";"; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{less_or_equal:} & \quad \text{begin} \ out contrib[1] \leftarrow ";"; \ out contrib[2] \leftarrow "="; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{greater_or_equal:} & \quad \text{begin} \ out contrib[1] \leftarrow ";"; \ out contrib[2] \leftarrow "="; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{equivalence_sign:} & \quad \text{begin} \ out contrib[1] \leftarrow "="; \ out contrib[2] \leftarrow "="; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{double_dot:} & \quad \text{begin} \ out contrib[1] \leftarrow ";"; \ out contrib[2] \leftarrow ";"; \ send out(\text{str}, 2); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

This code is used in section 113.

116* Single-character identifiers represent themselves, while longer ones appear in byte_mem. All must be converted to lowercase, with underlines removed. Extremely long identifiers must be chopped.

\[
\begin{align*}
\text{define} & \quad \text{up_to}(\#) \equiv \# - 24, \# - 23, \# - 22, \# - 21, \# - 20, \# - 19, \# - 18, \# - 17, \# - 16, \# - 15, \# - 14, \# - 13, \\
\end{align*}
\]

\[
\begin{align*}
\# - 12, \# - 11, \# - 10, \# - 9, \# - 8, \# - 7, \# - 6, \# - 5, \# - 4, \# - 3, \# - 2, \# - 1, \# \\
\end{align*}
\]

\[
\begin{align*}
(\text{Cases related to identifiers 116*}) \equiv \\
\end{align*}
\]

\[
\begin{align*}
"A", \text{up_to}("Z"): & \quad \text{begin if} \ \text{force_lowercase} \ \text{then} \ \text{out_contrib}[1] \leftarrow \text{cur_char} + \#40 \\
\end{align*}
\]

\[
\begin{align*}
\text{else} \ \text{out_contrib}[1] \leftarrow \text{cur_char}; \\
\text{send out(\text{ident}, 1);}
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
"a", \text{up_to}("z"): & \quad \text{begin if} \ \text{force_uppercase} \ \text{then} \ \text{out_contrib}[1] \leftarrow \text{cur_char} - \#40 \\
\end{align*}
\]

\[
\begin{align*}
\text{else} \ \text{out_contrib}[1] \leftarrow \text{cur_char}; \\
\text{send out(\text{ident}, 1);}
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{identifier:} & \quad \text{begin} \ k \leftarrow 0; \ j \leftarrow \text{byte_start}[\text{cur_val}]; \ w \leftarrow \text{cur_val} \ \text{mod} \ \text{ww}; \\
\text{while} \ (k < \text{max_id_length}) \land \ (j < \text{byte_start}[\text{cur_val} + \text{ww}]) \ \text{do} \\
\text{begin} \ \text{incr}(k); \ \text{out_contrib}[k] \leftarrow \text{byte_mem}[w, j]; \ \text{incr}(j); \\
\text{if} \ \text{force_uppercase} \land (\text{out_contrib}[k] \geq "a") \ \text{then} \ \text{out_contrib}[k] \leftarrow \text{out_contrib}[k] - \#40 \\
\text{else if} \ \text{force_lowercase} \land (\text{out_contrib}[k] \leq "z") \ \text{then} \ \text{out_contrib}[k] \leftarrow \text{out_contrib}[k] + \#40 \\
\text{else if} \ \neg \text{allow_underlines} \land (\text{out_contrib}[k] = ");" \ \text{then} \ \text{decr}(k); \\
\end{align*}
\]

\[
\begin{align*}
\text{end;}
\end{align*}
\]

\[
\begin{align*}
\text{send out(\text{ident}, k);}
\end{align*}
\]

end;

This code is used in section 113.
In order to encourage portable software, TANGLE complains if the constants get dangerously close to the largest value representable on a 32-bit computer ($2^{31} - 1$).

\[\text{define } \text{digits} \equiv "0", "1", "2", "3", "4", "5", "6", "7", "8", "9"\]

(Cases related to constants, possibly leading to \texttt{get\_fraction} or \texttt{reswitch})

\[\text{digits}: \begin{align*}
\text{begin} \; & n \leftarrow 0; \\
\text{repeat} \; & \text{cur\_char} \leftarrow \text{cur\_char} - "0"; \\
& \text{if } n \geq 146346314 \text{ then } \text{err\_print}(\texttt{!Constant\_too\_big}) \\
& \text{else } n \leftarrow 10 * n + \text{cur\_char}; \\
& \text{cur\_char} \leftarrow \text{get\_output}; \\
\text{until} \; & (\text{cur\_char} > "9") \lor (\text{cur\_char} < "0"); \\
\text{send\_val}(n); \; & k \leftarrow 0; \\
& \text{if } \text{cur\_char} = "e" \text{ then } \text{cur\_char} \leftarrow "E"; \\
& \text{if } \text{cur\_char} = "E" \text{ then goto } \texttt{get\_fraction} \\
& \text{else goto reswitch}; \\
\end{align*}\]

\texttt{check\_sum}: \text{send\_val(pool\_check\_sum)};

\texttt{octal}: \begin{align*}
\text{begin} \; & n \leftarrow 0; \; \text{cur\_char} \leftarrow "0"; \\
& \text{repeat} \; \text{cur\_char} \leftarrow \text{cur\_char} - "0"; \\
& \text{if } n \geq 10000000000 \text{ then } \text{err\_print}(\texttt{!Constant\_too\_big}) \\
& \text{else } n \leftarrow 8 * n + \text{cur\_char}; \\
& \text{cur\_char} \leftarrow \text{get\_output}; \\
\text{until} \; & (\text{cur\_char} > "7") \lor (\text{cur\_char} < "0"); \\
\text{send\_val}(n); \; & \text{goto reswitch}; \\
\end{align*}\]

\texttt{hex}: \begin{align*}
\text{begin} \; & n \leftarrow 0; \; \text{cur\_char} \leftarrow "0"; \\
& \text{repeat if } \text{cur\_char} \geq "A" \text{ then } \text{cur\_char} \leftarrow \text{cur\_char} + 10 - "A" \\
& \text{else } \text{cur\_char} \leftarrow \text{cur\_char} - "0"; \\
& \text{if } n \geq 40000000 \text{ then } \text{err\_print}(\texttt{!Constant\_too\_big}) \\
& \text{else } n \leftarrow 16 * n + \text{cur\_char}; \\
& \text{cur\_char} \leftarrow \text{get\_output}; \\
\text{until} \; & (\text{cur\_char} > "F") \lor (\text{cur\_char} < "0") \lor ((\text{cur\_char} > "9") \land (\text{cur\_char} < "A"); \\
\text{send\_val}(n); \; & \text{goto reswitch}; \\
\end{align*}\]

\texttt{number}: \text{send\_val(\texttt{cur\_val})}.

\texttt{.} \texttt{.}: \begin{align*}
\text{begin} \; & k \leftarrow 1; \; \text{out\_contrib}[1] \leftarrow "."; \; \text{cur\_char} \leftarrow \text{get\_output}; \\
& \text{if } \text{cur\_char} = "\text{.}" \text{ then } \\
& \begin{align*}
& \text{begin} \; \text{out\_contrib}[2] \leftarrow "."; \; \text{send\_out(str, 2); } \\
& \end{align*} \\
& \text{else if } (\text{cur\_char} \geq "0") \land (\text{cur\_char} \leq "9") \text{ then goto } \texttt{get\_fraction} \\
& \text{else begin } \text{send\_out(misc, "."}; \; \text{goto reswitch}; \\
& \end{align*} \\
\end{align*}\]

This code is used in section 113.
The evaluation of a numeric expression makes use of two variables called the accumulator and the next_sign. At the beginning, accumulator is zero and next_sign is +1. When a + or − is scanned, next_sign is multiplied by the value of that sign. When a numeric value is scanned, it is multiplied by next_sign and added to the accumulator, then next_sign is reset to +1.

define add_in(#) ≡
   begin accumulator ← accumulator + next_sign * (#); next_sign ← +1;
end

procedure scan_numeric(p : name_pointer); { defines numeric macros }
   label reswitch, done;
   var accumulator: integer; { accumulates sums }
      next_sign: −1 .. +1; { sign to attach to next value }
   q: name_pointer; { points to identifiers being evaluated }
   val: integer; { constants being evaluated }
   begin ⟨Set accumulator to the value of the right-hand side 158⟩;
      if abs(accumulator) ≥ ’10000000000 then
         begin err_print(’!UValueUtooUbig;U’, accumulator : 1); accumulator ← 0;
            end;
         equiv[p] ← accumulator + ’10000000000; { name p now is defined to equal accumulator }
      end;

158* (Set accumulator to the value of the right-hand side 158) ≡
   accumulator ← 0; next_sign ← +1;
   loop begin next_control ← get_next;
      reswitch: case next_control of
         digits: begin ⟨Set val to value of decimal constant, and set next_control to the following token 160⟩;
            add_in(val); goto reswitch;
            end;
         octal: begin ⟨Set val to value of octal constant, and set next_control to the following token 161⟩;
            add_in(val); goto reswitch;
            end;
         hex: begin ⟨Set val to value of hexadecimal constant, and set next_control to the following token 162⟩;
            add_in(val); goto reswitch;
            end;
         identifier: begin q ← id_lookup(normal);
            if ilk[q] ≠ numeric then
               begin next_control ← "*"; goto reswitch; { leads to error }
                  add_in(equiv[q] − ’10000000000);
                  end;
            end;
            "+": do_nothing;
            "−": next_sign ← −next_sign;
         format, definition, module_name, begin_Pascal, new_module: goto done;
         ";": err_print(’!UOmitUsemicolonUinUnumericUdefinition’);
      othercases {Signal error, flush rest of the definition 159}
      endcases;
      done:
   This code is used in section 157*. 
165*
procedure scan_repl(t : eight_bits);  { creates a replacement text }
  label continue, done, found, reswitch;
  var a: sixteen_bits;  { the current token }
    b: ASCII_code;  { a character from the buffer }
    bal: eight_bits;  { left parentheses minus right parentheses }
  begin bal ← 0;
  loop begin continue: a ← get_next;
    case a of
      "": if t = parametric then incr(bal);
      ":": if t = parametric then
        if bal = 0 then err_print(´!\_Extra\)`
        else decr(bal);
    ":": if t = parametric2 then incr(bal);
      ":": if t = parametric2 then
        if bal = 0 then err_print(´!\_Extra\]`)`
        else decr(bal);
      "": Copy a string from the buffer to tok_mem 168;
      ":": if (t = parametric) \(\lor\) (t = parametric2) then a ← param;
      In cases that a is a non-ASCII token (identifier, module_name, etc.), either process it and change a to a byte that should be stored, or goto continue if a should be ignored, or goto done if a signals the end of this replacement text 167
    othercases do_nothing
  endcases;
  app_repl(a);  { store a in tok_mem }
end;

166*  ⟨Make sure the parentheses balance 166*⟩ ≡
  done: next_control ← a;  ⟨Make sure the parentheses balance 166*⟩;
  if text_ptr > max_texts − zz then overflow(´text´);
  cur_repl_text ← text_ptr; tok_start[text_ptr + zz] ← tok_ptr[z]; incr(text_ptr);
  if z = zz − 1 then z ← 0 else incr(z);
end;

This code is used in section 165*. 
(Scan the definition part of the current module 173*) \equiv

next_control ← 0;

loop begin continue: while next_control ≤ format do
  begin next_control ← skip_ahead;
    if next_control = module_name then
      begin { we want to scan the module name too }
        loc ← loc − 2; next_control ← get_next;
      end;
    end;
  if next_control ≠ definition then goto done;
  next_control ← get_next; { get identifier name }
  if next_control ≠ identifier then
    begin err_print(´!Definition flushed, must start with `, identifier of length > 1´);
      goto continue;
    end;
  next_control ← get_next; { get token after the identifier }
  if next_control = "=" then
    begin scan_numeric(id_lookup(numeric)); goto continue;
      end
  else if next_control = equivalence_sign then
    begin define_macro(simple); goto continue;
      end
  else (If the next text is ‘(#)==’ or ‘[#]==’, call define_macro and goto continue 174*);
    err_print(´!Definition flushed since it starts badly´);
  end;
  done:

This code is used in section 172.
174* (If the next text is ‘(#)==’ or ‘[#]==’, call define_macro and goto continue 174*) ≡

if next_control = "(" then
begin next_control ← get_next;
if next_control = "#" then
begin next_control ← get_next;
if next_control = ")" then
begin err_print(´!Use==for macros´); next_control ← equivalence_sign;
end;
if next_control = equivalence_sign then
begin define_macro(parametric); goto continue;
end;
end;
end;
end
else if next_control = "[" then
begin next_control ← get_next;
if next_control = "#" then
begin next_control ← get_next;
if next_control = "]" then
begin next_control ← get_next;
if next_control = "=" then
begin err_print(´!Use==for macros´); next_control ← equivalence_sign;
end;
if next_control = equivalence_sign then
begin define_macro(parametric2); goto continue;
end;
end;
end;
end
This code is used in section 173*. 
**Debugging.** The Pascal debugger with which TANGLE was developed allows breakpoints to be set, and variables can be read and changed, but procedures cannot be executed. Therefore a `debug_help` procedure has been inserted in the main loops of each phase of the program; when `ddt` and `dd` are set to appropriate values, symbolic printouts of various tables will appear.

The idea is to set a breakpoint inside the `debug_help` routine, at the place of `breakpoint:` below. Then when `debug_help` is to be activated, set `trouble_shooting` equal to `true`. The `debug_help` routine will prompt you for values of `ddt` and `dd`, discontinuing this when `ddt ≤ 0`; thus you type `2n + 1` integers, ending with zero or a negative number. Then control either passes to the breakpoint, allowing you to look at and/or change variables (if you typed zero), or to exit the routine (if you typed a negative value).

Another global variable, `debug_cycle`, can be used to skip silently past calls on `debug_help`. If you set `debug_cycle > 1`, the program stops only every `debug_cycle` times `debug_help` is called; however, any error stop will set `debug_cycle` to zero.

```c
#define term_in stdin
(Globals in the outer block 9) +≡
  debug trouble_shooting: boolean; { is debug_help wanted? }
  ddt: integer; { operation code for the debug_help routine }
  dd: integer; { operand in procedures performed by debug_help }
  debug_cycle: integer; { threshold for debug_help stopping }
  debug_skipped: integer; { we have skipped this many debug_help calls }

gubed
```

**180* The debugging routine needs to read from the user’s terminal.**

```c
(set initial values 10) +≡
  debug trouble_shooting ← true; debug_cycle ← 1; debug_skipped ← 0;
  trouble_shooting ← false; debug_cycle ← 99999; { use these when it almost works }

gubed
```
The main program. We have defined plenty of procedures, and it is time to put the last pieces
of the puzzle in place. Here is where TANGLE starts, and where it ends.

begin initialize;  ⟨Initialize the input system 134⟩;
print(banner);    { print a “banner line” }
printLn(version_string); ⟨Phase I: Read all the user’s text and compress it into tok_mem 183⟩;
stat for ii ← 0 to zz − 1 do max_tok_ptr[ii] ← tok_ptr[ii];
tats ⟨Phase II: Output the contents of the compressed tables 112⟩;
if string_ptr > 256 then ⟨Finish off the string pool file 184⟩;
stat ⟨Print statistics about memory usage 186⟩; tats
{ here files should be closed if the operating system requires it }
{ Print the job history 187 };
new_line;
if (history ≠ spotless) ∧ (history ≠ harmless_message) then uexit(1)
else uexit(0);
end.
§188* System-dependent changes. Parse a Unix-style command line.

\[
\text{define } \text{argument_is}(\#) \equiv \text{strcmp}(	ext{long_options}[\text{option_index}].\text{name}, \#) = 0
\]

(Define \text{parse_arguments} 188*) \equiv

\text{procedure} \text{parse_arguments};
\text{const} n\_\text{options} = 10; \{ \text{Pascal won’t count array lengths for us.} \}
\text{var} \text{long_options} : \text{array} [0..n\_\text{options}] \text{of} \text{getopt}\_\text{struct};
\text{getopt}\_\text{return}\_\text{val} : \text{integer}; \text{option_index} : \text{c\_int\_type}; \text{current}\_\text{option} : 0..n\_\text{options}; \text{len} : \text{integer};
\text{begin} \{ \text{Define the option table 189*} \}
\text{unambig}\_\text{length} \leftarrow \text{def}\_\text{unambig}\_\text{length};
\text{repeat} \text{getopt}\_\text{return}\_\text{val} \leftarrow \text{getopt}\_\text{long}\_\text{only}(\text{argv}, \text{argv},’\’, \text{long}\_\text{options}, \text{address}\_\text{of}(\text{option}\_\text{index}));
\text{if} \text{getopt}\_\text{return}\_\text{val} = -1 \text{then}
\text{begin do nothing; } \{ \text{End of arguments; we exit the loop below.} \}
\text{end}
\text{else if} \text{getopt}\_\text{return}\_\text{val} = "?" \text{then}
\text{begin usage}(\text{my}\_\text{name});
\text{end}
\text{else if} \text{argument_is}(’help’) \text{then}
\text{begin usage}\_\text{help}(\text{TANGLE}\_\text{HELP}, \text{nil});
\text{end}
\text{else if} \text{argument_is}(’version’) \text{then}
\text{begin print}\_\text{version}\_\text{and}\_\text{exit}(\text{banner}, \text{nil}, ’D.E. Knuth’, \text{nil});
\text{end}
\text{else if} \text{argument_is}(’mixedcase’) \text{then}
\text{begin force_yuppercase} \leftarrow \text{false}; \text{force_ylowercase} \leftarrow \text{false};
\text{end}
\text{else if} \text{argument_is}(’uppercase’) \text{then}
\text{begin force_yuppercase} \leftarrow \text{true}; \text{force_ylowercase} \leftarrow \text{false};
\text{end}
\text{else if} \text{argument_is}(’lowercase’) \text{then}
\text{begin force_yuppercase} \leftarrow \text{false}; \text{force_ylowercase} \leftarrow \text{true};
\text{end}
\text{else if} \text{argument_is}(’underlines’) \text{then}
\text{begin allow_yunderlines} \leftarrow \text{true};
\text{end}
\text{else if} \text{argument_is}(’strict’) \text{then}
\text{begin strict_mode} \leftarrow \text{true};
\text{end}
\text{else if} \text{argument_is}(’loose’) \text{then}
\text{begin strict_mode} \leftarrow \text{false};
\text{end}
\text{else if} \text{argument_is}(’length’) \text{then}
\text{begin len} \leftarrow \text{atoi}(\text{optarg});
\text{if} (\text{len} \leq 0) \lor (\text{len} > \text{max_id}\_\text{length}) \text{then} \text{len} \leftarrow \text{max_id}\_\text{length};
\text{unambig}\_\text{length} \leftarrow \text{len};
\text{end}; \{ \text{Else it was a flag; getopt has already done the assignment.} \}
\text{until} \text{getopt}\_\text{return}\_\text{val} = -1; \{ \text{Now optind is the index of first non-option on the command line.} \}
\text{if} (\text{optind} + 1 \neq \text{argv}) \land (\text{optind} + 2 \neq \text{argv}) \text{then}
\text{begin write}\_\text{ln}(\text{stderr}, \text{my}\_\text{name}, ’:\:\text{Need_one_or_two_file_arguments.’}); \text{usage}(\text{my}\_\text{name});
\text{end}; \{ \text{Supply } "\text{.web}" \text{and } "\text{.ch}" \text{extensions if necessary.} \}
\text{web}\_\text{name} \leftarrow \text{extend}\_\text{filename}(\text{cmdline}(\text{optind}), ’\text{.web’});
\text{if} \text{optind} + 2 = \text{argv} \text{then}
\text{begin chg}\_\text{name} \leftarrow \text{extend}\_\text{filename}(\text{cmdline}(\text{optind} + 1), ’\text{.ch’});
end:  { Change ".web" to ".p" and use the current directory. }
    pascal_name ← basename_change_suffix(web_name, ".web", ".p");
end;
This code is used in section 2*. 

189* Here are the options we allow. The first is one of the standard GNU options.
(Define the option table 189*) ≡
    current_option ← 0; long_options[current_option].name ← 'help';
    long_options[current_option].has_arg ← 0; long_options[current_option].flag ← 0;
    long_options[current_option].val ← 0; incr(current_option);
See also sections 190*, 191*, 192*, 193*, 194*, 195*, 196*, 197*, and 198*.
This code is used in section 188*.

190* Another of the standard options.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'version'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

191* Use all mixed case.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'mixedcase'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

192* Use all uppercase.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'uppercase'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

193* Use all lowercase.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'lowercase'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

194* Allow underlines.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'underlines'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

195* Strict comparisons.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'strict'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);

196* Loose comparisons.
(Define the option table 189*) +≡
    long_options[current_option].name ← 'loose'; long_options[current_option].has_arg ← 0;
    long_options[current_option].flag ← 0; long_options[current_option].val ← 0; incr(current_option);
Loose comparisons.

\[\text{(Define the option table 189*) } \equiv \]
\[\text{long_options}[\text{current_option}].\text{name} \leftarrow \text{`length'}; \text{long_options}[\text{current_option}].\text{has_arg} \leftarrow 1; \]
\[\text{long_options}[\text{current_option}].\text{flag} \leftarrow 0; \text{long_options}[\text{current_option}].\text{val} \leftarrow 0; \text{incr}(\text{current_option});\]

An element with all zeros always ends the list.

\[\text{(Define the option table 189*) } \equiv \]
\[\text{long_options}[\text{current_option}].\text{name} \leftarrow 0; \text{long_options}[\text{current_option}].\text{has_arg} \leftarrow 0; \]
\[\text{long_options}[\text{current_option}].\text{flag} \leftarrow 0; \text{long_options}[\text{current_option}].\text{val} \leftarrow 0;\]

Global filenames.

\[\text{(Globals in the outer block 9) } \equiv \]
\[\text{web_name, chg_name, pascal_name, pool_name: } \text{const c_string}; \]
\[\text{force_uppercase, force_lowercase, allow_underlines, strict_mode: } \text{boolean}; \]
\[\text{unambig_length: 0 . max_id_length};\]
**Index.** Here is a cross-reference table for the **TANGLE** processor. All modules in which an identifier is used are listed with that identifier, except that reserved words are indexed only when they appear in format definitions, and the appearances of identifiers in module names are not indexed. Underlined entries correspond to where the identifier was declared. Error messages and a few other things like “ASCII code” are indexed here too.

The following sections were changed by the change file: 1, 2, 8, 12, 17, 20, 21, 22, 24, 26, 28, 34, 38, 47, 50, 53, 58, 63, 64, 85, 89, 90, 93, 105, 110, 114, 116, 119, 157, 158, 165, 166, 173, 174, 179, 180, 182, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200.

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>-help</td>
<td>189</td>
</tr>
<tr>
<td>-length</td>
<td>197</td>
</tr>
<tr>
<td>-loose</td>
<td>196</td>
</tr>
<tr>
<td>-lowercase</td>
<td>193</td>
</tr>
<tr>
<td>-mixedcase</td>
<td>191</td>
</tr>
<tr>
<td>-strict</td>
<td>195</td>
</tr>
<tr>
<td>-underlines</td>
<td>194</td>
</tr>
<tr>
<td>-uppercase</td>
<td>192</td>
</tr>
<tr>
<td>-version</td>
<td>190</td>
</tr>
</tbody>
</table>

@d is ignored in Pascal text: 167.
@f is ignored in Pascal text: 167.
@p is ignored in Pascal text: 167.

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>74, 87, 165</td>
</tr>
<tr>
<td>abs</td>
<td>103, 157</td>
</tr>
<tr>
<td>accumulator</td>
<td>157<em>158</em>159</td>
</tr>
<tr>
<td>add_in</td>
<td>157<em>158</em></td>
</tr>
<tr>
<td>address_of</td>
<td>188*</td>
</tr>
<tr>
<td>allow_underlines</td>
<td>58<em>63</em>116<em>188</em>199*</td>
</tr>
<tr>
<td>Ambiguous prefix</td>
<td>69</td>
</tr>
<tr>
<td>and_sign</td>
<td>15, 114</td>
</tr>
<tr>
<td>app</td>
<td>99, 101, 102, 103, 111</td>
</tr>
<tr>
<td>app_repl</td>
<td>93<em>165</em>166*167, 168, 169</td>
</tr>
<tr>
<td>app_val</td>
<td>99, 103, 111</td>
</tr>
<tr>
<td>argc</td>
<td>188*</td>
</tr>
<tr>
<td>argument_is</td>
<td>188*</td>
</tr>
<tr>
<td>argv</td>
<td>2<em>188</em></td>
</tr>
<tr>
<td>ASCII code</td>
<td>11, 72</td>
</tr>
<tr>
<td>ASCII code</td>
<td>11, 12*, 13, 27, 28<em>38</em>, 50*, 65, 94, 95, 100, 126, 139, 141, 165*</td>
</tr>
<tr>
<td>atoi</td>
<td>188*</td>
</tr>
<tr>
<td>b</td>
<td>87, 97, 165</td>
</tr>
<tr>
<td>bad_case</td>
<td>107, 109, 110*</td>
</tr>
<tr>
<td>bal</td>
<td>87, 93*, 141, 142, 165*, 166*</td>
</tr>
<tr>
<td>banner</td>
<td>1<em>182</em>188*</td>
</tr>
<tr>
<td>basename_change_suffix</td>
<td>64<em>188</em></td>
</tr>
<tr>
<td>begin</td>
<td>3</td>
</tr>
<tr>
<td>begin_comment</td>
<td>72, 76, 121, 139, 147</td>
</tr>
<tr>
<td>begin_Pascal</td>
<td>139, 156, 158*, 167, 175</td>
</tr>
<tr>
<td>boolean</td>
<td>28<em>29, 124, 127, 143, 179</em>, 199*</td>
</tr>
<tr>
<td>brace_level</td>
<td>82, 83, 98, 121</td>
</tr>
<tr>
<td>break_ptr</td>
<td>94, 95, 96, 97, 98, 101, 102, 106, 107, 109, 110*, 111, 122</td>
</tr>
<tr>
<td>breakpoint</td>
<td>179*181</td>
</tr>
<tr>
<td>buf_size</td>
<td>8<em>27, 28</em>, 31, 50*, 53*, 124, 126, 127, 128, 132</td>
</tr>
<tr>
<td>byte_field</td>
<td>78, 79</td>
</tr>
<tr>
<td>byte_mem</td>
<td>37, 38*, 39, 40, 41, 48, 49, 53*, 56, 61, 63*, 66, 67, 68, 69, 75, 87, 90*, 113, 116*</td>
</tr>
<tr>
<td>byte_ptr</td>
<td>39, 40, 42, 61, 67, 90*, 91, 186</td>
</tr>
<tr>
<td>byte_start</td>
<td>37, 38*, 39, 40, 42, 49, 50*, 56, 61, 63*, 67, 68, 75, 81, 90*, 116*, 143</td>
</tr>
<tr>
<td>c</td>
<td>53*, 66, 69, 139, 140, 141, 145</td>
</tr>
<tr>
<td>c_int_type</td>
<td>188*</td>
</tr>
<tr>
<td>Can’t output ASCII code n</td>
<td>113</td>
</tr>
<tr>
<td>carriage_return</td>
<td>15, 17*, 28*</td>
</tr>
<tr>
<td>Change file ended...</td>
<td>130, 132, 137</td>
</tr>
<tr>
<td>Change file entry did not match</td>
<td>138</td>
</tr>
<tr>
<td>change_buffer</td>
<td>126, 127, 128, 131, 132, 138</td>
</tr>
<tr>
<td>change_changing</td>
<td>125, 132, 134, 137</td>
</tr>
<tr>
<td>change_file</td>
<td>2*, 23*, 24*, 32, 124, 126, 129, 130, 132, 137</td>
</tr>
<tr>
<td>change_limit</td>
<td>126, 127, 128, 131, 132, 136, 138</td>
</tr>
<tr>
<td>changing</td>
<td>32, 124, 125, 126, 128, 132, 134, 135, 138</td>
</tr>
<tr>
<td>char</td>
<td>12*, 14</td>
</tr>
<tr>
<td>check_break</td>
<td>97, 101, 102, 103, 111</td>
</tr>
<tr>
<td>check_change</td>
<td>132, 136</td>
</tr>
<tr>
<td>check_sum</td>
<td>72, 76, 119*, 139</td>
</tr>
<tr>
<td>check_sum_prime</td>
<td>64*</td>
</tr>
<tr>
<td>chg_name</td>
<td>24*, 188*, 199*</td>
</tr>
<tr>
<td>chop_hash</td>
<td>50*, 52, 60, 62</td>
</tr>
<tr>
<td>chopped_id</td>
<td>50*, 53*, 58*, 63*</td>
</tr>
<tr>
<td>chr</td>
<td>12*, 13*, 17*, 18</td>
</tr>
<tr>
<td>cmdlinename</td>
<td>188*</td>
</tr>
<tr>
<td>compress</td>
<td>147</td>
</tr>
<tr>
<td>confusion</td>
<td>35, 89*</td>
</tr>
<tr>
<td>const_c_string</td>
<td>199*</td>
</tr>
<tr>
<td>Constant too big</td>
<td>119*</td>
</tr>
<tr>
<td>continue</td>
<td>5, 113, 128, 129, 165*, 167, 172, 173*, 174*</td>
</tr>
<tr>
<td>control_code</td>
<td>139, 140, 143, 150</td>
</tr>
<tr>
<td>control_text</td>
<td>139, 150</td>
</tr>
<tr>
<td>count</td>
<td>69</td>
</tr>
<tr>
<td>cur_byte</td>
<td>78, 79*, 83, 84, 85*, 87, 90*, 93*</td>
</tr>
</tbody>
</table>
cur_end:  78, 79, 83, 84, 85, 87, 90.
cur_module:  143, 151, 167, 175.
cur_name:  78, 79, 83, 84, 85.
cur_repl:  78, 79, 80, 83, 84, 85.
cur_repl_text:  164, 165, 170, 175, 178.
cur_state:  79, 84, 85.
cur_val:  86, 87, 89, 116, 119, 121.
current_option:  188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198.
decl:  145.
decl_str:  179, 181.
def:  28.
def_unambig_length:  8, 188.
definition:  139, 156, 158, 167, 173.
Definition flushed...:  173.
digits:  119, 158.
do_nothing:  6, 93, 102, 113, 145, 158, 165, 188.
Double @ sign missing:  149.
double_chars:  50, 64, 143, 149.
double_dot:  72, 114, 147.
EBCDIC:  115.
eight_bits:  37, 38, 53, 82, 87, 95, 101, 113, 139, 140, 141, 145, 156, 165, 170.
else:  7.
end:  3, 7.
end_comment:  72, 76, 121, 139, 147.
end_field:  78, 79.
end_of_definition:  156, 159.
endcases:  7.
eof:  28.
eoln:  28.
equal:  66, 67, 68.
equiv:  37, 38, 47, 48, 50, 60, 62, 63, 64, 67, 84, 88, 89, 90, 157, 158, 170, 178.
equivalence:  15, 114, 147, 173, 174, 176.
error:  28, 31, 34, 63, 88, 90.
error_message:  9, 187.
extend_filename:  188.
extension:  66, 68, 69.
Extra ):  165.
Extra }):  145.
Extra @):  121.
Extra ]):  165.
f:  28.
false:  28, 29, 125, 126, 127, 132, 134, 144, 146, 180, 183, 188.
fatal_error:  34, 35, 36.
fatal_message:  9, 187.
fflush:  22.
final_limit:  28.
first_text_char:  12, 18.
flag:  189, 190, 191, 192, 193, 194, 195, 196, 197, 198.
flush_buffer:  97, 98, 122.
force_line:  72, 76, 113, 139.
force_lowercase:  58, 63, 116, 188, 199.
force_uppercase:  58, 63, 116, 188, 199.
form_feed:  15, 28.
format:  139, 156, 158, 167, 173.
forward:  30.
frac:  100, 101, 102, 104, 113, 120.
Fraction too long:  120.
get_fraction:  113, 119, 120.
get_line:  124, 135, 140, 141, 145, 153.
getc:  28.
getopt:  188.
getopt_long_only:  188.
getopt_return_val:  188.
getopt_struct:  188.
greater:  66, 68, 69.
greater_or_equal:  15, 114, 147.
gubed:  3.
h:  51, 53.
harmless_message:  9, 182, 187.
has_arg:  189, 190, 191, 192, 193, 194, 195, 196, 197, 198.
hash:  39, 50, 52, 55.
hash_size:  8, 50, 51, 52, 53, 54, 58.
hex:  72, 76, 119, 139, 150, 158.
history:  9, 10, 182, 187.
Hm... n of the preceding...:  133.
i:  16, 53.
id_first:  50, 53, 54, 56, 57, 58, 61, 64, 143, 148, 149.
normal: 47*50*53*57, 59, 60, 61, 89*158*167.
Not present: <section name>: 88.
not_equal: 15, 114*147.
not_found: 5, 53*63*.
not_sign: 15, 114*.
num_or_id: 95, 101, 102, 107, 111.
number: 86, 89*119*.
numeric: 47*53*59, 64*89*158*173*.
octal: 72, 76, 119*139, 158*.
Omit semicolon in numeric def...: 158*.
open_input: 24*134*.
optary: 188*.
opind: 188*.
option_index: 188*.
or_sign: 15, 114*.
ord: 13.
other_cases: 124, 125, 134, 138.
othercases: 7.
others: 7.
out_app: 95, 102, 104, 106, 108.
out_buf: 31, 33, 94, 95, 96, 97, 99, 100, 109, 110*181, 184*.
out_buf_size: 8*31, 94, 97, 99.
out_contr: 100, 101, 105*113, 114*116*117, 118, 119*120, 121, 181*.
out_ptr: 33, 94, 95, 96, 97, 98, 99, 101, 102, 106, 107, 109, 110*111, 122, 181*.
out_sign: 95, 103, 104, 107, 108.
out_val: 95, 103, 104, 106, 107, 108.
output_state: 78, 79.
overflow: 36, 61, 67, 73, 84, 90*93*165*.
pack: 61.
param: 72, 76, 87, 93*165*.
parametric: 47*53*85*89*90*93*164, 165*, 166*174*.
parametric2: 47*53*85*89*90*93*165*174*.
parser_arguments: 2*188*.
Pascal text flushed...: 176.
Pascal_file: 2*25, 26*97*.
pascal_name: 26*188*199*.
phase_one: 29, 31, 183, 186*.
pool: 2*25, 26*64, 184*.
pool_check_sum: 40, 42, 64*119*184*.
pool_name: 64*199*.
pop_level: 85*87, 90*91*.
pref: 66, 68*.
pref_lookup: 69, 151.
Preprocessed string is too long: 64*.
preprocessed strings: 64*149.
prime_the_change_buffer: 128, 134, 137.
print: 20*31, 32, 33, 49, 63, 74, 75, 76, 88, 93*.
print_id: 49, 75, 88, 90*181*.
print_ln: 20*32, 33, 182*.
print_nl: 20*28*63*88, 90*112, 155, 181, 184, 186, 187*.
print_repl: 74, 181.
print_version_and_exit: 188*.
Program ended at brace level n: 98.
push_level: 84, 88, 89*92*.
q: 53*66, 69, 157*.
r: 69*.
read: 181.
read_ln: 28*.
repl_field: 78, 79*.
restart: 5, 87, 88, 89*90*92, 101, 102, 104, 135, 145, 150*.
reswitch: 5, 113, 117, 119*120, 157*158*165*169*.
return: 5, 6*.
rewrite: 26*.
rewritebin: 64*.
rlk: 48, 66, 67, 69*.
s: 53*.
scan_module: 171, 172, 183*.
scan_numeric: 156, 157*173*.
scan_repl: 164, 165*170, 175*.
scanning_hex: 143, 144, 145, 146, 150*.
Section ended in mid-comment: 142.
Section name didn't end: 154.
Section name too long: 155*.
semi_ptr: 94, 96, 97, 98, 101*.
send_out: 100, 101, 112, 113, 114*116*117, 118, 119*120, 121, 122*.
send_sign: 100, 106, 112, 113*.
send_the_output: 112, 113*.
send_val: 100, 107, 112, 119*.
set_element_sign: 15, 114*.
sign: 95, 102, 106, 108*.
sign_val: 95, 102, 104, 106, 107, 108*.
sign_val_sign: 95, 102, 106, 108*.
sign_val_val: 95, 102, 106, 108*.
simple: 47*53*89*90*164, 173*.
sixteen_bits: 37, 38*50*66, 69, 73, 74, 78, 87, 101, 165*.
skip_ahead: 140, 150, 159, 173*176, 183*.
skip_comment: 141, 145*.
Sorry, x capacity exceeded: 36*.
spaceless: 9, 10, 182*187*.
stack: 78, 79, 84, 85*.
stack_ptr: 78, 79, 83, 84, 85*87, 90*113, 117, 118*.
stack_size: 8*79, 84.
This can't happen

t
v
usage
update
text
text
text
String too long
strict
store:
stderr
154
INDEX TANGLE changes for C

Use == for macros

uppercase:

This identifier was defined...

tok

This identifier has already....

This identifier was defined....

tok_mem:

Two numbers occurred....

Use == for macros: 174*

Value too big: 157*

verbatim: 72, 76, 113, 118, 139, 167, 169.

Verbatim string didn't end: 169.

Verbatim string too long: 118.

version_string: 182*

vgetc: 28*


WEB file ended....: 132.


web_name: 24*, 64*, 188*, 199*

Where is the match....: 129, 133, 137.

wi: 41, 42.

wo: 185, 186.

write: 20* 34*, 64*, 97, 184.

write_ln: 20*, 64*, 97, 184, 188*.


x: 73.

xchr: 13, 14, 16, 17*, 18, 32, 33, 49, 63*, 64*, 75, 76, 97, 155, 167, 181, 184.

xclause: 6.

xord: 13, 16, 18, 28*

You should double @ signs: 168, 169.

z: 44.

zi: 45, 46.

zo: 80, 83, 84, 85*, 87, 90, 93*.

zp: 74, 75.

zz: 8*, 38*, 43, 44, 45, 46, 74, 80, 83, 84, 85*, 90*, 91, 165*, 182*, 186.

value too big: 157*

verbatim: 72, 76, 113, 118, 139, 167, 169.

Verbatim string didn't end: 169.

Verbatim string too long: 118.

version_string: 182*

vgetc: 28*


WEB file ended....: 132.


web_name: 24*, 64*, 188*, 199*

Where is the match....: 129, 133, 137.

wi: 41, 42.

wo: 185, 186.

write: 20*, 34*, 64*, 97, 184.

write_ln: 20*, 64*, 97, 184, 188*.


x: 73.

xchr: 13, 14, 16, 17*, 18, 32, 33, 49, 63*, 64*, 75, 76, 97, 155, 167, 181, 184.

xclause: 6.

xord: 13, 16, 18, 28*

You should double @ signs: 168, 169.

z: 44.

zi: 45, 46.

zo: 80, 83, 84, 85*, 87, 90*, 93*.

zp: 74, 75.

zz: 8*, 38*, 43, 44, 45, 46, 74, 80, 83, 84, 85*, 90*, 91, 165*, 182*, 186.
(Append out_val to buffer 103) Used in sections 102 and 104.
(Append the decimal value of v, with parentheses if negative 111) Used in section 107.
(Cases involving \{ and \} 121) Used in section 113.
(Cases like <> and := 114) Used in section 113.
(Cases related to constants, possibly leading to get_fraction or reswitch 119) Used in section 113.
(Cases related to identifiers 116) Used in section 113.
(Check for ambiguity and update secondary hash 62) Used in section 61.
(Check for overlong name 155) Used in section 153.
(Check if q conflicts with p 63) Used in section 62.
(Check that all changes have been read 138) Used in section 183.
(Change that = or \equiv follows this module name, otherwise return 176) Used in section 175.
(Compare name p with current identifier, goto found if equal 56) Used in section 55.
(Compiler directives 4) Used in section 2.*.
(Compress two-symbol combinations like ':=' 147) Used in section 145.
(Compute the hash code h 54) Used in section 53*.
(Compute the name location p 55) Used in section 53*.
(Compute the secondary hash code h and put the first characters into the auxiliary array chopped_id 58) Used in section 57.
(Contribute to the outer block 8) Used in section 2*.
(Contribute is * or / or DIV or MOD 105) Used in section 104.
(Copy a string from the buffer to tok_mem 168) Used in section 165*.
(Copy the parameter into tok_mem 93) Used in section 90*.
(Copy verbatim string from the buffer to tok_mem 169) Used in section 167.
(Define and output a new string of the pool 64) Used in section 61.
(Define parse_arguments 188) Used in section 2*.
(Do special things when c = "\n", "\", "{", "}"; return at end 142) Used in section 141.
(Empty the last line from the buffer 98) Used in section 112.
(Enter a new identifier into the table at position p 61) Used in section 57.
(Enter a new module name into the tree 67) Used in section 66.
(Error handling procedures 30, 31) Used in section 2*.
(Expand macro a and goto found, or goto restart if no output found 89) Used in section 87.
(Expand module a = '24000, goto restart 88) Used in section 87.
(Finish off the string pool file 184) Used in section 182*.
(Force a line break 122) Used in section 113.
(Get a preprocessed string 149) Used in section 145.
(Get an identifier 148) Used in section 145.
(Get control code and possible module name 150) Used in section 145.
(Get the buffer ready for appending the new information 102) Used in section 101.
(Give double-definition error, if necessary, and change p to type t 59) Used in section 57.
(Globals in the outer block 9, 13, 23, 25, 27, 29, 38*, 40, 44, 50*, 65, 70, 79, 80, 82, 86, 94, 95, 100, 124, 126, 143, 156, 164, 171, 179*, 185, 199*) Used in section 2*.
(Go to found if c is a hexadecimal digit, otherwise set scanning_hex ← false 146) Used in section 145.
(Handle cases of send_val when out_state contains a sign 108) Used in section 107.
(If end of name, goto done 154) Used in section 153.
(If previous output was * or /, goto bad_case 109) Used in section 107.
(If previous output was DIV or MOD, goto bad_case 110) Used in section 107.
(If the current line starts with \@y, report any discrepancies and return 133) Used in section 132.
(If the next text is '(#)==' or '[@]==', call define_macro and goto continue 174) Used in section 173*.
(In cases that a is a non-ASCII token (identifier, module_name, etc.), either process it and change a to a byte that should be stored, or goto continue if a should be ignored, or goto done if a signals the end of this replacement text 167)  Used in section 165*.
(Initialize the input system 134)  Used in section 182*.
(Initialize the output buffer 96)  Used in section 112.
(Initialize the output stacks 83)  Used in section 112.
(Insert the module number into tok_mem 177)  Used in section 175.
(Local variables for initialization 16, 41, 45, 51)  Used in section 2*.
(Make sure the parentheses balance 166*)  Used in section 165*.
(Move buffer and limit to change_buffer and change_limit 131)  Used in sections 128 and 132.
(Other printable characters 115)  Used in section 113.
(Phase I: Read all the user’s text and compress it into tok_mem 183)  Used in section 182*.
(Phase II: Output the contents of the compressed tables 112)  Used in section 182*.
(Print error location based on input buffer 32)  Used in section 31.
(Print error location based on output buffer 33)  Used in section 31.
(Print statistics about memory usage 186)  Used in section 182*.
(Print the job history 187)  Used in section 182*.
(Put a parameter on the parameter stack, or goto restart if error occurs 90*)  Used in section 89*.
(Put module name into mod_text[1 .. k] 153)  Used in section 151.
(Read from change_file and maybe turn off changing 137)  Used in section 135.
(Read from web_file and maybe turn on changing 136)  Used in section 135.
(Reduce sign_val_val to sign_val and goto restart 104)  Used in section 102.
(Remove a parameter from the parameter stack 91)  Used in section 85*.
(Remove p from secondary hash table 60)  Used in section 59.
(Scan the definition part of the current module 173*)  Used in section 172.
(Scan the module name and make cur_module point to it 151)  Used in section 150.
(Scan the Pascal part of the current module 175)  Used in section 172.
(Send a string, goto reswitch 117)  Used in section 113.
(Send verbatim string 118)  Used in section 113.
(Set accumulator to the value of the right-hand side 158*)  Used in section 157*.
(Set c to the result of comparing the given name to name p 68)  Used in sections 66 and 69.
(Set initial values 10, 14, 17*, 18, 21*, 26*, 42, 46, 48, 52, 71, 144, 152, 180*)  Used in section 2*.
(Set val to value of decimal constant, and set next_control to the following token 160)  Used in section 158*.
(Set val to value of hexadecimal constant, and set next_control to the following token 162)  Used in section 158*.
(Set val to value of octal constant, and set next_control to the following token 161)  Used in section 158*.
(Signal error, flush rest of the definition 159)  Used in section 158*.
(Skip over comment lines in the change file; return if end of file 129)  Used in section 128.
(Skip to the next nonblank line; return if end of file 130)  Used in section 128.
(Special code to finish real constants 120)  Used in section 113.
(Start scanning current macro parameter, goto restart 92)  Used in section 87.
(Types in the outer block 11, 12*, 37, 39, 43, 78)  Used in section 2*.
(Update the data structure so that the replacement text is accessible 178)  Used in section 175.
(Update the tables and check for possible errors 57)  Used in section 53*. 