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Mortran3 User's Guide

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Appendix *page*

1. INTRODUCTION

This Guide is divided into two parts:

- Part I -- The Programming Language.
- Part II -- The Definition Language.

The programming language (more accurately, the *notation*) is defined by set of *transformation rules*. *Transformation* of Mortran3 *notation* into FORTRAN *notation* results from the application of these rules by the Mortran3 *processor*.

The definition language is used to define new programming notations. Briefly, the user supplies a *prototype* of a new notation, and a *prototype* of the FORTRAN notation into which his notation is to be transformed. The details of how this is done is the subject of Part II.

"Language" *versus* "Notation"

We are compelled by usage to describe "languages", even though that term (as it is applied in computer-related contexts) has been abused to the point of becoming virtually meaningless.[1] Current use of the term "high-level language" usually implies the existence of a program called a *compiler*. The compilers refered to in this document are FORTRAN compilers; they transform FORTRAN notations into "machine-dependent" binary notations.

The binary notations into which a FORTRAN program is transformed (translated) depend upon the computer that will "execute" the program. Consequently, a different FORTRAN compiler is required for each different computer on which FORTRAN programs will be "run".

We regard FORTRAN compilers as *hardware-extensions*. From this point of view, the *portability* of FORTRAN programs derives from the fact that virtually all "maxi" and "mini" computers, and indeed, many "micro" computers have been *extended* in this sense: they have FORTRAN compilers.

The Processor

The Mortran3 *processor* exists in two forms:

Form I: A FORTRAN program of less than *2000* lines, and
Form II: A Mortran program of less than *600* lines.

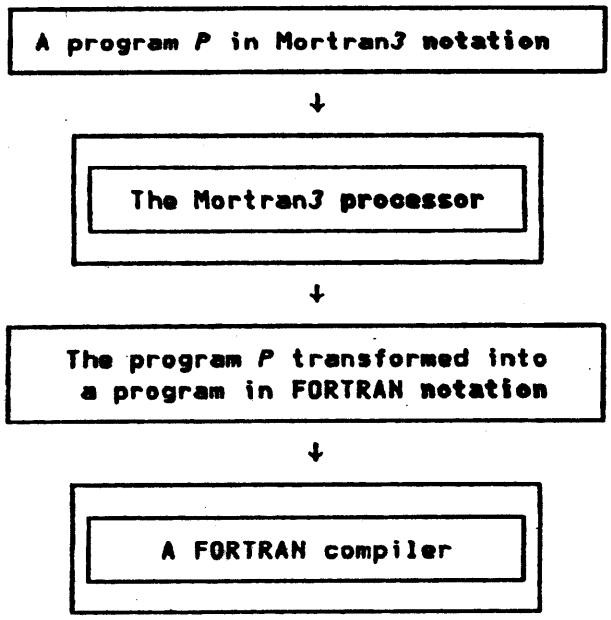
---

[1] Examples: Machine-language (meaning either binary notation or assembler notation), Machine-oriented-language (meaning a notation for writing compilers), Higl-level language, Procedural language, Non-Procedural language, Structured language, *et cetera, ad absurdum*.

When Form I is compiled it produces a *processor*. This processor can, given the necessary rules, transform Form II into Form I. Given other rules, the processor can transform Form II into notations *other* than FORTRAN.

Precompilation

The Mortran3 processor (as described here)[2] is a *precompiler*. A precompiler's *output* is a compiler's *input*.



Portability

The portability of a FORTRAN program depends largely[3] upon the extent to which the program conforms to the (*1966* ANSI)[4] FORTRAN standard.

The Mortran3 "language" does not produce FORTRAN statements that violate the *1966* ANSI FORTRAN standard. Consequently, Mortran3 programs may be made portable to the same extent that FORTRAN programs may be made portable.

---

[2] The Mortran3 processor may be used for other purposes. See the Mortran3 Reference Manual.

[3] The precision with which arithmetic operations are performed is not dealt with here.

[4] FORTRAN 77, at this time, is not in widespread use. Pascal seems a more likely candidate for the "portable language" for the near future.

PART I. The Programming Language

FEATURES

Free-form
- Column and line (card) boundaries may be ignored.
- Continuation marks are not required.

Labels
- Alphanumeric labels of arbitrary length are accepted.
- FORTRAN statement labels (numbers) are accepted.

Local Procedures.

Nested block structure

Controlled execution of blocks:
- Sequential control
  IF, ELSE, ELSEIF, UNLESS, and GOTO.
- Iterative control (Loops)
  WHILE, UNTIL, FOR, LOOP, and DO.
  EXIT (jump out of) any loop
  NEXT (go to next iteration of) any loop
  Tests for loop termination may be made at the
  beginning of a loop
  end of a loop
  both begining and end of a loop
  none of the above (i.e. "Forever" loops)
- Multi-level control statements.
  Multi-level iterative control.
  EXIT (*alphanumeric label*)
  NEXT (*alphanumeric label*).
  Multi-level sequential control.
  EXECUTE *Local Procedure*.
  GOTO *alphanumeric label*.

Comments may be inserted anywhere in the program text.

Operators
- Relational operators may be denoted by: <, <=, =, ¬=, =>, and >.
  The operators <= and => may also be denoted by =< and >= respectively.
  The symbols ≤, ≠, and ≥ may be used if the user's display device is capable of representing them.
- Logical operators may be denoted by: &(and), |(or), and ¬(not).

Conditional (alternate) compilation

Abbreviations

Multiple assignment statements
Input/output statements may be abbreviated.

DIRECTIVES

Directives do not involve transformation of notations, rather they are instructions to the processor.

Listing Directives

- Automatic printing of the nesting level.
- Automatic indentation according to nesting level (optional).
- Interleaving of the Mortran3 Source program as COMMENTS in the generated FORTRAN program (optional).
- Inclusion of Mortran3 COMMENTS as COMMENTS in the generated FORTRAN program (optional).

Other Directives

- FORTRAN source text may be interspersed with Mortran3 source text.
- Mortran source input-unit **switching**.
- Mortran source input-unit **rewinding**.
- Mortran input line-length may be set by the programmer.
- The number of columns of the input line that are intepreted as program text may be set by the programmer.
- Automatic termination of Mortran comments at the end of an input line.
- Tracing of the transformation process.

2. PROGRAMMING CONVENTIONS

Form

Statements may begin anywhere on a line, and may end anywhere on the same line or on a succeeding line.

- Continuation marks are not required (nor permitted).
- The end of a statement is determined by a semicolon (;).

This convention (with the convention for blanks described below) permits **free-form** programming in which column and line boundaries may be ignored.

Line Length

The line length *L* may be set by the programmer: $20 \leq L \leq 120$. (Default: *80*.)

The number *C* of columns to be intepreted as program text may be set by the programmer: $10 \leq C \leq L$. (Default: *72*.)

Strings

A *string* is a sequence of characters enclosed in apostrophes (as in 'TWINE'). An apostrophe within a string is denoted by a pair of apostrophes (as in '''Twas brillig, and the slithy toves...').

On output, Mortran3 will convert strings to the *1966* FORTRAN standard nH format *if directed to do so* by he programmer. (See appendix A).

- Example: 'DON''T' will be converted to 5HDON'T

Comments

Comments are enclosed in quotation marks (as in "BALDERDASH!"). A comment may contain any character *except* a quotation mark.

Comments may be inserted anywhere in the program text except:
- Within a string a comment becomes part of the string.
- In transformation rules. (See Part II.)

```
          Example:   CALL SUB (A "INPUT" , B "OUTPUT");
 Is equivalent to:   CALL SUB ( A , B );
```

Labels

An alphanumeric label is a sequence of characters enclosed in colons (as in :CONSERVATIVE:).

- The characters may be any combination of letters and digits.
- The length is arbitrary.

:THIS ABSURDLY LONG ALPHANUMERIC LABEL IS A VALID LABEL:

- Alphanumeric labels are intended to supplant FORTRAN statement labels, but FORTRAN statement labels (numbers) are allowed in most contexts.

Blanks

A sequence of two or more blanks is equivalent to a single blank except in *strings*, where all blanks are preserved.

Blanks are *significant* in some Mortran3 contexts.

- :THIS LABEL: is equivalent to :THIS LABEL:
  :THIS LABEL: is not equivalent to :THISLABEL:

- DO1I=1,N is acceptable in FORTRAN.
  In contrast, keywords must be followed by at least one blank in Mortran3.

Summary of conventions

- Terminate statements with a semicolon (;).
- Enclose comments in quotation marks (").
- Enclose labels in colons (:).
- Enclose character strings in apostrophes (').
- An arbitrary number of blanks may be substituted for a single blank *except in strings*.

3. STRUCTURE

3.1 STATEMENTS

A valid FORTRAN statement becomes a valid Mortran3 statement when:

(3-1)
- The statement is terminated by a semicolon,
- Continuation marks (if any) are deleted, and
- Hollerith fields are converted to strings.[5]

Subject to (3-1), FORTRAN may be regarded as a *subset* of Mortran3; Conversely, Mortran3 may be regarded as an *extension* of FORTRAN. Most of the "extensions" are related to block structure and to the control of the execution of blocks.

3.2 BLOCKS

A Mortran3 block is a sequence of Mortran3 statements enclosed in the special characters [and]. Let S_i (i=1,n) be a sequence of Mortran3 statements:

(3-2) $S_1;\ S_2;\ S_3;\ldots;S_n;$

The *sequence* (3-2) becomes a *block* when it is enclosed in brackets:

(3-3) $[\ S_1;\ S_2;\ S_3;\ldots;S_n;\ ]$

Blocks may be nested. That is, a block may *contain* one or more blocks. For example, one could insert the block [T_i] (i=1,m) in (3-3) producing:

$$[\ S_1;\ S_2;\ [\ T_1;\ T_2;\ T_3\ldots T_m;\ ]\ S_3\ldots S_n;\ ]$$

The block [T_i] is completely contained or *nested* within the block [S_i].

Example of a block: [X=Y; CALL WUNDER(BAR); B=E;]

---

[5] For example, 15HTHIS THING is converted to 'THIS THING '.

3.3 CONTROL

- An ellipsis enclosed in brackets [...] will denote an arbitrary block.
- A control *phrase* controls the execution of a block.
- A control *clause* is a control phrase followed by the block it controls.
- When referring to blocks:

  executed means: control is transferred to the first statement **within** the block.

  skipped means: control is transferred to the first statement **following** the block.

3.3.1 Sequential control

The simplest sequential control clause is the IF-clause.

3.3.1.1 IF

```
IF e [...]
```

where e is an arbitrary logical expression
- If e is TRUE, the block is executed.
- If e is FALSE, the block is skipped.

Example (3-5)

```
IF A=B & C>D [ C=D; E=F; ] G=H;
```

FORTRAN generated by Mortran3 from (3-5)

```
    IF(A.NE.B .OR. C.LE.D)GO TO L1
    C=D
    E=F
L1  CONTINUE
    G=H
```

The label L1 is a FORTRAN statement label (integer constant) generated by Mortran. One or more such labels is generated for each control phrase.

Notice that DeMorgan's laws have been applied in (3-5):

The expression	¬(A=B & C>D)
becomes	A.NE.B..OR.C.LE.D

DeMorgan's laws will be applied to expressions with FORTRAN operators (.LT., .LE., .EQ., etc.) as well.

3.3.1.2 UNLESS

```
UNLESS e [...]
```

- If e is FALSE, the block is executed.
- If e is TRUE, the block is skipped.

3.3.1.3 ELSE

An IF-clause (or an UNLESS-clause) may be followed by an ELSE-clause:

```
IF e [...] ELSE [...]
```

- If e is TRUE, the IF-block is executed and the ELSE-block is skipped.
- If e is FALSE, the IF-block is skipped and the ELSE-block is executed.

Example (3-7)

```
IF A < B [ C=D; E=F; ]
    ELSE [ G=H; I=J; ]   K=L;
```

```
      IF(A.GE.B)GO TO L1
      C=D
      E=F
      GO TO L2
   L1 CONTINUE
      G=H
      I=J
   L2 CONTINUE
      K=L
```

3.3.1.4 ELSEIF

IF/ELSE-clauses may be nested to a depth of *50*. But nesting IF/ELSEs is not always desirable; In some situations, one wants to *avoid* nesting. For example, consider the following "case analysis" problem:

(*3-8*)
```
IF p [A] ELSE [ IF q [B] ELSE [ IF r [C] ELSE [D] ] ]s;
```

where p,q, and r are logical expressions
A,B,C, and D are blocks of statements
s denotes the first statement following the nest.

- If p is TRUE, block A is executed and control is transferred to s.
- If p is FALSE and q is TRUE, block B is executed and control is transferred to s.
- If p and q are FALSE and r is TRUE, block C is executed and control is transferred to s.
- If p,q, and r are all FALSE, block D is executed, and control is transferred to s.

Using "structured programming" principles to expose the level of nesting, we could re-write (*3-8*) as:

(*3-9*)
```
IF p [A]
ELSE [ IF q [B]
       ELSE [ IF r [C]
              ELSE [D]
            ]
     ]
s;
```

But (*3-9*) is awkward because each ELSE-clause increases the level of nesting. The ELSEIF-clause combines an ELSE-clause with an IF-clause:

```
IF     p [A]
ELSEIF q [B]
ELSEIF r [C]
  ELSE   [D]
s;
```

Thus, the tests are made at the same nest level.

An arbitrary number of ELSEIF-clauses may follow an IF-clause.

In addition to the advantages mentioned above, the ELSEIF generates "cleaner" FORTRAN:

```
IF p [A] ELSEIF q [B] ELSEIF r[C] ELSE [D] s;
```

```
      IF(¬(p)) GO TO L1
      A
      GO TO L4
L1    IF(¬(q))GO TO L2
      B
      GO TO L4
L2    IF(¬(r))GO TO L3
      C
      GO TO L4
L3    D
L4    CONTINUE
      s
```

The nested IF/ELSE example generates more "CONTINUE" statements:

```
IF p [A] ELSE [IF q [B] ELSE [IF r[C] ELSE [D] ] ] s;
```

```
      IF(¬(p)) GO TO L1
      A
      GO TO L6
L1    IF(¬(q)) GO TO L2
      B
      GO TO L5
L2    IF(¬(r)) GO TO L3
      C
      GO TO L4
L3    D
L4    CONTINUE
L5    CONTINUE
L6    CONTINUE
      s
```

3.3.1.5 FORTRAN IF

The FORTRAN logical IF:
is equivalent to:

```
IF(e) statement;
IF e [statement;]
```

The IF-phrase is the preferred form because an ELSE-clause (or an an ELSEIF-clause) may not follow a FORTRAN IF.

```
incorrect:  IF(X=Y) CALL SOME(HELP);  ELSE [ ...]
  correct:  IF X=Y [CALL SOME(HELP);] ELSE [ ...]
```

3.3.1.6 Summary of IF, ELSE, and ELSEIF

- An IF-clause may appear by itself.
- An IF-clause may be followed by an ELSE-clause.
- An IF-clause may be followed by an arbitrary number of ELSEIF-clauses.
- The last in a sequence of ELSEIF-clauses may be followed by an ELSE-clause

3.3.2 Iterative Control

A Mortran3 loop is a block which is preceded by and, optionally, followed by a loop-control phrase. (We will shorten this to "phrase" in most contexts.)

- A loop is terminated means: control is transferred to the first statement following the loop.

3.3.2.1 WHILE

```
WHILE e [...]
WHILE e [...] REPEAT
```

- REPEAT is optional.
- IF e is FALSE, the loop is terminated.
- If e is TRUE (1 the block is executed and
  (2 control is returned to test e again.

Example (3-11)

```
      WHILE A<B [...]
  ------------------------
  L1 IF(A.GE.B)GO TO L2
     . . .
     GO TO L1
  L2 CONTINUE
```

3.3.2.2 LOOP

If one wanted to test at the end of a WHILE-loop instead of the beginning, one could write

(3-12)

```
LOOP [...] WHILE e ;
```

In (3-12) the block is always executed once. Then, while e is TRUE, the block is executed repeatedly. When e becomes FALSE the loop is terminated.

3.3.2.3 UNTIL

```
UNTIL e [...]
```

- IF e is TRUE, the loop is terminated.
- If e is FALSE (1 the block is executed and
  (2 control is returned to test e again.

Example (3-14)

```
UNTIL X>Y [...]
---------------
   L1 IF(X.GT.Y)GO TO L2
      . . .
      GO TO L1
   L2 CONTINUE
```

Tests for loop termination may be made at both ends of a loop. For example, if e1 and e2 are logical expressions, the following test at both the beginning and the end:

```
WHILE e1 [...] UNTIL e2 ;
WHILE e1 [...] WHILE e2 ;
UNTIL e1 [...] WHILE e2 ;
UNTIL e1 [...] UNTIL e2 ;
```

The FORTRAN generated for the first example is:

```
WHILE e1 [...] UNTIL e2;
------------------------
   L1 IF(¬(e1))GO TO L2
      . . .

      IF(e2)GO TO L2
      GO TO L1
   L2 CONTINUE
```

Any Mortran3 loop may be tested at both ends, including the ones we haven't described yet: three flavors of FOR loops, two flavors of DO loops and the "Forever" loop.

3.3.2.4 FOR

The loop control phrases discussed up to this point do not involve *control variables*, that is, variables that are automatically incremented (decremented) for each execution of the loop. The FOR loop involves a control variable.

```
FOR V=Ax BY Ai TO Af [...]
```

- *V* is the *control* variable.
  V may be a subscripted variable.
  V must be of type REAL or INTEGER.

- *Ax*, *Ai*, and *Af* are arbitrary arithmetic expressions.
  Ax is the *initial* value
  Ai is the *increment*
  Af is the *final* value
-

The values of *Ax*, *Ai*, and *Af* may be negative.

Ax is assigned to *V* and the test for loop termination is made:

The test: (3-15) $Ai*(V-Af)>0$

- If (3-15) is TRUE, the loop is terminated.
- If (3-15) is FALSE:
  (1 the block is executed
  (2 *V* is incremented by the value of *Ai*
  (3 control is passed to the test.
- Multiplication by *Ai* corrects the *sign* of (*V-Af*).

Example (3-16)

```
FOR X=.4 TO -.3 BY -.01 [ ... ]
-------------------------------------
   X=.4
   GO TO L3
L1 X=X+(-.01)
L3 IF((-.01)*(X-(-3)).GT.0)GO TO L2
   . . .
   GO TO L1
L2 CONTINUE
```

This trivial example is presented to make the following points:

- The increment in (3-16) is negative
- The control variable X is assigned both zero and negative values.
- The loop is terminated only when X ≤ -0.3. In the statements indicated by the ellipsis in (3-16), the programmer may change *V* or any of the *variables* of *Ax, Ai, or Af*.

  1) Changes in the variables of *Ax* will have no effect on the loop, since the assignment *V=Ax* is not re-executed.

  2) Changing the value of the variables of *Ai* or *Af* might be useful for asymptotic processes.

Assuming a "straightforward" application of the FOR-loop: If *Ai* and/or *Af* are expressions whose evaluation is time-consuming, (and time is important) assignment of *Ai* and *Af* to temporary variables outside the loop may be indicated.

The FOR-loop has three forms:

```
FOR V=Ax BY Ai TO Af [...]
FOR V=Ax TO Af BY Ai [...]
FOR V=Ax TO Af [...]
```

where *V, Ax, Ai,* and *Af* are as above

- If no increment (BY *Ai*) is given the integer *1* is assumed.

3.3.2.5 DO

(3-17) DO *i*=*j*,*k*,*n* [...]

where *i*,*j*,*k*, and *n* must conform to FORTRAN requirements for DO loops.

A standard FORTRAN DO loop is generated from (3-17). Therefore, *i*,*j*,*k*, and *n* must all be of type INTEGER and may not be subscripted variables or expressions.

3.3.2.6 The "compact" DO

There is one exception to the rule that loops must be preceded by control phrases.

(3-18) [*i*=*j*,*k*,*n*; ...]

(3-18) generates a standard FORTRAN DO loop. This form permits compact notation for nests like the following example.

Example (3-19) [I=1,N1; [J=1,N2; [K=1,N3; ...]]]

```
      DO 10 I=1,N1
      DO 20 J=1,N2
      DO 30 K=1,N3
      . . .
   30 CONTINUE
   20 CONTINUE
   10 CONTINUE
```

This "oddball" notation has been severely criticized on the ground that it too "terse" and tends to obscure rather than clarify loop control. It is included for "compatability" with Mortran2, and because the author likes it.

3.3.2.7 "Forever" loops

```
LOOP [...]
LOOP [...] REPEAT
```

REPEAT is optional

The "forever" loop generates the following FORTRAN:

```
L1 CONTINUE
   ...
   GO TO L1
L2 CONTINUE
```

The "exit" from "forever" loops must be made by a statement within the loop. The label L2 is generated by Mortran3 as the "target" for the EXIT, whose description follows.

3.3.2.8 EXIT

EXIT is "shorthand" for "jump out of **this loop**", where **this loop** refers to the **innermost** loop in which the EXIT appears.

```
EXIT;
IF (e) EXIT;
IF e [...EXIT;]
```

In the "forever" loop EXIT generates "GOTO L2", where L2 refers to the "target" mentioned above.

But EXIT may appear in *any* Mortran3 loop.

In a Mortran3 loop, EXIT causes a transfer of control to the first statement following the loop in which it occurs. For nested loops, the EXIT is from the innermost loop to the next level out.

3.3.2.9 NEXT

NEXT is "shorthand" for "go to the next iteration of this loop", where this loop refers to the innermost loop in which the NEXT appears.

```
NEXT;
IF (e) NEXT;
IF e [...NEXT;]
```

NEXT transfers control to the beginning of the loop in which it occurs.

- The control variable (if any) is incremented
- The test (if any) for loop termination is made.
- If tests at both ends of the loop are involved, only the test at the beginning of the loop is made.
- In FOR-loops and DO-loops, NEXT generates GOTO L1, where L1 refers to the label on the statement that increments the control variable.
- In DO-loops, the statement that increments the control is the CONTINUE that marks the end of the "range" of the DO.

Phrases control the execution of blocks. But notice that EXIT and NEXT refer to *iterative* control phrases, and not to *sequential* control phrases.

Example: UNTIL A=B [...IF C=D [...EXIT;] P=Q;...] R=S;...

In this example EXIT transfers control to the statement R=S, and not to the statement P=Q.

3.3.3 Multi-level Control

There are two categories: sequential, and iterative.

- Multi-level iterative control statements are:
  EXIT:*label*:
  NEXT:*label*:

- Multi-level sequential control statements are:
  EXECUTE *procedure name*
  LEAVE
  GOTO :*label*:

3.3.3.1 Multi-level EXIT

In nested loops, it may be desirable to EXIT more than one level. EXIT of more than one level of nesting may be made only from labeled loops. A labeled loop is a loop preceeded by an alphanumeric label. A Multi-level EXIT is made by:

```
EXIT :label: ;
```

EXIT:*label*: transfers control to the first statement following the labeled loop. The transfer of control takes place regardless of nesting, and thus provides a "multi-level" EXIT capability.

```
:bon: UNTIL mort
        [ cherchez; la verite;
          UNTIL eins=zwei
            [oktober;
             IF ( tod ) EXIT :bon:;
             IF (angst) EXIT;
             fest;
            ]
          cest; la vie;
        ]
ho;hum;
```

```
10 CONTINUE
11 IF(mort)GOTO 12
   cherchez
   la verite
21 IF(eins.EQ.zwei)GOTO 22
   oktober
   IF(tod)GOTO 12
   IF(angst)GOTO 22
   fest
   GOTO 21
22 CONTINUE
   cest
   la vie
   GOTO 11
12 CONTINUE
   ho
   hum
```

3.3.3.2 Multi-level NEXT

NEXT :label: transfers control in the manner described above for NEXT, but may be multi-level. The following example contains both single-level and multi-level EXITs and NEXTs.

```
:SEARCH: FOR V=Ax BY Ai TO Af
  [ ...
    :ROW: DO I=1,N
      [ ...
        :COL: DO J=1,M

          [...
             UNTIL e0
                [...
                 IF(e1) EXIT :SEARCH: ;
                 ...
                 IF(e2) NEXT :SEARCH: ;
                 ...
                 IF(e3) NEXT :ROW: ;
                 ...
                 IF(e4) EXIT :ROW: ;
                 ...
                 IF(e5) NEXT :COL: ;
                 ...
                 IF(e6) NEXT;
                 ...
                 IF(e7) EXIT;
                 ...
                ] "end UNTIL"
           ...
          ] "end COL"
       ...
       ]  "end ROW"
   ...
  ] "end SEARCH"
```

```
10      CONTINUE
        V=Ax
        GOTO 13
11      V=V+(Ax)
13      IF((Ai)*(V-(Af))
       *  .GT.0)GOTO 12
        ...
20      CONTINUE
        DO 21 I=1,N
        ...
30      CONTINUE
        DO 31 J=1,M
        ...
41      IF(e0)GOTO 42
        ...
        IF(e3)GOTO 12
        ...
        IF(e4)GOTO 11
        ...
        IF(e3)GOTO 21
        ...
        IF(e4)GOTO 22
        ...
        IF(e5)GOTO 31
        ...
        IF(e6)GOTO 41
        ...
        IF(e7)GOTO 42
        ...
        GOTO 41
42      CONTINUE
Cend UNTIL
        ...
31      CONTINUE
32      CONTINUE
Cend COL
        ...
21      CONTINUE
22      CONTINUE
Cend ROW
        ...
        GOTO 11
12      CONTINUE
Cend SEARCH
```

3.3.3.3 EXECUTE local procedure

A *local procedure* has the form:

```
name PROCEDURE [ ...]
```

where *name* is alphanumeric.

A local procedure is "called" by the statement:

```
EXECUTE name;
```

Any number of EXECUTE statements may *precede* a procedure.

The "calls" must precede the Procedure

```
    . . .
    EXECUTE PHI ;
    . . .
    EXECUTE PHI ;
    . . .
PHI PROCEDURE [ ... ]
    . . .
```

After the procedure is executed control is returned to the first statement following the EXECUTE statement. An EXECUTE statement must not follow a procedure:

This sequence is correct

```
    . . .
    EXECUTE PHI ;
    . . .
PHI PROCEDURE [ ... ]
    . . .
```

Not this:

```
    EXECUTE PHI ;
    . . .
```

- The *first* EXECUTE statement will "call" PHI, and will return correctly.

- The *second* EXECUTE statement will "call" PHI, but will not return correctly.

Multiple returns from a procedure are written:

```
LEAVE name;
```

Example of FORTRAN generated for procedures:

```
      ...
      EXECUTE RHO;
      ...
      EXECUTE PHI;
      ...
      EXECUTE PHI;
      ...
      EXECUTE RHO;
      ...
PHI PROCEDURE  [ ... LEAVE PHI; ... ]
 ...
RHO PROCEDURE  [ ... LEAVE RHO; ... ]
 ...
```

```
        ...
        ASSIGN  10 TO KP20
        GOTO 21
10      CONTINUE
        ...
        ASSIGN  30 TO KP40
        GOTO 41
30      CONTINUE
        ...
        ASSIGN  50 TO KP40
        GOTO 41
50      CONTINUE
        ...
        ASSIGN  60 TO KP20
        GOTO 21
60      CONTINUE
        ...
        GOTO 43
42      GOTO KP40,(30, 50)
41      CONTINUE
        ...
        GOTO  42
        ...
        GOTO 42
43      CONTINUE
        ...
        GOTO 23
22      GOTO KP20,(10, 60)
21      CONTINUE
        ...
        GOTO  22
        ...
        GOTO 22
23      CONTINUE
        ...
```

CAVEAT !

Program units containing local procedures must avoid identifiers of the form:

KPn

where n comprises 2 to 4 decimal digits.
(See the example above.)

Moreover, the program unit must not override the FORTRAN convention that identifiers beginning with "K" default to type INTEGER.

Examination of the FORTRAN generated for EXECUTE and PROCEDURE statements will reveal that:

1) It is not possible to "fall-into" a procedure, because a *branch around* the procedure is generated by Mortran3.

2) It is not necessary to issue LEAVE statements explicitly unless multiple returns are needed.

3) EXIT :*name*: is equivalent to LEAVE *name*. LEAVE should be used to avoid confusion with loops.

It should also be pointed out that "GOTO *procedure name*" will generate a FORTRAN compile-time error of "MISSING LABEL". (See the following section.)

4. CONTROL SUMMARY

4.1 SUMMARY OF ITERATIVE CONTROL

We can now summarize MORTRAN loops in the following chart:

optional	*choose one*		*optional*		*optional*
	WHILE e1				
	UNTIL e1		NEXT;		
	LOOP		EXIT;		WHILE e2;
:*label*:	FOR *V*=*Ax* BY *Ai* TO *Af*	[...	EXIT :*label*:;	...]	UNTIL e2;
	FOR *V*=*Ax* TO *Af* BY *Ai*		NEXT :*label*:;		REPEAT
	FOR *V*=*Ax* TO *Af*				
	DO *i*=*j*,*k*,*n*				

where:

- e1 and e2 are logical expressions.
- *V* is a (subscripted) variable of type INTEGER or REAL.
- *Ax*, *Ai*, and *Af* are arbitrary arithmetic expressions,

  Ax is the *initial* value.
  Ai is the *increment*.
  Af is the *final* value.

- *i*, *j*, *k*, and *n* are standard FORTRAN DO variables:

  i is a non-subscripted INTEGER variable.
  j, *k*, and *n* are non-subscripted INTEGER variables *or INTEGER constants*.

The "compact" DO-loop does not "fit" in the above chart, however, the rules that apply to DO *i*=*j*,*k*,*n* [...] also apply to the "compact" DO-loop [*i*=*j*,*k*,*n*;...]

4.2 SUMMARY OF SEQUENTIAL CONTROL

Sequential control statements are IF, IF-ELSE, ELSEIF, and GOTO.

4.2.1 GOTO :label:

This statement generates a standard FORTRAN GOTO statement. Mortran3 does not prohibit branching into the range of a loop, consequently:

- If the loop is a DO-loop, no error will be generated by Mortran3, but an error will be generated by most FORTRAN compilers.

- Similarly, GOTO *procedure name* will not generate Mortran3 errors, but will generate FORTRAN compile-time errors.

5. MISCELLANEOUS FEATURES

5.1 MULTIPLE ASSIGNMENT

```
/ V1, V2, V3,..., Vn /=expression;
```

produces:

```
V1=expression
V2=expression
V3=expression
 ...
Vn=expression
```

NOTICE to Mortran2 users: this has been changed.

Mortran2 produced

```
V1=expression
V2=V1
V3=V2
 ...
Vn=Vn-1
```

This was changed because:

1) The Mortran2 version may cause conversion errors when the *Vi* are different types.

2) This new version is "what one would expect".

5.2 INPUT-OUTPUT ABBREVIATIONS

These abbreviations may be used to read and write from the "standard" units.

Input

```
INPUT  i-o list;(format list);
```

Where *i-o list* and *format list* must meet standard FORTRAN requirements.

Example:

```
INPUT X,Y ; (2F9.3);
```

Produces:

```
      READ(5, 10)X,Y
10    FORMAT (2F9.3)
```

Output

```
OUTPUT i-o list;(format list);
```

Where *i-o list* and *format list* must meet standard FORTRAN requirements.

Example:

```
OUTPUT  Z ; (' VOILA LE Z ',E12.6)
```

Produces:

```
      WRITE(6, 20)Z
20    FORMAT (' VOILA LE Z ',E12.6)
```

INPUT and OUTPUT may be generalized to include other logical i-o units. (see Part II).

PART II. The Definition Language

6. INTRODUCTION TO NOTATIONAL TRANSFORMATIONS

The programming language described in Part I is defined by a set of *transformation rules*. The *transformation* from Mortran notation to FORTRAN notation is the result of the *application* of these rules by the Mortran3 *processor*.

The application of a rule involves:

- "Recognition" of a notational "form" and
- Substitution of FORTRAN "form(s)" for the "form" that was "recognized".

We will give precise definitions of these "fuzzy" statements later. Before going into that, we present a simple, useful example.

6.1 A USEFUL EXAMPLE

Suppose one has a program in which *subscripts* are calculated, and that errors will result if the subscripts are not within certain ranges. For example:

```
3 < J < 7
```

One could insert IF, WRITE, and FORMAT statements that issue error messages if these variables are not within the given ranges. But such error-checking statements are obtrusive; they distract our attention from more important aspects of the program. A much less obtrusive (and easier to write) notation might be:

Example (6-1)

```
ASSERT 3 < J < 7 ;
```

One wants to transform notations like (6-1) into FORTRAN statements that would produce run-time error messages like:

```
ASSERTION "3<J<7" VIOLATED: J=33
```

A more general form of (6-1) is:

```
(6-2)   ASSERT digit1 < letter < digit2;
```

The FORTRAN notation one wants to substitute for (6-2) should depend upon the *actual* letters and digits corresponding to *digit1*, *letter*, and *digit2*.

The transformation described above could be defined by:

```
        REPLACE {ASSERT{DIGIT}<{LETTER}<{DIGIT}}
        WITH
(6-3)   { IF( ¬({P1}<{P2} & {P2}<{P3}) ) OUTPUT {P2};
          (' ASSERTION "{P1}<{P2}<{P3}" VIOLATED: {P2} =',I3);
        }
```

A transformation *rule* is defined by (6-3). An *application* of (6-3) is illustrated in the following example:

```
Statement   ASSERT 7 < K < 9 ;
            ------------------------------------------
Produces:       IF(7.GE.K.OR.K.GE.9)WRITE(6,10)
            10  FORMAT(' ASSERTION "7<K<9"  VIOLATED: K =',I3)
```

"7" corresponds to the 1st {DIGIT} in (6-3)
"K" corresponds to the {LETTER} in (6-3)
"9" corresponds to the 2nd {DIGIT} in (6-3)

1) In (6-3), {DIGIT} and {LETTER} are parameter markers.

2) In the example, 7, K, and 9 are actual parameters.

3) There are three parameter markers in (6-3).

4) There are nine parameter references in (6-3)
   Five of them are denoted by {P2}
   Two of them are denoted by {P1}
   Two of them are denoted by {P3}

5) OUTPUT is a notation described in Part I.

6) The braced quantities {DIGIT} and {LETTER} are parameter markers.
   The quantities DIGIT and LETTER are specifiers.

   - In this case the specifiers are primitives; they are "built-in".

But the programmer may define specifiers that suit his own needs. For example, a specifer may be defined that describes a variable name. A FORTRAN variable name is:

A letter followed by not more than 5 letters or digits.

A Mortran3 specifier that could be used to "recognize" a FORTRAN variable name is defined by the following SPECIFY statement:

```
(6-4)   SPECIFY FORTNAME AS  LETTER (0,5)[LETTER|DIGIT] ;
```

Following the definition (6-4), {FORTNAME} could replace {LETTER} in the ASSERT rule definition above so that the ASSERT notation could be used with FORTRAN variable names instead of single letters. But something must be done about DIGIT also. The "something" follows:

```
SPECIFY CONSTANT AS (1,7)[DIGIT];
```

Now, one can re-write the transformation rule as:

```
        REPLACE {ASSERT{CONSTANT}<{FORTNAME}<{CONSTANT}}
        WITH
(6-6)   {  IF( ¬({P1}<{P2} & {P2}<{P3}) ) OUTPUT {P2};
           (' ASSERTION "{P1}<{P2}<{P3}" VIOLATED: {P2} =',I9);
        }
```

Following the definition of (6-6), one might write:

```
ASSERT 1234 < INDEX < 5678;
```

Producing, at run-time:

```
ASSERTION "1234<INDEX<5678" VIOLATED: INDEX=98765
```

This introductory example is intended to whet your appetite for bigger and better things so that you will read Part II, which is excerpted from "The Mortran3 Reference Manual" (by yours truly). And maybe even wade through the Reference Manual itself!

7. TRANSFORMATION RULES

The Mortran3 *processor* may be regarded as a *device* that accepts and applies transformation rules.

- A rule may be defined at any point in a program.
- A rule applies to all program text after it is defined.[6]
- A rule may define one or more rules. (Definitions may be nested.)

To define a rule, the programmer writes:

```
REPLACE {template} WITH {value}
```

- The keywords REPLACE and WITH are intended as a constant reminder that a rule defines a substitutive function.[7]
- *Template* describes a user-defined notation.
- *Value* comprises text (and/or a prescription constructing text) that will be substituted for the user-defined notation.
- The *braces* are *delimiters*.

7.1 THE SIMPLEST EXAMPLE.

In the simplest type of rule, both the template part and the value part are made up of *literal symbols* (symbols that denote themselves). This type of rule merely substitutes one symbol-string for another symbol-string.

Example (7-1)

```
REPLACE {SIZE} WITH {22}
```

Rule (7-1) would transform all occurrences of (say):

```
        DIMENSION A(SIZE)
into    DIMENSION A(22)
```

Rules like (7-1) are, by themselves, of limited usefulness.[8]

The user may define rules of considerable power and flexibility by including *braced quantities* within the template and value parts. If braced quantities are included in the template and value parts the braces must be balanced, just as parentheses must be balanced in FORTRAN expressions.

---

[6] The scope of rule application may be restricted by the programmer (See Section 'The Scope of Rules' below.)

[7] A function that is evaluated by substitution as opposed to transfer of control. See "Mortran3 Reference Manual", appendix E for a FORTRAN analogy.

[8] They may be used like FORTRAN 77's PARAMETER statement.

Braced quantities in rule definitions denote function references.

- In the template part they denote **recognition** functions.
- In the value part they denote **evaluation** functions.

7.2 THE TEMPLATE PART

A template comprises literal symbols and, optionally, braced quantities.

- Templates **must** contain **literal symbols**.
- Templates **may** contain **braced quantities**.

The name **within** the braces is the name of a **recognition** function.
The name **and** the braces comprise a parameter **marker**.

7.2.1 Parameter Markers

A parameter marker may be thought of as a "place holder":

template (7-2) `THIS {WORD} IS FALSE.`

Template (7-2) is made up of:

- Literal symbols: "THIS IS FALSE.".
- A parameter marker: {WORD}
- A specifier: WORD

A specifier is the **name** of a function. The function specifies *criteria* that must be met by an **actual** parameter.

Assume that WORD has been *specified* (described below) as:

"a contiguous string of upper-case letters"

Then, (7-2) would match `THIS SENTENCE IS FALSE.` ; parameter: "SENTENCE".

- A template may contain up to *35* parameter **markers**.
- The parameter markers in a template are "positional". That is, they are numbered (by Mortran) from the left, starting with one.

template (7-3) ({WORD}.{WORD})

Template (7-3) has *two* parameter markers. Both parameter markers are denoted by {WORD}.

(7-3) would match: (THIS.THAT)

1st actual parameter is "THIS"
2nd actual parameter is "THAT"

Template (7-3) would also match:

- (A.B)
- (ANTIDISESTABLISHMENTARIANISM.DIALECTICALMATERIALISM)

Template (7-3) would not match:

- (3.14) because 3 is not a word.
- (A.EQ.B) because EQ.B is not a word.

One "tells Mortran" how to "recognize" a parameter by means of the SPECIFY statement, which is described in the next section.

7.2.2 Specifiers

A *specifier* is the *name* of a *recognition* function. The function is defined by a SPECIFY statement:

```
SPECIFY specifier AS specification;
```

- A specification is a **boolean** function.
  (1) A specification is **met** or it is **not-met**.
  (2) A specification comprises:
    (a) Specifiers.
    (b) **Primitive** specifiers.
    (c) **Primitive** specifications.
      1) Specifiers are user-defined.
      2) **Primitives** are system-defined.

- A specifier is **satisfied** if its specification is met.

> A template will **not** match a segment of text unless **all** of its specifiers are satisfied.

Example:

```
SPECIFY HEXDIGIT AS (0...F);
```

- This SPECIFY statement defines the specifier HEXDIGIT.
- HEXDIGIT would be satisfied by one of the symbols *0* through F. HEXDIGIT would not be satisfied by any other symbol.
- The parameter marker {HEXDIGIT} would "match" a single digit. The parameter marker {HEXDIGIT} would not "match" any other symbol.
- (*0*...F) is an example of a *primitive* specification.

Example:

```
SPECIFY LCASE AS (a...z);
```

- This specify statement defines the specifier LCASE, which would be satisfied by one lower-case letter.
- The specification part of this specify statement is an example of a primitive specification, namely, a *qualifier*.

There are a number of **primitive** (system defined) specifiers. Three very useful ones are LETTER, DIGIT, and ALPHA; They are predefined by the system as follows:

```
        a   SPECIFY LETTER AS (A...Z);
(7-4)   b   SPECIFY DIGIT  AS (0...9);
        c   SPECIFY ALPHA  AS [LETTER|DIGIT];
```

Notice that (7-4)-c is specified in terms of other specifiers, namely LETTER and DIGIT. LETTER and DIGIT comprise a *list* of two *alternatives*. ALPHA is satisfied if either LETTER or DIGIT is satisfied. The symbol "|" is the "alternation symbol". The square brackets delimit the list of two alternatives. (In general, the number of alternatives in a list is arbitrary.)

Square brackets also delimit entities that are *quantified*.

Example:

```
SPECIFY FNAME AS LETTER(0,5)[ALPHA];
```

- The specification part contains a *quantifier*.
  - a) The entity being quantified is enclosed in square brackets.
  - b) The quantifier is enclosed in parentheses.
- The quantifier may be read
  - a) "at least zero, but not more than five" or
  - b) "optionally at most five".
- FNAME would be satisfied by a letter followed, optionally, by at most 5 letters or digits.
- FNAME would be satisfied by a standard FORTRAN variable name.

Example:

```
SPECIFY THING AS 'T'(2)[LETTER|DIGIT];
```

- THING would be satisfied by the letter T followed by exactly two symbols.
- Each of the symbols may be either a letter or a digit.
- The specification part in this example comprises
  - a) the literal 'T',
  - b) two specifiers LETTER and DIGIT,
  - c) one quantifier, (2)
  - d) a list comprising two alternatives, [LETTER|DIGIT].

7.2.2.1 Forward references in Specifications

Forward references are permitted in specifications. For example,

```
(7-5)   SPECIFY QUADRUPED AS (4)[LEG];

        SPECIFY LEG AS [ 'LIMB '| 'EXTREMITY '];
```

In (7-5) LEG is referred to before it is defined; LEG is a *forward reference*.

Forward references may increase the computation done during transformations.

It should also be pointed out that QUADRUPED will be satisfied by any of *16* (=2^4) possible arrangements of LIMB and EXTREMITY.

If we write "L " for "LIMB " and "E " for "EXTREMITY ", then the following arrangements would satisfy the specifier QUADRUPED.

```
L L L L , L L L E , L L E L , L L E E ,
L E L L , L E L E , L E E L , L E E E ,
E L L L , E L L E , E L E L , E L E E ,
E E L L , E E L E , E E E L , E E E E
```

7.2.2.2 Specifying "Optional"

There are two ways that a specification may be made "optional".

```
(7-6)-a   SPECIFY APPENDAGE AS ['TAIL'|''];

     -b   SPECIFY APPENDAGE AS (0,1)['TAIL'];
```

Both (7-6)-a and (7-6)-b specify that APPENDAGE is "optional". In other words, the text "TAIL" will satisfy the the specifier APPENDAGE, but APPENDAGE will be satisfied whether or not the text "TAIL" is present.

- If "TAIL" is present, it becomes the actual argument.
- If "TAIL" is absent, the actual argument is NULL.

More about this in the subsection 'NULL Parameters' below.

7.3 THE VALUE PART

The value part comprises any or all of the following:

- Literal symbols
- Strings
- Braced quantities
- Evaluation-time IF-THEN-ELSEs.

Braced quantities (not in strings) always denote function references. The simplest of the function references are the *parameter references*.

7.3.1 Parameter References

A parameter reference is a primitive function that refers to an *actual* argument. The first of these is denoted by:

{Pn}

$1 \le n \le 35$

The primitive function invoked by {Pn} returns actual argument n.

- n is the parameter reference number
- n corresponds to the relative position (from the left) of the parameter *marker*.

- The number of parameter markers may not exceed *35*, but any number of parameter references may appear in the value part.

- The parameter reference number n may not exceed the number of parameter markers. (If it does the error message "NO SUCH ARGUMENT IN TEMPLATE" will result.)

Other primitives that refer to actual parameters are:

	1	{LENGTH n}
(7-7)	*2*	{EXIST n}
	3	{NULL n}

- (7-7)-*1* returns the length of actual argument n.
- (7-7)-*2* and -*3* refer the "existence" or "non-existence" of the nth actual argument.

Briefly, the parameter "exists" if its length is greater than zero, and is "null" if its length is equal to zero. But see the section "NULL Parameters" below.

7.3.1.1 Left-to-right Substitution

Normally, the value part of a rule is substituted for the template part on a strict left-to-right (L-R) basis.

```
(7-8)   REPLACE {({LETTER}.{LETTER})}
          WITH  {  {P1}(1)* {P2}(1)
                 + {P1}(2)* {P2}(2)
                 + {P1}(3)* {P2}(3)
                }
```

- The template part of rule (7-8) contains two parameter markers.

- The value part of rule (7-8) contains six parameter references.
  Three of them refer to the first actual parameter.
  Three of them refer to the second actual parameter.

Application of (7-8) to the

program text	(A.B)
produces	A(1)*B(1) + A(2)*B(2) + A(3)*B(3)

Since (7-8) contains only literal symbols, parameter markers, and parameter references, application of (7-8) involves the following steps:

1. The template part matches the text (A.B).

2. The parameters A and B are saved and the text "(A.B)" is deleted.

3. Beginning at the point where the text "(A.B)" was deleted, the value part is substituted. The substitution proceeds left-to-right and symbol-by-symbol until a parameter reference is encountered.

4. The actual parameter referred to is inserted at the reference point.

5. Left-to-right substitution resumes until the next parameter reference is encountered.

> Upon completion of the substitution, the newly substituted text is re-scanned to determine whether other rules may be applied to it.

Simple left-to-right substitution may be altered by the programmer through the use of primitive evaluation functions and evaluation-time IF-ELSEs described below.

7.3.1.2 NULL Parameters

The programmer may define notations whose parameters are described in considerable detail by means of SPECIFY statements.

In particular, he may specify that a parameter is "optional". One of the ways he may do this is illustrated in the following example:

```
          a-  SPECIFY BIPED AS        (2)[ LEG ];

(7-9)     b-  SPECIFY APPENDAGE AS    (0,1)[TAIL];

          c-  SPECIFY APPENDAGE AS    [TAIL|''];
```

Both (7-9)-b and (7-9)-c specify that APPENDAGE is "optional". (7-9)-a specifies that BIPED requires exactly 2 occurrences of LEG. Now consider the template fragment:

```
...{BIPED}{APPENDAGE}...
```

If the specifier BIPED is satisfied, and the "..." parts are satisfied, then the template matches regardless of whether or not the specifier TAIL is satisfied. In other words, the specifier APPENDAGE will always be satisfied.

> If a specifier has been defined as **optional**, then:
>
> - The **actual** parameter **EXISTS** if it contains at least one symbol.
> - The **actual** parameter is **NULL** if it contains no symbols.

(NULL = does not EXIST = contains no symbols.)

Now, in the *value* part of a rule, the programmer may well want to know whether the BIPED has a tail or not, and to take action accordingly. The programmer may test for the existence of a parameter that has been declared optional. More about this following the evaluation-time IF-ELSE.

Simple left-to-right substitution may be altered by:

- Evaluation function references.
- Evaluation-time IF-THEN-ELSEs.

7.4 PRIMITIVE EVALUATION FUNCTIONS

A primitive evaluation function reference is denoted by:

{*NAME argument*}

- *NAME* is the name of the function and
- *argument* is a symbol-string.

The *argument* of an evaluation function may contain other function references. In other words, function references may be nested. Nested primitive references (excepting parameter references) are evaluated from the innermost outward.

7.4.1 Order of evaluation

Let P,Q, and R denote primitive function names, and let an ellipsis denote an arbitrary symbol-string.

(*7-10*) {P...{Q ...{R ...} ...} ...}

In (*7-10*), the primitive R is evaluated first. The argument of Q then includes the symbol-string resulting from R's evaluation, and so on until P is evaluated. (Each evaluation results in the removal of the name and delimiting braces of the function.)

Let upper-case letters denote the names of primitive functions,
lower-case letters denote symbol-strings, and
boldface letters denote evaluated symbol-strings.

Then,	{P ab{Q cd{R ef} gh} ij}	is evaluated as follows:
	{P ab{Q cdefgh} ij}	(after R is applied.)
	{P **abcdefghij**}	(after Q is applied.)
	abcdefghij	(after P is applied.)

7.4.2 The REDUCE primitive

First, we illustrate with a contrived example involving 3 rules:

```
(7-11)-a  REPLACE {xxx} WITH {1n3}
      -b  REPLACE {n}   WITH {2}
      -c  REPLACE {123} WITH {ONE,TWO,THREE!}
```

Rules (7-11) will transform "xxx" into "123", but "123" will not be transformed into "ONE,TWO,THREE!". Rules (7-11) will be applied in the following steps:

1) "xxx" is replaced by "1n3" by (7-11)-a.
2) "n" is replaced by "2" by (7-11)-b.

As pointed out in section "L-R Substitution" above, the substituted text is "re-scanned" to determine whether other rules may be applied. But the text is re-scanned from the point at which the last substitution was made. In this example, "123" will not be matched because the re-scan begins at "23" after (7-11)-b is applied. We can *force* the application of (7-11)-c by re-writing (7-11)-a to invoke REDUCE:

```
(7-11)-a-REV   REPLACE {xxx} WITH {REDUCE{1n3}}
```

Then, "xxx" will be transformed into "ONE,TWO,THREE!" in the following steps:

1) "xxx" is reduced to "1n3" by (7-11)-a-REV.
2) "n" is reduced to "2" by (7-11)-b.
3) "123" is reduced to "ONE,TWO,THREE!" by (7-11)-c.
4) "xxx" is replaced by "ONE,TWO,THREE!"

7.4.2.1 REDUCED text vs. REPLACED text.

The distinction between reduced and replaced is an important one.

> REDUCE rescans *all* of its argument until all rules have been applied to the argument. When no further reduction is possible, the reduced string replaces the matched string.

If the argument of REDUCE contains other invocations of REDUCE then the innermost is re-scanned first. (This is not unlike nested FUNCTION references in FORTRAN.)

REDUCE is automatically invoked by the COMPUTE primitive.

7.4.3 The COMPUTE primitive

Again, the contrived introductory example:

```
(7-12)-a  REPLACE {TWO} WITH {2}
      -b  REPLACE {SIX} WITH {6}
      -c  REPLACE {APE} WITH {{COMPUTE 3*(TWO+SIX) }}
```

Rules (7-12) will transform "APE" into "24" in the following steps:

1) TWO is reduced to 2 by (7-12)-a.
2) SIX is reduced to 6 by (7-12)-b.
3) The constant expression "3*(2+6)" is evaluated.
4) The value is converted to the two characters "2" and "4".
5) The text "24" replaces the text "APE".

- COMPUTE returns the value expressed as a digit-string.
- COMPUTE's argument must be reducible to a constant expression.
  (IF it is not reducible, various error messages will result)

7.4.3.1 Constant expressions

Constant expressions comprise integer constants and operators.

An expression like : DOGS > CATS
could reduce to (say): POODLES+CORGIES > SIAMESE+ALLEY
and then to (say): 5+7 > 2+32768
this last is a constant expression.

Constant expressions are either integer expressions
or logical expressions.

A constant expression comprises:	
Integer constants	(contiguous digit-strings)
Arithmetic operators	(+,-,*,/,**)
Relational operators	(<, <=, =, ¬=, =>, >)
or	(LT, LE, EQ, NE, GE, GT)
Logical operators	(AND , OR , NOT)
or	(& , | , ¬)
Parentheses	

(The FORTRAN operators .AND., .EQ., .NE., etc. are NOT acceptable in this context.)

7.4.3.2 Constant Logical Expressions

For constant *logical* expressions COMPUTE returns:
the digit *1* (TRUE) or
the digit *0* (FALSE)

Assuming rules (*7-12*)-a and (*7-12*)-b above,

```
            {COMPUTE  TWO LT SIX }    returns 1 (TRUE)
            {COMPUTE  TWO < SIX  }    returns 1 (TRUE)
            {COMPUTE  TWO EQ SIX }    returns 0 (FALSE)
   {COMPUTE  TWO*SIX+6 >  30-TWO  }   returns 0 (FALSE)
   {COMPUTE  TWO*SEX+6 >  30-TWO  }   issues error mesage if "SEX" is not
                                      reducible. Returns 0.
```

NOTE

An arithmetic expression that evaluates to zero is not distinguishable from a logical expression that evaluates to FALSE. Therefore, it is possible (but not advisable) to perform arithmetic operations on logical expressions.

7.4.4 Evaluation-time IF-ELSE

The evaluation-time IF-ELSE is written:

```
[IF]      predicate    [true-part]
[ELSE]                 [false-part]
```

- *predicate* is (1 a *constant* expression,[9]
  (2 a *string* expression
  (3 the *primitive* EXIST
  (4 the *primitive* NULL

- *true-part* and *false-part* are symbol strings.

The IF-ELSE in a programming language controls the order of execution of the statements in a program.

This *evaluation time* [IF]-[ELSE] controls the substitution of symbol-strings. This [IF]-[ELSE] should be regarded as a function that returns the symbol-string *false-part* if *predicate* is FALSE, and the symbol-string *true-part* otherwise.

- Evaluation-time [IF]-[ELSE]'s may be nested.

---

[9] More precisely, it is an exression that must be *reducible* to a constant expression. (See subsection 'Constant Expressions'.)

7.4.4.1 String Expressions

String expressions involve two types of strings:

1) Literals enclosed in apostrophes (like 'THIS').
2) Parameter markers enclosed in apostrophes (like '{P3}').

A parameter reference enclosed in apostrophes converts the *actual argument* to a string. String expressions are written:

S1 relation S2

- *S1* must be a string
- *S2* may be (1 a string, or (2 a specifier
- relation is 1) the symbol "="
  2) the symbol "¬"

If *S1* is not a string, unpredictable errors will result.
If *S2* is not a string, it is assmumed to be a specifier.

In summary, string expressions may contain

- Strings
  - Literals
  - Parameter references
- Specifiers

If both arguments are strings, the strings are compared.

If the first argument is a string and the second argument is a specifier, then if the string satisfies the specifier and if the relation is '=' then TRUE is returned.

Undefined specifiers in string expressions result in an error message and a value of FALSE for the predicate.

The following are valid string expressions involving strings only:

'{P1}'='{P3}'	TRUE when parameter 1 is identical to parameter 3.
'{P1}'¬'{P3}'	FALSE when parameter 1 is identical to parameter 3.
'{P1}'='THIS'	TRUE when parameter 1 is the literal THIS.
'THIS'='{P1}'	TRUE when parameter 1 is the literal THIS.
'{P1}'¬'THIS'	TRUE when parameter 1 is not the literal THIS.

The following string expressions involve a string and a specifier:

'{P*i*}'=FNAME	TRUE when parameter *i* satisfies the specifier FNAME.
'{P*i*}'=FNSME	issues an error mesage if FNSME has not been defined in a SPECIFY statement and returns FALSE.

7.4.4.2 The primitives NULL and EXIST

Actual parameters may be NULL (contain no symbols). This can happen when a specifier has been defined as optional. (See subsection NULL Parameters.) The primitives EXIST and NULL may be used to determine the status of actual arguments.

```
{EXIST n}
{NULL  n}
```

n refers to the nth actual parameter

```
{EXIST n} returns TRUE  if actual argument n is not null.
{EXIST n} returns FALSE if actual argument n is     null.

{NULL n}  returns TRUE  if actual argument n is     null.
{NULL n}  returns FALSE if actual argument n is not null.
```

These primitives are especially useful in evaluation time IF-ELSE predicates.

7.5 RECURSIVE APPLICATION OF RULES.

A rule may be evaluated recursively. Direct[10] recursion results when the *name* of the rule appears in the *value part* of the rule. We give two illustrations:

- The first illustrates the transformation of a functional *notation* for factorial into an *expression*.
- The second calculates the factorial.

First, we transform the *notation*: !*d* (where *d* is a digit)
into the *notation*: d*(d-*1*)*(d-*2*)*...*(*1*)

(7-13)
```
REPLACE {!{DIGIT}}

  WITH  {[IF] {P1}>1 [ {P1} * ! {COMPUTE {P1}-1} ]

              [ELSE] [ 1 ]
        }
```

Rule (7-13) will transform: !4
into: 4*3*2*1
in the following steps:

First step: !4 is replaced by 4*!3
Second step: !3 is replaced by 3*!2
Third step: !2 is replaced by 2*!1
Fourth step: !1 is replaced by 1

- Rule (7-13) is not intended to be useful; It is intended to be a simple illustration of recursive application of a rule.
- The name (!) appears in the value part of (7-13) with a new argument, to wit: !{COMPUTE {P1}-1}.
- When {P1}=1, the predicate returns FALSE, and the the digit "1" is substituted, preventing further recursion.

---

[10] Indirect recursion can also take place when two or more rules "invoke" one another.

In the second example, the factorial is computed by *nested* invocations of COMPUTE:

```
(7-14)  REPLACE {!{DIGIT}}
           WITH {[IF] {P1}>1 [{COMPUTE {P1}*!{COMPUTE {P1}-1} } ]
                      [ELSE]  [ 1 ]
                 }
```

Rule (7-14) will transform !5 into 120 as follows:

```
!5 is reduced:
 {COMPUTE 5*!4}                          (nest level=1)

!4 is reduced:
 {COMPUTE 5*{COMPUTE 4*!3}}                          (level=2)

!3 is reduced:
 {COMPUTE 5*{COMPUTE 4*{COMPUTE 3*!2}}                          (level=3)

!2 is reduced:
 {COMPUTE 5*{COMPUTE 4*{COMPUTE 3*{COMPUTE 2*{COMPUTE !1}}}}  (level=4)
```

Now, because the argument of !1 is not greater than 1, recursion stops and 1 is substituted. The nest is then evaluated from the innermost outward:

```
{COMPUTE 5*{COMPUTE 4*{COMPUTE 3*{COMPUTE 2*1}}}
{COMPUTE 5*{COMPUTE 4*{COMPUTE 3*2}}}
{COMPUTE 5*{COMPUTE 4*6}}
{COMPUTE 5*24}
120
```

When computation is complete (level=0),replace the text "!5" with "120".

If the ELSE part of (7-14) is removed, !5 will not return 120 as one might expect, it will return 0, and COMPUTE will issue the error messages:

```
*WARNING INVALID C-EXPRESSION
*STRANGE (2*)
```

Rule (7-14) (without the ELSE part) attempts to compute:

(5*(4*(3*(2*))))

which is meaningless. Rather than abandon the rule, it issues error messages and computes:

(5*(4*(3*0)))

which may not be what was intended. Thus, the ELSE part of (7-14) serves a purpose other than assuring the correct value for arguments of ! that are less than or equal to zero.

7.5.1 Unwanted Recursion

An improperly defined rule can rapidly fill Mortran's workspace or waste time in infinite recursion.

Space-filling example (7-15)

```
REPLACE{A}WITH{AA}
```

Rule (7-15) will replace the first "A" encountered in the input text with "AA", and then replace the first "A" of "AA" with "AA" resulting in "AAA", and so on until the remaining workspace is filled. Then Mortran will issue the message "MORTRAN WORKSPACE EXHAUSTED", and stop.

For those cases where one actually wants this type of rule, one should use the *primitive* EMIT (see appendix A). In the case cited above, one should write:

```
REPLACE {A} WITH {{EMIT AA}}
```

Time-wasting example (7-16)

```
REPLACE{A}WITH{A}
```

Example (7-16) will repeatedly replace "A" with "A" until the replacement limit (default *100*) is reached. Then Mortran will issue the error message "*100* RULES EVALUATED WITH NO OUTPUT", and turn on TRACE. TRACE is turned on so that the user may find the unwanted recursion without re-submitting the job. (See appendix A for a description of TRACE.)

7.6 THE SCOPE OF RULES

A rule is global[11] to the text following its definition unless the scope is restricted by the processor directives[12] !LOCAL and !END LOCAL.

The !LOCAL directive (in effect) marks all subsequent rules as "temporary". The !END LOCAL directive deletes all "temporary" rules, and recovers the space they occupied.

This feature is useful in a number of ways, among them:

- Rules may defined that apply only within a SUBROUTINE or FUNCTION subprogram.
- Because rule definitions may be nested, the creation and elimination of rules that "live" only to carry out some temporary need is facilitated.
- In the current version !LOCAL directives may *not* be nested. (This will be corrected in the next version.)

---

[11] Applies everywhere.

[12] See appendix D for a list of directives.

7.7 REMOVING RULES AND SPECIFIERS

There are two ways of removing Rules and Specifiers:

1) By defining them within a LOCAL range as described above.
2) By the statements:

```
REMOVE RULE 'template'
REMOVE SPECIFIER 'specifier'
```

The recovery of the space left by REMOVEd rules or specifiers is automatic in the LOCAL case, but is not automatic for explicit REMOVE statements. The user can force the recovery of "dead" space by the directive !RECOVER. In either case, the recovery procedure prints the following:

```
nnn     LOCATIONS REGAINED BY RECOVERY
mmm     LOCATIONS REMAINING
pp      PERCENT RULE CAPACITY REMAINING
```

Recovery is also automatically invoked whenever the Rule and Specifier storage space is exhausted.

7.8 INTERNAL COUNTERS

There are 35 user-accessable counters, 1...9, and A...Z.

Each of these counters can hold one integer.

The user may access these counters with the following primitives:

{INCR c}	increment counter c, c=(1...9,A...Z)
{DECR c}	decrement counter c, c=(1...9,A...Z)
{SETR c=e}	set counter c to the value of expression e.
{COPY c}	returns value of c (base 10) as a digit string.
{COPY c BASE b}	returns value of c (base b) as a digit string.

The expression e must be reducible to a constant integer expression. A simple example will illustrate the uses of COPY.

```
        SPECIFY NUM AS (1,8)[DIGIT];

(7-17)   REPLACE {SHOW DIGITS IN {ARB} BASE {NUM}}
           WITH { {SETR A={P1}}
                  DIGITS OF {P1} BASE  10  ARE: {COPY A };
                  DIGITS OF {P1} BASE {P2} ARE: {COPY A BASE {P2}};
              }
```

Examples of the application of (7-17) follow:

```
The text:  SHOW DIGITS IN 2**8-1 BASE 2;
  yields:       DIGITS OF 2**8-1 BASE 10 ARE: 255
  yields:       DIGITS OF 2**8-1 BASE 2 ARE: 11111111

The text:  SHOW DIGITS IN 8**3-1 BASE 8;
  yields:       DIGITS OF 8**3-1 BASE 10 ARE: 511
  yields:       DIGITS OF 8**3-1 BASE 8 ARE: 777

The text:  SHOW DIGITS IN 8**4-1 BASE 16;
  yields:       DIGITS OF 8**4-1 BASE 10 ARE: 4095
  yields:       DIGITS OF 8**4-1 BASE 16 ARE: FFF

The text:  SHOW DIGITS IN 8*9/2+4 BASE 36;
  yields:       DIGITS OF 8*9/2+4 BASE 10 ARE: 40
  yields:       DIGITS OF 8*9/2+4 BASE 36 ARE: 14

The text:  SHOW DIGITS IN 220 BASE 22;
  yields:       DIGITS OF 220 BASE 10 ARE: 220
  yields:       DIGITS OF 220 BASE 22 ARE: A0
```

7.9 THE LENGTH PRIMITIVE

The LENGTH primitive is written

```
{LENGTH r}
```

where r is a *parameter reference number*

A parameter reference number is a number base *35* denoted by *1* through Z. If there are fewer than r parameter *markers*, the error message

NOSUCH ARG. IN TEMPLATE OF RULE

will result.

We give three examples of its use:

```
SPECIFY WORD AS (1,11)[LETTER];

REPLACE {COUNT{WORD}} WITH {{P1} HAS {LENGTH 1} LETTERS}
```

The text: COUNT THIS
yields: THIS HAS *4* LETTERS

The text: COUNT BALDERDASH
yields: BALDERDASH HAS *10* LETTERS

The second example illustrates its use in a hypothetical naming convention, to wit:

1. Scalars are denoted by two-letter names
2. Vectors are denoted by three-letter names
3. Matrices are denoted by four-letter names

Now suppose one wants to transform |*name*| into FORTRAN FUNCTION calls according to this convention.

```
SPECIFY NAME AS (1,4)[LETTER]

REPLACE {|{NAME}|}
   WITH { [IF] {LENGTH 1}=2 [ ABS({P1}) ]
          [IF] {LENGTH 1}=3 [ LENGTH({P1}) ]
          [IF] {LENGTH 1}=4 [ DETERM({P1}) ]
        }
```

```
Example:    I*|XX|     + J*|YYY|        + K*|ZZZZ|
 yields:    I*ABS(XX) + J*LENGTH(YYY) + K*DETRM(ZZZZ)
```

The third example is an extension of the COPY example from the previous chapter.

```
SPECIFY NUM AS (1,8)[DIGIT];

REPLACE {SIZE({ARB})} WITH { {LENGTH 1} }

REPLACE {SHOW DIGITS IN {NUM} BASE {NUM}}
   WITH { {SETR A={P1}}
          THE SIZE({COPY A BASE {P2}})
          DIGITS OF {P1}({P2}) ARE:
          {COPY A BASE {P2}}
        }
```

The text: SHOW DIGITS IN 255 BASE 2
yields: THE 8 DIGITS OF 255(2) ARE: 11111111

The text: SHOW DIGITS IN 511 BASE 8
yields: THE 3 DIGITS OF 511(8) ARE: 777

The point of this example is that the ancillary rule SIZE is necessary because the argument of LENGTH is *a parameter reference number*. In other words an instance of the template SIZE({ARB}) must be recognized in order to determine the length of its argument.

7.18 APPENDING TEXT.

Text may be appended to the value part of an existing rule. There are two forms:

(7-18) APPEND {*value*} TO {*template*}

and

(7-19) APPEND '*value*' TO '*template*'

The two forms differ in one respect only: the latter preserves ALL blanks in its *template* part.

APPEND can produce two effects:

1) It can append *value* to the value part of a previously defined rule whose template part is identical to *template*.

2) It can define a new rule if no rule with a template identical to *template* exist. In other words, it defaults to:

REPLACE {*template*} WITH {*value*}

NOTE: In searching for a rule with template identical to *template*, the entire template (including parameter markers) is compared, as opposed to normal rule aplication. In other words, in this case parameter markers are treated as if they were literals.

For example, consider the following:

```
(7-20) 1   APPEND { FOUR          } TO {LINCOLN}
       2  APPEND {SCORE AND SEVEN} TO {LINCOLN}
```

Assuming that no rule whose template is LINCOLN exists, then

(7-20)-1 Defines a rule whose template is LINCOLN and whose value is FOUR.

(7-20)-2 Appends SCORE AND SEVEN to FOUR, so that the value of LINCOLN becomes FOURSCORE AND SEVEN.

Notice that leading and trailing blanks have been deleted and that embedded blanks have been reduced to a single blank in the appended text. This is done so that the value part will conform to the "canonical" form for rule definition.

If it is desired that blanks be preserved in the appended text, the alternate form of APPEND should be used. Using the alternate form with the same example:

```
          1   APPEND 'FOUR'             TO 'LINCOLN'
   (7-21) 2   APPEND 'SCORE AND SEVEN'  TO 'LINCOLN'
          3   APPEND ' YEARS   AGO '    TO 'LINCOLN'
```

Again, assuming that no rule whose template is LINCOLN exists:

If one denotes a blank by a lower case "b", then the final value of LINCOLN produced by (7-21) would be:

```
                FOURSCOREbANDbSEVENbYEARSbbbAGOb
or              FOURSCORE AND SEVEN YEARS   AGO
```

In summary:

- Text may be APPENDed to a previoulsy DEFINEd rule.
- The alternate form may be used after the "standard" form, and *vice versa*.

7.11 SPECIAL SYMBOLS

7.12 THE RESERVED SYMBOL

One symbol is reserved for "system" use and may not be used by the programmer in any context whatever, save one: it may be changed. The default setting for the reserved symbol is "@". If this symbol *must* be used for other purposes, (e.g. the operating system demands its use), the reserved symbol may be changed. The reserved symbol may be set by the processor directive

```
!SETrRESERVED              (where "r" denotes an ASCII symbol.)
```

For example, !SET#RESERVED would cause the symbol "#" to become the reserved symbol. Subsequent to !SET#RESERVED, the symbol "@" would become available for other purposes.

7.13 OTHER "SPECIAL" SYMBOLS

In addition to the reserved symbol, Mortran3 recognizes a number of symbols (in some context) as "special". There are three categories:

a) Delimiters:
   - Parentheses ------ ()
   - Braces ---------- {}
   - Brackets --------- []
   - Quotation mark --- "
   - Apostrophe[13] ----- '

b) Two directive indicators:
   - Bang ---------- !
   - Percent ---------- %

c) One terminator:
   - Semicolon -------- ;

---

[13] The apostrophe may also be treated as an "ordinary" symbol. Mortran3's treatment of the apostrophe depends upon a toggle that may be set by the !STRING processor directive. See appendix A and also the subsection "The Apostrophe" below.

7.13.1 Terminators and Delimiters

We will use the terms *delimiter* and *terminator* in the following sense:

- A *terminator* marks the *end* of an object
- *Delimiters* mark both the *beginning* and the *end* of an object.

For example, an exclamation point *terminates* this sentence! In contrast, a remark (like this) is often *delimited* by parentheses. But a remark, like this, may also be delimited by commas. In written Engilsh, a "parenthetical remark" is not necessarily a remark within parentheses; it may be a remark set off by commas.

Some delimiters (like parentheses) employ separate, symmetric symbols[14] to mark the beginning and end of the delimited text. The FORTRAN "language" uses parentheses as delimiters in many contexts, but makes little use of terminators. The FORTRAN "END statement" terminates (sub)programs. But statements are not explicitly terminated. Rather, they are implicitly terminated at the end of a line unless the following line is a "continuation line".

Mortran3 "language statements" are terminated by semicolons as described in Part One.

In contrast, REPLACE{*template*}WITH{*value*} is not a statement; it is a function definition. It is not terminated by a semicolon, because both the template and value parts may contain semicolons. Both the template and value parts are *delimited* by braces; consequently neither may contain unbalanced braces.

7.13.1.1 The Apostrophe

The apostrophe is *not* the same (conceptually) as a quotation mark. But most FORTRAN compilers have been extended[15] to include the apostrophe as a "legal"

---

[14] The French language employs the symbols "<" and ">" to delimit quotations. Typesetters in most languages employ separate, symmetric symbols to delimit quotations. But "programming languages" do not. One reason is that the most widely used character sets, EBCDIC and ASCII, do not define "left quotation mark" and "right quotation mark".

[15] The *1966* FORTRAN standard does not include the apostrophe in its character set and does not define a "string" or a "literal" data type. In section *4.2.6*, the standard says: "Hollerith Type. A Hollerith datum is a string of characters. This string may consist of any characters capable of representation by the processor. The blank character is a valid and significant character in a Hollerith datum.

character, and they employ the apostrophe as a delimiter for "literal" data or "strings". Mortran3's predecessor, Mortran2, delimited its "patterns" (templates) with apostrophes. And thereto hangs a tale of horror. To illustrate, consider the following form of the Universal Truth:

```
It don't matter!
```

We may write this in a FORMAT statement using the (extended) FORTRAN convention, as:

```
'It don''t matter!'
```

Here, literal data is *delimited* by apostrophes, and a single apostrophe is denoted by a *pair* of apostrophes. But suppose we want to quote ol' Joe as having said: "It don't matter!".

```
'Ol'' Joe said: ''It don''''t matter!'''
```

Here, a single apostrophe delimits the outer quotation and a pair of apostrophes denote a single apostrophe and also delimit the inner quotation, while four apostrophes denote an apostrophe within the inner quotation. If we quote ol' Pete quoting ol' Joe, we get:

```
'Ol'' Pete said: ''Ol'''' Joe said: ''''It don''''''''t matter!'''''''
```

Using symmetric "French quotes" we could re-write the latter as:

```
<Ol' Pete said: <Ol' Joe said: <It don't matter!>>>
```

MORAL:

```
Usin' a single symbol as a delimiter
ain't a 'specially good practice.[16]
```

---

[16] FORTRAN delimits logical and relational operators with ".". This does not improve the readability of FORTRAN predicates. Compare (.1<A<.2) to (A.GT..1.AND..2.GT.A).

Mortran2 fell into the trap illustrated by the above examples. Mortran2 "patterns" (templates) were delimited by apostrophes, following the extended FORTRAN convention for strings.

Mortran3 has eliminated this horror to a large extent, but vestiges remain. In particular, Mortran3 must still accept and process FORMAT statements using this convention. Moreover, Mortran3 must permit user-defined transformation rules that *generate* FORTRAN-compatable data for FORMAT statements.

Mortran3's intepretation of the apostrophe depends upon a toggle that may be set by the programmer. The toggle is turned "ON" by the processor directive "!STRINGS;" and is turned "OFF" by the processor direcive "!NOSTRINGS;". The default setting is "ON", which means that the apostrophe is a delimiter of strings. "OFF" means that the apostrophe is treated like any other symbol.

Appendix A

PROCESSOR CONTROL

There are two types of processor control directives:

- Free-form
- Column-one-restricted.

Free-form directives may appear anywhere on a line. Any number of Free-form directives may appear on a line.

Column-one-restricted directives *MUST* begin in column one and only one directive per line is recognized. (Column-one-restricted directives are a hold-over from Mortran2, and will be eliminated in future versions.)

A.1 FREE-FORM DIRECTIVES.

!ANNOTATE; Interleave Mortran source in FORTRAN output.
Mortran statements become COMMENTs in FORTRAN output.

!NOANNOTATE; Turn off !ANNOTATE.

!COMMENTS; Print Mortran comments as FORTRAN comments.
Mortran comments are output to FORTRAN file with 'C' in column one.

!NOCOMMENTS; Turn off !COMMENTS.

!LIST; Turn on Mortran listing

!NOLIST; Turn off !LIST.

!DEFINE; Print out rules at point of definition.

!NODEFINE; Turn off !DEFINE.

!LABELS n; Reset FORTRAN statement label generator to n.

!LOCAL;	Begin "local" rule definitions. Local rules apply to the text between the !LOCAL and !END LOCAL directives.
!END LOCAL;	Remove all rules defined after BEGIN LOCAL, and recover space.
!RECOVER	Recover workspace occupied by "dead" rules.
!SEQUENCE n;	n=1, Put the Mortran3 source from columns L-8 thru L into columns 73 thru 80 of the FORTRAN text. (where L is the line length.) n=2, Put Mortran3 generated sequence numbers into columns 73 thru 80 of the FORTRAN text. n=(*anything else*), Put *blanks* into columns 73 thru 80 of the FORTRAN text.
!TRACE n;	n=2 print template and parameters each time a rule is applied, NOT including nested applications. n=3 print template and parameters each time a rule is applied, INCLUDING nested applications. n=6 print template and parameters each time a rule is ATTEMPTED, INCLUDING nested applications. (Produces VOLUMINOUS output. Not normally used.)

A.2 COLUMN-ONE-RESTRICTED DIRECTIVES.

%An For n=1 same as !ANNOTATE; above
n=2 same as !NOANNOTATE; above

%Bn Set input buffer size to 80<n<132

%Cn Set "significant column" to 10<n<buffersize

%Dn For n=1 same as !DEFINE; above
n=2 same as !NODEFINE; above

%F Set FORTRAN mode

%In Set automatic indentation to n columns per nesting level.

%L same as !LIST; above

%M Return to Mortran mode

%N same as !NOLIST; above

%Q Terminate comments at end-of-line.

%Rn Rewind Unit n

%Sn Same as !SEQUENCE n; above.

%Tn Same as !TRACE n; above

%Un Switch to FORTRAN logical unit number n for Mortran3 input

Appendix B

PRIMITIVE SPECIFICATIONS.

There are four types of primitive specifications:

QUALIFIERS
QUANTIFIERS
ALTERNATIVES
LITERALS

These primitives provide the interface to the text containing user-defined notations. The Mortran processor defines a "recogniiton function" for each user-defined SPECIFY statement. The *specifier* part becomes the *name of the function*. When a specifier is used as a parameter marker in a REPLACE statement, the recognition function is invoked. Therefore, **ALL** user-defined recognition functions (specifiers) must (ultimately) be resolvable in terms of these four primitives.

B.1 QUALIFIERS

$(S_1 \ldots S_2)$

where: S1 *and* S2 are symbols,
and S1 ≤ S2

This primitive[17] qualifies a single *text* symbol.
Let T be a text symbol. Then,

$(S_1 \ldots S_2)$ returns *met* if $S_1 \leq T \leq S_2$ and *not-met* otherwise.

---

[17] This primitive depends upon Mortran's internal representation of symbols. In the present context it suffices to note that *0<1...<9<A<B...<Y<Z* . See Appendix C.

B.2 QUANTIFIERS.

(*min*,*max*)[specification]
(*exact*)[specification]

min, *max*, and *exact* must be reducible to *constant expressions*.[18]

- Quantifiers are enclosed in parentheses
- The specifications to which they apply are enclosed in square brackets.
- (*min*,*max*) returns *met* for no fewer than *min* nor more than *max* occurrences.
- (*exact*) returns *met* for exactly *exact* occurrences.

[18] See the Subsection "Constant Expressions".

B.3 ALTERNATIVES

A *list* of *alternatives* is written:

$$[\ A_1 \mid A_2 \mid \ldots \mid A_n\ ]$$

Where the *Ai* are alternative *specifications*.

- The entire *list* returns *met* or *not-met*.
- The alternatives are examined left-to-right.
- If an alternative returns *met*, the remaining alternatives are skipped.
- If the *list* is exhausted, *not-met* is returned.
- The number of alternatives is not limited.
- An alternative may not be NULL (empty), but it may be the empty string: ''. An entire list of alternatives may be specified as "optional" by including the empty string as the last alternative. Because the empty string is always satisfied, it must be the last of the alternatives.
- A list of alternatives may quantified.

  In particular, $(0,1)[A_1|A_2|\ldots|A_n]$

  is equivalent to $[A_1|A_2|\ldots|A_n|'']$.

- An unquantified list of alternatives:

  $[\ldots|\ldots|\ldots]$

  is equivalent to $(1)[\ldots|\ldots|\ldots]$

B.4 LITERALS

LITERALS in specifications are written:

'string'

where *string* is an arbitrary symbol-string.

Within *string*, a single apostrophe must be

represented by a pair of apostrophes.

Literals in specifications should not be confused with *literal symbols* in *rule definitions*.

Literal symbols in rule definitions (REPLACE statements) are NOT enclosed in apostrophes.

- In a rule that does not contain apostrophes:
  In the template part, all symbols not enclosed in braces are literal symbols.

- In a rule containing apostrophes,

  (1 There must be an even number of apostrophes.
  (2 The doubling rule applies for embedded apostrophes.
  (3 In the template part the apostrophes must match the text.
  (4 In the value part the apostrophes are generated.

In summary:

In specifications a string denotes a sequence of literal symbols. In rule defininitions a string denotes a literal in the FORTRAN sense.

Appendix C

PRIMITIVE EVALUATORS

All primitive evaluation function references[19] are denoted by:

{*name arg*}

where *name* is the name of the function and
arg is an arbitrary string of symbols.

Primitive evaluation function references may be nested. The "depth" of the nesting is limited only by the amount of "work-space" available to Mortran. (In other words, there is no fixed limit on the nesting level.)

Evaluation is from the innermost of the nest outward.

C.1 REDUCE

{REDUCE arg} Recursively apply all (system and user) rules to the argument until no rule is applicable.

C.2 COMPUTE

{COMPUTE arg} Invoke REDUCE.
REDUCEd argument should be constant expression.
- If it is, returns value of constant expression.
- If it is not, issues error message and returns *0*.

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[19] Except the evaluation-time IF-ELSE.

C.3 COUNTER PRIMITIVES

There are 35 user-accessable counters, 1...9, and A...Z.

Each of these counters can hold one binary integer.

The following primitives refer to these counters.

{INCR c}	increment counter c, c=(1...9,A...Z)
{DECR c}	decrement "
{SETR c=e}	set counter c to the value of expression e.
{COPY c}	returns value of c (base 10) as a digit string.
{COPY c BASE b}	returns value of c (base b) as a digit string.

C.4 PARAMETER PRIMITIVES

{Pn}	Returns the nth actual parameter.
{LENGTH n}	Returns the number of symbols in actual parameter n.
{EXIST n}	returns 1 (true) if actual parameter n is not NULL[20] returns 0 (false) if actual parameter n is NULL
{NULL n}	returns 1 (true) if actual parameter n is NULL returns 0 (false) if actual parameter n is not NULL

[20] Recall that a reference {Pn} may be NULL if the nth parameter marker has been specified as optional.

C.5 MISCELLANEOUS PRIMITIVES.

{WAIT arg} Returns arg verbatim.

This primitive may be used to override the 'innermost-outward' order of evaluation.

This primitive delays, for one pass, the application of embedded rules. It does not prevent application.

{EMIT (arg)} Prevents application of any rule to arg.
(Applies to system and user-defined rules.)

Useful for issuing error messages containing function references.

Also useful for preventing unwanted recursion.

The WAIT primitive delays application; the EMIT primitive prevents application.