GENERAL ELECTRIC
COMPUTERS

GE-625/635
ALGOL

ADVANCE INFORMATION

GENERAL ELECTRIC

XCPB-1087

GE-625/635

ALGOL

March 1966

GENERAL ELECTRIC

INFORMATION SYSTEMS DIVISION

GUIDE TO THE EFFECTIVE USE OF THIS MANUAL

This manual describes the ALGOL language as defined for use in preparing programs for the General Electric 625/635 computer system. Thus, the instruction forms, procedures, rules, etc. are those which are acceptable to the ALGOL compiler prepared for that computer system.

This is a reference manual for programmers. It is not intended to be a primer or introductory exposition on how to write computer programs in general or on the ALGOL language in particular. It may be used to learn the language; however, this would presuppose that the user is familiar with the basic machine and language-independent principles of computer programming.

Chapter I provides a definition and discussion of ALGOL. This includes a presentation of techniques and a detailed description of a sample ALGOL program.

Chapter II contains definitions of the elements of ALGOL.

Chapters III, IV, V, VI, and VII describe the various ALGOL statements and declarations.

Certain conventions have been used in preparing this manual's text. The ALGOL language itself has been differentiated from its descriptive prose by the use of two type styles. Thus, ALGOL appears in manifold while the prose appears in italics.

ALGOL is characterized by having relatively few distinct instructions* (statements and declarations) in comparison with other compiler languages (e.g., FORTRAN). The power of the language derives from its great flexibility in allowing many variations of each instruction form.

Traditionally, ALGOL manuals have dwelled upon the generalized forms of each instruction in the language repertoire after having presented definitions of terms, concepts, etc. The various derivable forms of the instructions which the user needs to implement an application were learned by inference in the remaining test, and through examples. Much was learned "on the computer".

This manual overcomes the problem of providing insight into the variations possible with each instruction. It presents each as a series of variations proceeding from the simplest to the most complex forms, thus providing the user with a wider insight into its utilization possibilities.

Each variation is presented as though it were a separate and distinct instruction in the ALGOL language. Each set of such variations is proceeded by a title page containing the generally accepted name attached to the forms included. Finally, each instruction (or variation) starts on a new page and is appropriately labelled on an upper corner.

It is of interest to note that Chapter III contains the list of instructions discussed in the text.

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*The word instruction has been avoided in the remainder of this manual. This has been done because it conflicts with the notion of statement and declaration as used in ALGOL.

These do not have generally accepted ALGOL names since, as discussed earlier, they are variations derived from those which do. The list contains the form of each instruction to be encountered in the text as well as a reference to the page on which it can be found.

TABLE OF CONTENTS

I. INTRODUCTION

A. *DEFINITION AND STRUCTURE OF THE ALGOL LANGUAGE*

Definition

ALGOL is an acronym for ALGOrithmic Language. The word "algorithm," as used here, implies ALGOL's unique capability as a tool for expressing problem solutions as efficient and precise procedures.

ALGOL is a language in which computer programs may be written.

ALGOL is a set of symbols and a set of rules. Associated with these are a set of definitions which are peculiar to a description of the language, its form and use.

There is a computer program associated with the ALGOL language. This program is called the "ALGOL compiler." All programs written in the ALGOL language must be processed by the ALGOL compiler prior to their execution as object programs.

Preparing a problem solution using the ALGOL language thus implies understanding the form and use of the language repertoire described in this manual. In addition, an ALGOL compiler for translation of the source coding (i.e., the ALGOL program produced by the user of the language) into machine coding (i.e., the language of the computer itself) must be available.

This manual does not discuss the ALGOL compiler as prepared for the General Electric 625/635. This is documented in other manuals. There is, however, a procedure which must be followed by the programmer in preparing an ALGOL program for processing by the ALGOL compiler. This includes organization of the source program, the preparation of control records for achieving various compiler options, etc. Appendix 4 of this manual presents this procedure.

Structure

The structure of ALGOL is distinct from the structure of programs written in the ALGOL language. This section discusses the former while Section I B, How To Write An ALGOL Program, discusses the latter.

ALGOL is composed of statements and declarations.

Statements are used to specify operations to be performed by the computer in solving a problem.

Declarations provide the ALGOL compiler with information needed to define and link together various elements of the computer program during processing. In addition, the existence of declarations within the language facilitates the definition of program parameters.

The statements and declarations are composed of symbols. Note that some ALGOL symbols might conventionally be termed "character strings"; however, the definition of a symbol in ALGOL does not imply a single character. Also, certain symbols are enclosed in apostrophes. These apostrophes are a part of the symbol and must always appear when the symbol is used.

Basic Symbols

a) *letters* - A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
letters are used for forming identifiers and strings.

b) *digits* - 0 1 2 3 4 5 6 7 8 9
digits are used for forming numbers, identifiers and strings.

c) *logical values* - 'TRUE' 'FALSE'

d) arithmetic operators

symbol	*definition*
+	*addition*
-	*subtraction*
×	*multiplication*
/	*division*
%	*division*
↑	*exponentiation*

e) relational operators

symbol	*definition**
'LS'	*less than* (<)
'LQ'	*less than or equal to* ($\leq$)
'EQ'	*equal to* (=)
'GQ'	*greater than or equal to* ($\geq$)
'GR'	*greater than* (>)
'NQ'	*not equal to* ($\neq$)

f) logical operators

symbol	*definition**
'EQV'	*equivalent* ($\equiv$)
'IMP'	*implies* ($\supset$)
'OR'	*or* ($\wedge$)
'AND'	*and* ($\vee$)
'NOT'	*negation* ($\neg$)

g) punctuation - the following symbols have definite functions in the ALGOL language

---

* *The symbols shown in this column are not available to the user for coding. They are included to show the mathematical meaning of the corresponding ALGOL symbol.*

symbol	*definition*	*use*
.	*period*	*decimal point in numbers*
,	*comma*	*separator for items in a list*
:	*colon*	*separator for statement label*
;	*semicolon*	*separator for statements*
(	*left parenthesis*	*enclose parameter lists; indicate*
)	*right parenthesis*	*expression evaluation*
[	*left bracket*	*enclose subscripts*
]	*right bracket*	
"	*left string quote*	*enclose strings*
\	*right string quote*	
'	*apostrophe*	*indicate exponent*
←	*arrow*	*assignment operator*
	blank space	*space within strings*

Note: Significant blanks are denoted by ␣ in the text of this manual.

h) ALGOL words - these words have a fixed meaning in the ALGOL language

'ARRAY'	'LABEL'
'BEGIN'	'NONLOCAL'
'BOOLEAN'	'OWN'
'CODE'	'PROCEDURE'
'COMMENT'	'REAL'
'DO'	'RENAME'
'ELSE'	'STEP'
'END'	'STRING'
'EXTENDED REAL'	'SWITCH'
'FOR'	'THEN'
'GOTO'	'UNTIL'
'IF'	'VALUE'
'INTEGER'	'WHILE'

There are six types of statements available in ALGOL. Their names and a brief description of their functions follow:

Statement Types

Name	*Functions*
Assignment	*To perform calculations and to assign a value to a variable or a group of variables*
Conditional	*To control the execution of individual statements or groups of statements*
Dummy	*To satisfy a programming protocol (described later) but it in itself performs no operation*
'FOR'	*To iterate a sequence of statements*
'GOTO'	*To transfer control*
Procedure	*To call a previously defined sequence of statements (e.g., a subroutine)*

There are four types of declarations available in ALGOL. Their names and a brief description of their functions follow:

Declaration Types

Name	*Functions*
'ARRAY'	*To define an array, specify its dimensions and its type*
'PROCEDURE'	*To define a subset of the computer program (e.g., a subroutine)*
'SWITCH'	*To specify control parameters which govern the sequence of program execution*
Type	*To specify the kind of value which a variable is to represent*

There are many rules of protocol in writing an ALGOL statement or declaration. The major part of this manual discusses these.

The ALGOL language is structured in such a way as to impose rules of combining statements and segregating these as programs or subprograms in their own right. These concepts are presented in the section entitled, "COMPOUND STATEMENTS AND BLOCKS."

ALGOL does not contain statements which allow direct control of the input/output process. Thus, no statements or declarations exist for reading from or writing on external devices (e.g., READ, WRITE, etc., in FORTRAN). To accomplish the usual input/output operations, procedures are provided which may be "called" by the user as subroutines. These procedures are described in detail in the section entitled, "INPUT/OUTPUT."

B. *HOW TO WRITE AN ALGOL PROGRAM*

The writing of any computer program presupposes an understanding of the problem to be solved and the selection of a programming language. Assuming these conditions to be satisfied, the following considerations are presented as a guide in the writing of ALGOL programs.

Form of an ALGOL Program

ALGOL programs are divided into logical sections called blocks. The entire program is also a block and must be enclosed within the symbols 'BEGIN' *and* 'END'. *A block may contain any number of sub-blocks within it.*

Variables, arrays, procedures and switches which are used in a block are defined in declarations at the beginning of the block. These declarations are followed by the statements of the block. Any statement of a block may in itself be a block (i.e. it must have block format as described in Section VI) and thus blocks may be nested to any depth.

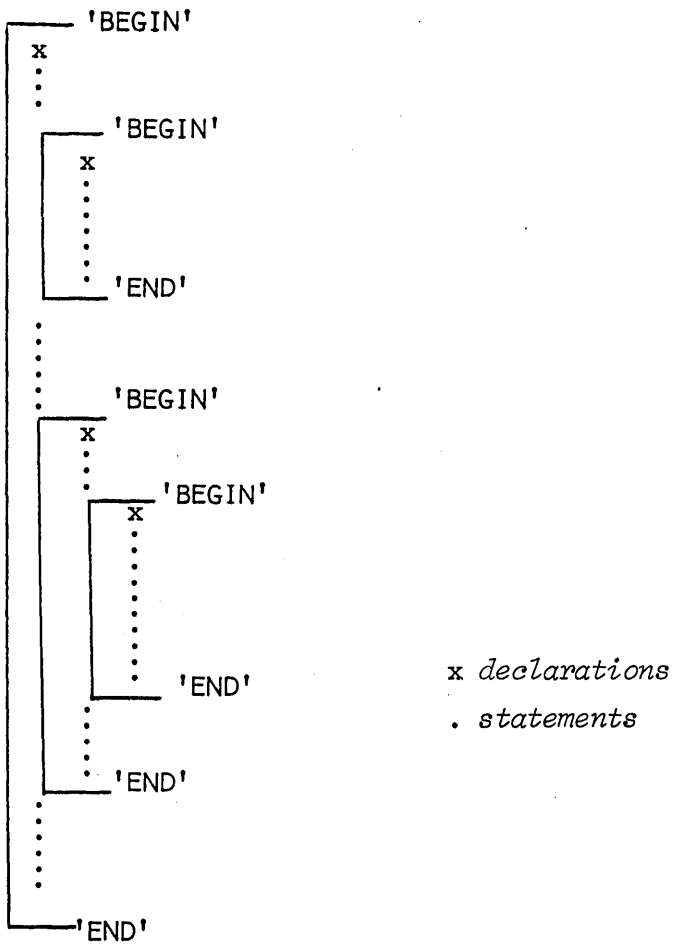
All ALGOL statements may be labelled with one or more statement labels, i.e. simple statements, compound statements and blocks may be labelled.

Execution of an ALGOL program starts with the first statement and continues successively from statement to statement. However, certain statements in the language have the power to change the sequence of statement execution.

Execution of the program is terminated when control reaches the 'END' *symbol of the outermost block of the program.*

The following diagram is given to suggest visually the structure of a typical (though arbitrary) ALGOL program. Each bracket denoted by ⌜'BEGIN' ⌞'END' *represents a block.*

The blocks are composed of declarations and statements (as discussed above). The declarations must precede the statements.



Note that this diagram represents an ALGOL program with three block levels and four blocks.

Writing Rules and Techniques

The ALGOL program may be written on coding forms designed specifically to handle the language.

Columns 1-72 of the coding form may be used for ALGOL statements and declarations.

The ALGOL code may appear anywhere within these columns.

The coding may appear in a completely free form. That is, any number of statements and/or declarations may appear on a single line.

A single statement or declaration may occupy as many lines as is desired.

Blanks may be used freely throughout the ALGOL code to improve the readability of the text. The only place in ALGOL in which blanks are significant is in strings. In all other instances they are disregarded by the compiler.

Since the line format of ALGOL programs is very flexible it is suggested that statement levels be indented on a new line to improve ease of reading and understanding a program.

Thus each new 'BEGIN' *symbol may be indented at a new margin, and the* 'END' *corresponding to the* 'BEGIN' *may be placed at the same margin. Also, since statements may contain other statements, each lower statement level may be indented. When a higher level is resumed later on, statements for that level may be placed at the proper level margin (see form of the example given in Section I. C.).*

It must be noted that these are merely suggestions which may be incorporated in order to make the program structure easy to follow. However, line indenting will in no way affect program execution.

Punctuation

When writing ALGOL statements and declarations there are two important rules of punctuation which must be employed.

Rule 1. *The symbol ; is used between statements and between declarations. However, the semi-colon may be omitted after the last simple statement of a compound statement or block. The symbol* 'END' *serves as a statement separator in this case.*

Examples

1.
```
A←2; 'GOTO' Z
```

2.
```
'BEGIN' 'INTEGER' A; 'REAL' B;
A←5.3; B←7.2 'END'
```

Rule 2. *The symbol : is used to separate a statement label from a statement.*

Examples

1.
```
L: A←B+C; P: 'GOTO' R
```

2.
```
T: 'BEGIN' I←I+1; J←J+1 'END'
```

Comments

If it is desired to place comments within the text of an ALGOL program, it may be done as follows:

To insert a comment between statements or declarations, or at the beginning of a compound statement or a block, the comment must be enclosed within the symbols 'COMMENT' *and ;*

Examples

1.
```
A←B; 'COMMENT' COMPUTING C; C←A
```

2.
```
'BEGIN' 'COMMENT' COMPUTING C;
    A←B; C←A 'END'
```

To place a comment after a compound statement or a block (i.e., after the symbol 'END') *the symbol* 'COMMENT' *is not necessary. A semi-colon must be used after the text if an* 'END' *or* 'ELSE' *symbol does not appear.*

Examples

1.
```
'BEGIN' A←B; C←A 'END'
    COMPUTING D;
    D←C
```

2.
```
'IF' A 'LS' B 'THEN'
    'BEGIN' A←B; C←A 'END'
    COMPUTING C D IF A LS B
    'ELSE' B←A
```

Study of the examples provided with the detailed descriptions of the ALGOL statements and declarations in Chapters IV and V should aid in the understanding of how ALGOL statements are formed, punctuated, etc.

C. EXAMPLE OF AN ALGOL PROGRAM

This section contains a sample ALGOL Program.

The purpose of the program is to merge two sets of numbers. The two sets are contained in locations a(1), a(2),...,a(i),..., a(n) and b(1), b(2),...,b(j),...,b(m). The numbers in each set are assumed to be arranged in increasing order. The merged set is contained in locations c(1), c(2),..., c(k),... .

The program operates as follows. The elements of arrays a and b are compared. At each comparison, the smaller element is put into the result array c. When the end of either array a or b is reached, any remaining elements in the other array are put into the result array.

Symbols used in the program:

Symbol	*Description*
A	*Identifier of input array*
B	*Identifier of input array*
C	*Identifier of output array*
N	*Subscript bound for array A*
M	*Subscript bound for array B*
R	*Subscript bound for array C*
I	*Subscript for array A*
J	*Subscript for array B*
K	*Subscript for array C*
P	*Controlled variable of* 'FOR' *statement*

A listing of the program follows. The program is assumed to be a block contained in a larger block wherein the value of N, M and R are assigned, and wherein P is defined.

Program	*Line*
'BEGIN' 'ARRAY' A[1:N], B[1:M], C[1:R]; 'INTEGER' I, J, K;	*100*
I←J←K←1;	*110*
START: 'IF' I 'GR' N 'THEN'	*120*
'BEGIN' P←0; Q: C[K+P]←B[J+P]; P←P+1; 'IF' P 'LQ' M-J 'THEN' 'GO TO' Q 'END'	*130*
'ELSE' 'IF' J 'GR' M 'THEN'	*140*
'BEGIN' P←0; S: C[K+P]←A[I+P]; P←P+1; 'IF' P 'LQ' N-I 'THEN' 'GO TO' S 'END'	*150*
'ELSE' 'BEGIN'	*160*
'IF' A[I] 'GQ' B[J] 'THEN'	*170*
'BEGIN' C[K]←B[J]; J←J+1 'END'	*180*
'ELSE' 'BEGIN' C[K]←A[I]; I←I+1 'END';	*190*
K←K+1; 'GO TO' START	*200*
'END'	*210*
'END'	*220*

A line by line description of this program appears on the following pages.

Line	*Description*
100	*Contains* 'BEGIN' *for the block, and declarations of variables used.*
110	*Contains an assignment statement which sets I, J and K to the value 1.*
120	*Contains statement label "START" and the beginning of a conditional statement which extends to line 210. The* 'IF' *clause checks whether all of the elements of array A have been compared.*
130	*Contains the true branch of the* 'IF' *clause of line 120. The true branch is a compound statement which moves the remaining elements, if any, of array B to array C.*
140	*Contains the start of the false branch of the* 'IF' *clause of line 120. The false branch extends to line 210. The* 'IF' *clause in this line checks whether all of the elements of array B have been compared.*
150	*Contains the true branch of the* 'IF' *clause of line 140. The true branch is a compound statement which moves the remaining elements of array A to array C.*
160	*Contains the start of the false branch of the* 'IF' *clause of line 140. The false branch is a compound statement enclosed within* 'BEGIN' *and* 'END' *and extends to line 210.*

Line

170 — *Contains an 'IF' clause which compares elements of arrays A and B.*

180 — *Contains the true branch of the 'IF' clause of line 170. The true branch is a compound statement which moves an element of array B to array C and then updates the B array subscript, J.*

190 — *Contains the false branch of the 'IF' clause of line 170. The false branch is a compound statement which moves an element of array A to array C and then updates the A array subscript, I.*

200 — *Contains an assignment statement to update the C array subscript, K, and a 'GOTO' statement to transfer control to the statement labelled "START."*

210 — *Contains 'END' for the compound statement starting on line 160.*

220 — *Contains 'END' for the block starting on line 100.*

The structure of the conditional statement of the program is shown in Figure 1.

If the condition of line 120 is true, the true branch, line 130, is taken and subsequent control goes to line 210, i.e. the false branch is skipped. If the condition of line 120 is false, control goes to the false branch, line 140.

If the condition of line 140 is true, the true branch, line 150, is taken and subsequent control goes to line 210, i.e. the false branch is skipped. If the condition of line 140 is false, control goes to the false branch, line 160.

If the condition of line 170 is true, the true branch, line 180, is taken and subsequent control goes to line 210, i.e. the false branch is skipped. If the condition of line 170 is false, control goes to the false branch, line 190.

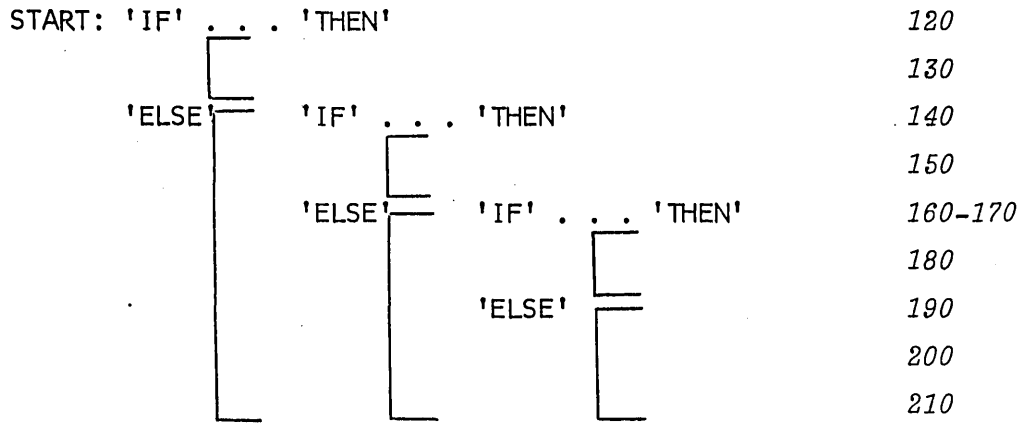


Figure 1. Outline of Conditional Statement

II. DEFINITIONS

1. *identifier:* *A name given to a variable, an array, a label, a switch, a procedure. The name may be composed of any number of letters and digits. However, the name must begin with a letter.*

Example:

A, BETA, M12, T12C7, TOTALAMOUNT

Blanks are not considered significant in ALGOL except in strings, and they may be used freely within identifiers.

Example:

AB LE *is considered the same identifier as* ABLE *or* ABL E.

Two different quantities may not have the same identifier unless they appear in different blocks. (See the section COMPOUND STATEMENTS AND BLOCKS for clarification.) Certain identifiers are reserved for standard procedures by the ALGOL compiler. (See the list of reserved identifiers in Appendix 1.)

2. *number:* *Integer, real number, extended real number.*

3. *integer:* *A whole number written without a decimal point consisting of 1 to 11 decimal digits. The range of an integer n is:*

3. *integer:* *(contd)*

$$-2^{35} \leq n \leq 2^{35} - 1$$

The precision is to 10 decimal digits.

Positive integers may have no sign or may be preceded by a plus sign. Negative integers must be preceded by a minus sign.

Example:

```
0,-452,+7586421,33
```

4. *real number:*

A series of from 1 to 9 decimal digits written with or without a decimal point. If the decimal point appears it must not be the last character.

An exponent part may be added to specify the integral power of 10 to which the number must be raised. The exponent part is separated from the digits by an apostrophe ('). The exponent may also appear alone.

The range of a real number n is:

$$-2^{127} \leq n \leq 2^{127}$$

The precision is to 8 decimal digits. Positive real numbers do not require a sign. However, a plus sign is permitted. Negative real numbers require a minus sign.

Example:

```
15.7, -.0045, +25.0, 1.7'-3, 5'3
```

5. *extended real number:*

A series of from 1 to 19 decimal digits written with or without a decimal point. If the decimal point appears it may not be the last character.

An exponent part may be added to specify the integral power of 10 to which the number must be raised.

The exponent part may also appear alone.

The range of an extended real number is:

$$-2^{127} \leq n \leq 2^{127}$$

The precision is to 18 decimal digits.

Positive extended real numbers do not require a sign. However a plus sign is permitted. Negative extended real numbers require a minus sign.

Example:

```
135982.7834, 21.762'-19
```

6. *string:*

A sequence of basic symbols enclosed in the left and right string quotes (" and \); or a sequence of basic symbols and strings enclosed in the string quotes.

Strings may be used as actual parameters of procedures.

6. *string:* *(contd)*

Examples of strings:

```
"A B C\
" A B " CDE\FG\
```

7. *variable:*

A quantity referred to by a name (the variable identifier) whose value may be changed.

The kind of quantity a variable may represent is determined by a type declaration and may be either integer, real, extended real or Boolean.

Example:

```
X, ABC, YZ5N,
THIS IS A VARIABLE
```

8. *subscripted variable:*

A subscripted variable has the form $a[b_1,b_2,\ldots,b_n]$ *where a is an array identifier and* $b_1,b_2,\ldots,b_n$ *are arithmetic expressions.*

The number of subscripts n must be the same as the number of dimensions declared for a.

Each subscript b_i *acts like a variable of type* 'INTEGER' *and the evaluation of the subscript is understood to be equivalent to an assignment to this integer variable.*

8. *subscripted variable: (contd)*

Evaluation of subscripts within a subscript list proceeds from left to right. The value of the subscripted variable is defined only if the value of each subscript expression is within the subscript bounds of the array.

Example:

```
AB[1,3], BOY['IF' B 'EQ' C 'THEN' 1 'ELSE' 2]
```

9. *simple arithmetic expression:*

A sequence of numbers, variables, subscripted variables or function calls separated by arithmetic operators and parentheses, which represents a rule for computing a numerical value.

Rules:

1. *All quantities used in an arithmetic expression must be of type real, extended real or integer.*

2. *For operators +, - or *, the result of calculation will be integer if both operands are integer; real if both operands are real; and extended real for all other cases.*

3. *There are 2 operators which denote division / and %. Both are defined for all combinations of real, extended real and integer quantities, however,*

   a) */ will give a result of type real only if both operands are real. In all other cases the result will be of type extended real.*

9. *simple arithmetic expression: (contd)*

b) % will give the same results as / except that the value will always be integral. The result is truncated not rounded to an integer, i.e.
5 % 3 = 1.

4. *Exponentiation -*

a) a↑b↑c is equivalent to $(a^b)^c$.

b) The types of the base and the exponent may be any combination of real, extended real, and integer.

c) If the exponent is an integer, the result is as follows:

exp	*base*	*result*
>0	*all*	*same type as base*
=0	*≠0*	*same type as base*
=0	*=0*	*operation is undefined*
<0	*≠0*	*real if base is real, otherwise extended real*
<0	*=0*	*operation is undefined*

d) If exponent is real or extended real the result is as follows:

9. *simple arithmetic expression: (contd)*

exp	*base*	*result*
>0, =0, <0		*real if base is real, otherwise extended real*
>0	=0	*real if base is real, otherwise extended real*
≤0	=0	*operation is undefined*
>0, =0, <0	<0	*operation is undefined*

5. *Hierarchy of operators -*
   1. *exponentiation* ↑
   2. *multiplication & division* * / %
   3. *addition & substraction* + -

6. *Expressions inside parentheses are evaluated first.*

7. *Evaluation proceeds basically from left to right within the hierarchy and within parentheses. Function calls and parenthesized quantities are evaluated from left to right.*

10. *'IF' clause arithmetic expression:*

'IF' a 'THEN' b 'ELSE' c, where a is a Boolean expression, b is a simple arithmetic expression, and c is either a simple arithmetic expression or an 'IF' clause arithmetic expression.

The 'IF' clause arithemetic expression causes one of several arithmetic expressions to be evaluated on the basis of the value of Boolean expressions.

The expression to be evaluated is selected as follows:

a) The Boolean expressions are evaluated one by one in sequence from left to right until one having a value 'TRUE' is found.

b) The value of the 'IF' clause arithmetic expression is the value of the first simple arithmetic expression following this Boolean expression.

11. *arithmetic expression:*

Either a simple arithmetic expression or an 'IF' clause arithmetic expression.

12. *simple Boolean expression:*

A sequence of variables, subscripted variables, function calls and relations possibly separated by logical operators and parentheses, which represents a rule for computing a logical value (i.e. 'TRUE' or 'FALSE').

12. *simple Boolean expression: (contd)*

Rules:

1. *Variables and functions used with the logical operators must be declared to be of type Boolean.*

2. *A relation is composed of two arithmetic expressions separated by a relational operator.*

   Example:

   ```
   A-B**C 'EQ' Z**Y
   ```

3. *A relation has a value of* 'TRUE' *if the relation is satisfied otherwise it has a value of* 'FALSE'.

4. *The logical operators are defined as follows:*

   a) 'NOT' *a is true or false if a is false or true, respectively.*

   b) *a* 'AND' *b is true if both a and b are true, otherwise it is false.*

   c) *a* 'OR' *b is false if both a and b are false, otherwise it is true.*

   d) *a* 'IMP' *b is false if a is true and b is false, otherwise it is true.*

   e) *a* 'EQV' *b is true if either both a and b are true or both are false, otherwise it is false.*

12. *simple Boolean expression: (contd)*

5. *The hierarchy of operations in evaluating a Boolean expression is as follows:*

    1. *arithmetic operators - same order as for arithmetic expressions*

    2. *relational operators*

    3. *logical operators*

6. *The hierarchy of logical operators is:*

    1. 'NOT'

    2. 'AND'

    3. 'OR'

    4. 'IMP'

    5. 'EQV'

7. *Expressions inside parentheses are evaluated first.*

13. 'IF' *clause Boolean expression:*

'IF' *a* 'THEN' *b* 'ELSE' *c, where b is a simple Boolean expression and a and c are either simple Boolean expressions or* 'IF' *clause Boolean expressions.*

The 'IF' *clause Boolean expression is evaluated in the same way as an* 'IF' *clause arithmetic expression.*

14. *Boolean expression:* — *Either a simple Boolean expression or an* 'IF' *clause Boolean expression.*

15. *expression:* — *Either an arithmetic expression or a Boolean expression.*

16. *statement label:* — *An identifier placed before a statement.*

A statement label must be followed by a colon to separate the label from the statement.

A statement may have more than one label, each one followed by a colon.

Statement labels are used so that a statement may be referenced.

Examples:

1) AB: A←B;

2) AC: 'BEGIN' A←C 'END'

3) AD: 'BEGIN' AE: A←E 'END'

4) AF: AG: AH: A←H;

17. *switch designator:* — *sw*[*a*], *where sw represents a switch identifier and a represents an arithmetic expression.*

18. *conditional designator:* — *A clause of the form* 'IF' *b* 'THEN' *c* 'ELSE' *d, where b represents a Boolean expression, c may be either a statement label, a switch designator, or a conditional designator enclosed within parentheses, and d may be either a statement label, a switch designator, or a conditional designator (which need not be enclosed within parentheses).*

19. *designational expression:* — *A statement label, a switch designator, or a conditional designator.*

20. *simple statement:* — *A statement which is not a compound statement or a block.*

Examples:

assignment

conditional

dummy

'FOR'

'GO TO'

procedure

III. STATEMENT AND DECLARATION FORMS

STATEMENT AND DECLARATION FORMS

A. *ASSIGNMENT STATEMENTS*

Name	*Form*	*Page*
Assignment, simple	$a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow e$	*40*
Assignment, 'IF' *clause*	$a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow$ 'IF' b_1 'THEN' e_1 'ELSE' e_2	*43*
Assignment, two 'IF' *clauses*	$a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow$ 'IF' b_1 'THEN' e_1 'ELSE' 'IF' b_2 'THEN' e_2 'ELSE' e_3	*45*
Assignment, n 'IF' *clauses*	$a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_m \leftarrow$ 'IF' b_1 'THEN' e_1 'ELSE' 'IF' b_2 'THEN' e_2 'ELSE' ... 'IF' b_n 'THEN' e_n 'ELSE' e_{n+1}	*47*

B. *CONDITIONAL STATEMENTS*

Name	*Form*	*Page*
Conditional, simple	'IF' b 'THEN' s	*50*
Conditional, 'ELSE'	'IF' b 'THEN' s_1 'ELSE' s_2	*52*
Conditional, two 'IF' *clauses*	'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2	*54*
Conditional, two 'IF' *clauses,* 'ELSE'	'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' s_3	*56*
Conditional, n 'IF' *clauses*	'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' ... 'IF' b_{n-1} 'THEN' s_{n-1} 'ELSE' 'IF' b_n 'THEN' s_n	*58*

B. CONDITIONAL STATEMENTS (contd)

Name	*Form*	*Page*
Conditional, n 'IF' *clauses,* 'ELSE'	'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' ... 'IF' b_{n-1} 'THEN' s_{n-1} 'ELSE' s_n	60

C. DUMMY STATEMENT

Name	*Form*	*Page*
Dummy	*(null form)*	63

D. 'FOR' *STATEMENTS*

Name	*Form*	*Page*
'FOR', *expression*	'FOR' $v \leftarrow e$ 'DO' s	65
'FOR', 'STEP' *clause*	'FOR' $v \leftarrow e_1$ 'STEP' e_2 'UNTIL' e_3 'DO' s	67
'FOR', 'WHILE' *clause*	'FOR' $v \leftarrow e$ 'WHILE' b 'DO' s	70
'FOR', *general*	'FOR' $v \leftarrow a_1, a_2, \ldots, a_n$ 'DO' s	72

E. 'GO TO' *STATEMENTS*

Name	*Form*	*Page*
'GO TO', *label*	'GO TO' a	75
'GO TO', *switch designator*	'GO TO' sw [a]	76
'GO TO', *conditional designator*	'GO TO' 'IF' b 'THEN' d_1 'ELSE' d_2	78

F. PROCEDURE STATEMENT

Name	*Form*	*Page*
Procedure statement	*name* $(a_1$ *t* a_2 *t ... t* $a_n)$	*82*

G. 'ARRAY' *DECLARATIONS*

Name	*Form*	*Page*
'ARRAY'	*type* 'ARRAY' $a_1,a_2,\ldots,a_n$	*89*
'ARRAY', 'OWN'	'OWN' *type* 'ARRAY' $a_1,a_2,\ldots,a_n$	*92*

H. 'PROCEDURE' *DECLARATIONS*

Name	*Form*	*Page*
'PROCEDURE' *declaration, simple*	'PROCEDURE' *name* $(a_1$ *t* a_2 *t ... t* $a_n)$*; s*	*94*
'PROCEDURE' *declaration, specification part*	'PROCEDURE' *name* $(a_1$ *t* a_2 *t ... t* $a_n)$*; sp list; sp list;...; sp list; s*	*97*
'PROCEDURE' *declaration, value and specification part*	'PROCEDURE' *name* $(a_1$ *t* a_2 *t ... t* $a_n)$*;* 'VALUE' *list; sp list; sp list;...; sp list; s*	*100*
'PROCEDURE' *declaration, function definition*	*type* 'PROCEDURE' *name* $(a_1$ *t* a_2 *t ... t* $a_n)$*;* 'VALUE' *list; sp list; so list;...; sp list; s*	*104*
'PROCEDURE' *declaration, separately compiled*	'CODE' 'BEGIN' $d_1;d_2;\ldots;d_n$ 'END'	*108*

I. 'SWITCH' DECLARATION

Name	*Form*	*Page*
'SWITCH'	'SWITCH' $sw \leftarrow d_1, d_2, \ldots, d_n$	*112*

J. TYPE DECLARATIONS

Name	*Form*	*Page*
Type	*type* $v_1, v_2, \ldots, v_n$	*116*
Type, 'OWN'	'OWN' *type* $v_1, v_2, \ldots, v_n$	*118*

The description of each statement and declaration in the ALGOL language is presented in the following section. Each starts on a new page with the format of its descriptive material given as shown below:

descriptive name

PURPOSE:

(A brief statement of the purpose of the statement or declaration)

FORM:

(Form of the statement or declaration)

(Definition of Symbols used in the Form line)

RULES:

(A list of rules governing the correct usage of the statement or declaration; includes restrictions, suggestions, etc.)

EXAMPLES:

(A list of examples illustrating the use of the statement or declaration)

IV. STATEMENTS

Assignment Statements

Assignment, simple

PURPOSE: *To perform numerical calculations; to perform Boolean operations; to assign a value to one or more variables or procedure identifiers in a single statement.*

FORM: $a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow e$

$a_1, a_2, \ldots, a_n$: *variable, subscripted variable or procedure identifier*

e: *arithmetic or Boolean expression*

RULES:

1. *This statement causes expression "e" to be evaluated and the result to be assigned to* $a_1, a_2, \ldots, a_n$. *(Note: there need be only one variable, e.g.,* $a_1 \leftarrow e$*).*

2. *The character "←" signifies assignment of the value of the expression to the variables.*

3. *The process of assignment is as follows:*
   a. *Subscripts, if any, occurring in the variables are evaluated from left to right.*
   b. *The expression "e" is evaluated.*
   c. *The value of the expression is assigned to all the variables* $a_1, a_2, \ldots, a_n$ *from right to left across the left side as follows: The value of e is assigned to* a_n, *the value of* a_n *is assigned to* a_{n-1}, *etc. Finally, the value of* a_2 *is assigned to* a_1.

4. *The types of the variables must be as follows:*
   a. *The types may be all Boolean. In this case, the expression "e" must be Boolean.*
   b. *The types may be real, extended real or integer. In this case, the expression "e" must be arithmetic.*
   c. *Boolean types may not be mixed with the other types.*

5. *When "e" is an arithmetic expression and its type and the type of variable* a_n *is different, the value of "e" is changed to the type specified by* a_n *before it is assigned to* a_n. *(See Definitions for forms of integers, real numbers and extended real numbers.)*

6. *In the case in which "e" is real or extended real and* a_n *is an integer, "e" is operated upon by the function* ENTIER *(e+.5). The result of* ENTIER *is the largest integer not greater than the value of the argument. This value is then assigned to* a_n.

7. *When the type of* a_i *and* a_{i-1} *is different, the value of* a_i, *is changed before it is assigned to* a_{i-1}.

8. *The case of an* a_i *being a procedure identifier is only used in defining functions. (See* 'PROCEDURE' *declaration, function definition.)*

EXAMPLES:

In these examples, A, B, C, and D identify 'REAL' *type variables. R and S identify* 'INTEGER' *type variables, and W identifies a* 'BOOLEAN' *type variable.*

1. A←B+C — *The value of B + C is assigned to A.*

2. `A←D←B+C`

   The value of B + C is assigned to A and D.

3. `A←R←3.9`

   4 is assigned to R and A.

4. `R←A←3.9`

   3.9 is assigned to A and 4 is assigned to R.

5. `J←1;`
   `S[J]←J←2`

   First, 1 is assigned to J. Then 2 is assigned to J and S[1].

6. `W←A 'GR' B`

   If the value of A is greater than the value of B, W is assigned the value 'TRUE' *otherwise, W is assigned the value* 'FALSE'.

'IF' *clause*

PURPOSE: *To permit a choice to be made as to which of two expressions is to be evaluated, based on the value of a Boolean expression; to assign the value of the evaluated expression to one or more variables or procedure identifiers.*

FORM: $a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow$ 'IF' b 'THEN' e_1 'ELSE' e_2

$a_1, a_2, \ldots, a_n$: *variable, subscripted variable or procedure identifier*

b: *Boolean expression*

e_1, e_2: *arithmetic or Boolean expression*

RULES:

1. *Subscripts, if any, occurring in the variables* $a_1, a_2, \ldots, a_n$ *are evaluated from left to right.*

2. *The Boolean expression "b" is evaluated.*

3. *If the value of b is* 'TRUE' *expression* e_1 *is evaluated; if* 'FALSE' e_2 *is evaluated.*

4. *After* e_1 *or* e_2 *is evaluated, this statement operates as a simple assignment statement with the evaluated expression.*

EXAMPLES:

1. P←'IF' Q 'LS' 10.0 'THEN' R 'ELSE' S + 17.5

   If Q<10, P receives the value of R, otherwise S + 17.5.

2. A←B←C←'IF' D 'THEN' E
   'OR' F 'ELSE' G 'AND' H

If D is true, the value of E 'OR' *F is assigned to A, B and C. Otherwise, the value of G* 'AND' *H is assigned.*

PURPOSE: *To permit a choice to be made as to which of three expressions is to be evaluated, based on the values of two Boolean expressions; to assign the value of the evaluated expression to one or more variables or procedure identifiers.*

FORM: $a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_n \leftarrow$ 'IF' b_1 'THEN' e_1 'ELSE' 'IF' b_2 'THEN' e_2 'ELSE' e_3

$a_1, a_2, \ldots, a_n$: *variable, subscripted variable or procedure identifier*

b_1, b_2: *Boolean expression*

e_1, e_2, e_3: *arithmetic or Boolean expression*

RULES:

1. *Subscripts, if any, occurring in the variables $a_1, a_2, \ldots, a_n$ are evaluated from left to right.*

2. *The Boolean expression "b_1" is evaluated.*

3. *If b_1 is true, e_1 is evaluated; if b_1 is false, b_2 is evaluated.*

4. *If b_2 is true, e_2 is evaluated; if b_2 is false, e_3 is evaluated.*

5. *After an expression is evaluated this statement operates as a simple assignment statement with the evaluated expression.*

EXAMPLES:

1.
```
R←'IF' T 'THEN' B-6.2 'ELSE'
  'IF' U 'THEN' C-7 'ELSE' D%3.5
```

If T is true R is assigned the value of B-6.2. If T is false and U is true, C-7 is assigned to R. Otherwise, D%3.5 is assigned to R.

Assignment, n
'IF' clauses

PURPOSE: *To permit a choice to be made as to which of a number of expressions is to be evaluated, based on the value of Boolean expressions; to assign the value of the evaluated expression to one or more variables or procedure identifiers.*

FORM:

$a_1 \leftarrow a_2 \leftarrow \ldots \leftarrow a_m \leftarrow$ 'IF' b_1 'THEN' e_1 'ELSE' 'IF'
b_2 'THEN' e_2 'ELSE' ... 'IF' b_n 'THEN' e_n 'ELSE' e_{n+1}

$a_1, a_2, \ldots, a_m$: *variable, subscripted variable or procedure identifier*

$b_1, b_2, \ldots, b_n$: *Boolean expression*

$e_1, e_2, \ldots, e_{n+1}$: *arithmetic or Boolean expression*

RULES:

1. *Subscripts, if any, occurring in the variables $a_1, a_2, \ldots, a_n$ are evaluated from left to right.*

2. *The Boolean expressions $b_1, b_2, \ldots, b_n$ are evaluated from left to right until one is found which has a value of* 'TRUE'.

3. *If b_i is found to be true, then e_i is evaluated.*

4. *If all the Boolean expressions are false, e_{n+1} will be evaluated.*

5. *After step 3 or 4 above, this statement operates as a simple assignment statement with the evaluated expression.*

EXAMPLE:

```
C←D[4,2,2] ← 'IF' B 'OR' E
'THEN' 5 'ELSE' 'IF' T 'THEN' 7.5
'ELSE' 'IF' A 'LS' C 'THEN' G
'ELSE' L
```

C and D [4,2,2] may be assigned the following values: 5 if either B or E is true; 7.5 if T is true; the value of G if the value of A is less than the value of C; the value of L if none of the above conditions are true.

Conditional Statements

Conditional,
simple

PURPOSE: *To permit a statement to be executed or skipped depending on the value of a Boolean expression.*

FORM: 'IF' *b* 'THEN' *s*

b: *Boolean expression*
s: *statement*

RULES:

1. *Statement s may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *dummy statement*
   d. 'FOR' *statement*
   e. *procedure statement*
   f. *compound statement*
   g. *block*

2. *Statement s may have a label.*

3. *If the Boolean expression has a value of* 'TRUE', *statement s is executed. If s does not explicitly specify its successor the statement following will be executed next.*

4. *If the Boolean expression has a value of* 'FALSE', *statement s is skipped and the following statement will be executed next.*

EXAMPLES:

1.
```
'IF' A 'GR' B 'THEN' D←E*F
```
*If the value of A is greater than the value of B, then the value of E*F is assigned to D. Otherwise, the assignment statement is skipped and the statement following it is executed.*

2.
```
'IF' L 'THEN' 'BEGIN' P←P+3;
R←17.5-T; L←'FALSE' 'END';
'GO TO' S9
```
If L is true the compound statement enclosed between 'BEGIN' *and* 'END' *will be executed; followed by* 'GO TO' *S9; if L is false only* 'GO TO' *S9 will be executed.*

Conditional,
'ELSE'

PURPOSE: *To permit a choice to be made as to which one of two specified statements is to be executed. The decision is based on the value of a Boolean expression.*

FORM: 'IF' *b* 'THEN' s_1 'ELSE' s_2

b: *Boolean expression*

s_1, s_2: *statement*

RULES:

1. *The statements* s_1 *and* s_2 *may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *procedure statement*
   d. *dummy statement*
   e. *compound statement*
   f. *block*

2. *Statement* s_2 *may also be a* 'FOR' *statement.*

3. *Statements* s_1 *and* s_2 *may be labelled.*

4. *If the Boolean expression has a value of* 'TRUE', *statement* s_1 *is executed. If* s_1 *does not explicitly specify its successor, then the statement following the conditional statement is executed next, i.e.* s_2 *is skipped.*

5. *If the Boolean expression has a value of* 'FALSE', *statement* s_2 *is executed. If* s_2 *does not explicitly specify its successor the statement following the conditional statement is executed next.*

EXAMPLES:

1.
```
'IF' A 'LS' B 'THEN'
T←T+1 'ELSE' B←B+1;
'GO TO' L1
```

If A is less than B T←T+1 is executed, followed by 'GO TO' *L1. If A is greater than or equal to B, B←B+1 is executed, followed by* 'GO TO' *L1.*

2.
```
'IF' R 'AND' S 'THEN' 'GO TO'
BOB 'ELSE' JOE: M←N+P; 'GO TO'
BOB
```

If the expression is true, control is transferred to the statement labelled BOB; if false, the statement labelled JOE is executed and then control goes to the statement labelled BOB.

Conditional, two 'IF' clauses

PURPOSE: *To permit a choice to be made as to which of two statements is to be executed or whether neither is to be executed, depending on the values of two Boolean expressions.*

FORM: 'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2

b_1, b_2: *Boolean expression*
s_1, s_2: *statement*

RULES:

1. *Statements* s_1 *and* s_2 *may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *dummy statement*
   d. *procedure statement*
   e. *compound statement*
   f. *block*

2. *Statement* s_2 *may also be a* 'FOR' *statement.*

3. *Statements* s_1 *and* s_2 *may be labelled.*

4. *If* b_1 *has a value of* 'TRUE', *statement* s_1 *is executed. If* s_1 *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

5. *If* b_1 *has a value of* 'FALSE', b_2 *is evaluated.*

6. *If* b_2 *has a value of* 'TRUE', *statement* s_2 *is executed. If* s_2 *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

7. *If* b_2 *has a value of* 'FALSE', *then* s_2 *is skipped and the statement following the complete conditional statement is executed next.*

EXAMPLE:

```
'IF' A 'EQ' B 'THEN' MODE (C,D)
'ELSE' 'IF' A 'GR' B 'THEN' MEAN
(T,D); R←D*F
```

*If A=B, procedure MODE is executed, followed by R←D*F. If A≠B but A>B, then procedure MEAN is executed followed by R←D*F. If A<B, then only R←D*F is executed.*

Conditional, two 'IF' *clauses,* 'ELSE'

PURPOSE: *To permit a choice to be made as to which of three statements is to be executed depending upon the value of two Boolean expressions.*

FORM: 'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' s_3

b_1, b_2: *Boolean expression*
s_1, s_2, s_3: *statement*

RULES:

1. *Statements* s_1, s_2, *and* s_3 *may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *dummy statement*
   d. *procedure statement*
   e. *compound statement*
   f. *block*

2. *Statement* s_3 *may also be a* 'FOR' *statement.*

3. *Statements* s_1, s_2 *and* s_3 *may be labelled.*

4. *If* b_1 *has a value of* 'TRUE', *statement* s_1 *is executed. If* s_1 *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

5. *If* b_1 *is false,* b_2 *is evaluated.*

6. *If* b_2 *has a value of* 'TRUE', *statement* s_2 *is executed. If* s_2 *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

7. *If* b_2 *has a value of* 'FALSE', *statement* s_3 *is executed. If* s_3 *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

EXAMPLE:

```
'IF' L 'THEN' 'GO TO' BOY 'ELSE'
'IF' R 'GR' S 'THEN' 'BEGIN'
A←A+1; CALC (F,10) 'END' 'ELSE'
'GO TO' CAT; R←R+1
```

If L is true, control goes to the statement labelled BOY; if L is false, R is compared to S; if R>S, the compound statement is executed followed by R←R+1. If R≤S, control goes to the statement labelled CAT.

Conditional, n
'IF' clauses

PURPOSE: *To permit a choice to be made among a number of statements as which one should be executed, or whether none is to be executed, depending upon the value of Boolean expressions.*

FORM:

'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' ...
'IF' b_{n-1} 'THEN' s_{n-1} 'ELSE' 'IF' b_n 'THEN' s_n

$b_1, b_2, \ldots, b_n$: *Boolean expression*
$s_1, s_2, \ldots, s_n$: *statement*

RULES:

1. *Each statement* $s_1, s_2, \ldots, s_n$ *may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *dummy statement*
   d. *procedure statement*
   e. *compound statement*
   f. *block*

2. *Statement* s_n *may be a* 'FOR' *statement.*

3. *Statements* $s_1, s_2, \ldots, s_n$ *may be labelled.*

4. *The Boolean expressions are evaluated in the order* $b_1, b_2, \ldots,$ *until one having a value of* 'TRUE' *is found. If* b_i *is true, statement* s_i *is executed. If statement* s_i *does not explicitly specify its successor, the statement following the conditional statement is executed next.*

5. *If none of the Boolean expressions is true, the statement following the complete conditional statement is executed next.*

EXAMPLE:

```
'IF' M 'THEN' A←A+1 'ELSE'
'IF' N 'THEN' 'GO TO' R1 'ELSE'
'IF' P 'THEN'
'FOR' 1←1 'STEP' 1 'UNTIL' 10 'DO'
A[I] ←I; L←M 'OR' P
```

If M is true, the value of A is increased by 1. If M is false and N is true, then 'GO TO' *R1 is executed. If M and N are false and P is true, the* 'FOR' *statement is executed. If M, N and P are all false, the statement L←M* 'OR' *P is executed.*

Conditional, n 'IF' *clauses,* 'ELSE'

PURPOSE: *To permit a choice to be made among a number of statements as to which one should be executed depending upon the value of Boolean expressions.*

FORM:

'IF' b_1 'THEN' s_1 'ELSE' 'IF' b_2 'THEN' s_2 'ELSE' ...
'IF' b_{n-1} 'THEN' s_{n-1} 'ELSE' s_n

$b_1, b_2, \ldots, b_{n-1}$: *Boolean expression*
$s_1, s_2, \ldots, s_n$: *statement*

RULES:

1. *Each statement* $s_1, s_2, \ldots, s_n$ *may be any one of the following:*
   a. *assignment statement*
   b. 'GO TO' *statement*
   c. *dummy statement*
   d. *procedure statement*
   e. *compound statement*
   f. *block*

2. *Statement* s_n *may be a* 'FOR' *statement.*

3. *Statements* $s_1, s_2, \ldots, s_n$ *may be labelled.*

4. *The Boolean expressions are evaluated in the order* $b_1, b_2, \ldots$, *until one having a value of* 'TRUE' *is found. If* b_i *is true, statement* s_i *is executed. If statement* s_i *does not explicitly specify its successor, the statement following the complete conditional statement is executed next.*

5. *If none of the Boolean expressions is true, statement* s_n *will be executed. If it does not explicitly specify its successor, the statement following the conditional statement is executed next.*

EXAMPLE:

```
'IF' A 'THEN' I←I+1 'ELSE'
'IF' B 'THEN' J←J+1 'ELSE'
'IF' C 'THEN' K←K+1 'ELSE'
L←L+1;
'IF' D 'THEN' 'GO TO' BAD
```

If A is true, the value of I is increased by one. If A is false and B is true, the value of J is increased by one. If A and B are false and C is true, the value of K is increased by one. If A, B and C are false, the value of L is increased by one. If D is true then 'GO TO' *BAD is executed. Otherwise, the statement following it is executed.*

Dummy Statement

PURPOSE: *To place a label at a particular point in the program.*

FORM: *(null form)*

RULES:

1. *This statement causes no operation.*

EXAMPLES:

1. `COUNT:;` — *COUNT is the label of a dummy statement.*

2. `B3: ; ABC:`
   `E←E+1` — *B3 is the label of a dummy statement.*

3. `'BEGIN'...;`
   `TOY: 'END'` — *TOY is the label of a dummy statement.*

'FOR' *Statements*

PURPOSE: *To permit a statement to be executed for a specified value of a controlled variable.*

FORM: 'FOR' *v*←*e* 'DO' *s*

v: *variable or subscripted variable*
e: *arithmetic expression*
s: *statement*

RULES:

1. *Variable v is called the controlled variable of the* 'FOR' *statement.*

2. *e represents a value which is assigned to v.*

3. *Statement s may be a simple statement, a compound statement or a block.*

4. *The* 'FOR' *statement causes the expression e to be evaluated and its value assigned to v. Then statement s is executed.*

5. *After statement s is executed with v having the value of e, the* 'FOR' *statement has been executed. If s does not explicitly specify its successor, the statement following the* 'FOR' *statement is executed next.*

6. *After execution of the* 'FOR' *statement, the value of v is undefined.*

7. *If control is transferred from the* 'FOR' *statement by a statement (within statement s), the value of v is available.*

8. *A* 'GO TO' *statement outside the* 'FOR' *statement may not refer to a label within the* 'FOR' *statement.*

EXAMPLES:

1. `'FOR' J←I 'DO' A[J]←0.0`

   This statement causes zero to be assigned to location A[I].

2. `'FOR' R←2*BOY↑ 2 'DO'`
   `'BEGIN' T←T+1; B[R]←-C[R]`
   `'END'`

   This statement results in -C[2 BOY↑ 2] assigned to B[2*BOY↑ 2]. Also, the value of T is increased by one.*

'FOR', 'STEP' *clause*

PURPOSE: *To permit a statement to be executed repeatedly for a specified initial value, increment and final value of a controlled variable.*

FORM: 'FOR' $v \leftarrow e_1$ 'STEP' e_2 'UNTIL' e_3 'DO' s

v: *variable or subscripted variable*
e_1, e_2, e_3: *arithmetic expression*
s: *statement*

RULES:

1. *Variable v is called the controlled variable of the* 'FOR' *statement.*

2. e_1 *represents the initial value for v;* e_2 *is the increment of v;* e_3 *is the final value for v.*

3. *Statement s may be a simple statement, a compound statement or a block.*

4. *The first step in the operation of the* 'FOR' *statement is that v is assigned the value of* e_1.

5. *Statement s may be executed a number of times as follows:*
   a. *A test is made to see if the value of v is beyond the bound specified by* e_3. *If it is, statement s will not be executed. The statement after s is executed next and the value of v is undefined.*

b. If v is within the bound, statement s is executed.

c. If s does not explicitly specify its successor, the value e_2 is then added to v (i.e. v←v+e_2). If the value of e_2 is positive, this will have the effect of increasing v. If the value of e_2 is negative, v will be reduced. The process is then repeated at step a.

6. If control is transferred from the 'FOR' *statement by a statement (within statement s), the value of v is available.*

7. The value of the controlled variable, the increment and the final value may be changed by statement s. Therefore, they are evaluated every time reference is made to them.

8. A 'GO TO' *statement outside a* 'FOR' *statement may not refer to a label within the* 'FOR' *statement.*

EXAMPLES:

1.
```
'FOR' I←1 'STEP' 1 'UNTIL'
10 'DO' A[I]←B[I]
```
These statements cause B[1] to B[10] to be assigned to A[1] to A[10].

2.
```
'FOR' K←9 'STEP' -2 'UNTIL'
5 'DO' X[K]←K↑2
```
These statements cause 81 to be assigned to X[9], 49 to be assigned to X[7], and 25 to be assigned to X[5].

3.
```
'FOR' L←1 'STEP' 1 'UNTIL' 5
'DO' 'BEGIN'
'FOR' A[L]←6 'STEP' 1 'UNTIL'
10 'DO' B[A[L],L]←L
'END'
```

The order of assignments caused by these statements is as follows:
6 to 10 is assigned to A[1]
as 1 is assigned to B[6,1]
to B[10,1],
6 to 10 is assigned to A[2]
as 2 is assigned to B[6,2]
to B[10,2], etc.
Finally,
6 to 10 is assigned to A[5]
as 5 is assigned to B[6,5]
to B[10,5].

'FOR', 'WHILE' *clause*

PURPOSE: *To permit a statement to be executed repeatedly for assigned values of a controlled variable with repetition controlled by the value of a Boolean expression.*

FORM: 'FOR' *v* ← *e* 'WHILE' *b* 'DO' *s*

v: *variable or subscripted variable*
e: *arithmetic expression*
b: *Boolean expression*
s: *statement*

RULES:

1. *Variable v is called the controlled variable of the* 'FOR' *statement.*

2. *Statement s may be a simple statement, a compound statement or a block.*

3. *This statement causes statement s to be executed repeatedly as long as the value of the Boolean expression b is true.*

4. *This statement operates as follows:*
   a. *e is evaluated and its value is assigned to v.*
   b. *The Boolean expression b is evaluated.*
   c. *If b is true, statement s is executed. If s does not explicitly specify its successor, the process is repeated at step a.*
   d. *If b is false, statement s is not executed and the statement following statement s is executed next. The value of v is undefined in this case.*

5. *If control is transferred from the* 'FOR' *statement by a* 'GO TO' *statement (within statement s), the value of v is available.*

6. *The values of either e or b may be changed by statement s.*

7. *A* 'GO TO' *statement outside a* 'FOR' *statement may not refer to a label within the* 'FOR' *statement.*

EXAMPLE:

```
J←1;
'FOR' I←J 'WHILE' I 'LS' 10 'DO'
'BEGIN'
   A[I]←I;
   J←J+1
'END'
```

These statements cause 1 to 9 to be assigned to A[1] to A[9].

'FOR'

general

PURPOSE: *To permit a statement to be executed repeatedly for various conditions governing a controlled variable.*

FORM: 'FOR' $v \leftarrow a_1, a_2, \ldots, a_n$ 'DO' s

v: *variable or subscripted variable*

$a_1, a_2, \ldots, a_n$: *arithmetic expression,* 'STEP' *clause, or* 'WHILE' *clause*

s: *statement*

RULES:

1. *Variable v is called the controlled variable of the* 'FOR' *statement.*

2. $a_1, a_2, \ldots, a_n$ *may be any combination of arithmetic expressions,* 'STEP' *clauses, or* 'WHILE' *clauses.*

3. *s may be a simple statement, a compound statement or a block.*

4. *If* a_i *is an arithmetic expression, a* 'STEP' *clause or a* 'WHILE' *clause, the* 'FOR' *statement operates as previously described. The order of operation is* $a_1, a_2, \ldots, a_n$.

EXAMPLE:

```
'FOR' X←3, 2 'STEP' 1 'UNTIL' 5,
70, 60, A 'WHILE' Z, 80 'DO'
P(X)
```

First, 3 is assigned to X and procedure P(X) is executed.

Then the 'STEP' *clause causes the following action: 2 is assigned to X and P(X) is executed. X is stepped by 1 three times causing it to assume the values 3, 4 and 5. P(X) is executed after each step of X. Next, X is assigned the value 70, and P(X) is executed.*

Then X is assigned the value 60, and P(X) is executed.

The 'WHILE' *clause causes the value of A to be assigned to X. If Z is true, P(X) is executed. This is repeated until Z becomes false. (The values of A and Z may be changed by execution of P(X)).*

Finally, 80 is assigned to X and P(X) is executed.

'GO TO' *Statements*

'GO TO',
label

PURPOSE: *To interrupt the normal sequence of statement execution by defining explicitly the successor of the current statement.*

FORM: 'GO TO' *a*

a: *statement label*

RULES:

1. *The statement* 'GO TO' *a causes control to go to the statement with label a.*

2. *A* 'GO TO' *statement outside a* 'FOR' *statement may not refer to a label within the* 'FOR' *statement.*

3. *A* 'GO TO' *statement outside a block may not refer to a label within that block.*

4. *A* 'GO TO' *statement outside a compound statement may refer to label within that compound statement.*

EXAMPLES:

1. 'GO TO' BOY

   This statement causes control to go to a statement labelled BOY.

2. 'GO TO' T12; M15: A←A+1;
   'IF' L 'THEN' 'BEGIN' C←D×E↑2;
   T12: A←B+C×F 'END'

   The 'GO TO' *statement causes control to go to a statement within a compound statement.*

'GO TO'
switch designator

PURPOSE: *To interrupt the normal sequence of statement execution by causing control to be transferred to one of a number of possible statements depending on the value of an arithmetic expression.*

FORM: 'GO TO' *sw* [*a*]

sw: *switch identifier*
a: *arithmetic expression*

RULES:

1. *The switch identifier "sw" must have been defined by a switch declaration in the current block or in an enclosing block.*

2. *The form sw [a] is called a switch designator.*

3. *The next statement to be executed is the one whose label is referenced through the switch declaration defining "sw".*

4. *This* 'GO TO' *statement operates as follows:*
   a. *The expression denoted by a is evaluated. From this value an integer k is established where k is the result of the function* ENTIER *(a + .5). That is, the largest integer not greater than the value of the argument, i.e., if a is 3.7, k=4.*
   b. *k specifies which element in the list of the switch declaration will be referenced, i.e., the leftmost element is numbered 1; the next is 2, etc.*

c. *If k is not within the range 1 to n (where n is the number of elements in the switch designator), control goes to the next statement in normal sequence.*

5. *A* 'GO TO' *statement outside a* 'FOR' *statement may not refer to a label within that* 'FOR' *statement.*

6. *A* 'GO TO' *statement outside a block may not refer to a label within that block.*

7. *A* 'GO TO' *statement outside a compound statement may refer to a label within that compound statement.*

EXAMPLE:

```
'BEGIN'
'SWITCH' AB←PB, QB;
'SWITCH' AC←PC, QC, AB[X];
 ...
'GO TO' AB[T];
 ...
'GO TO' AC[Y];
 ...
'END'
```

If T has the value 1 when the 'GO TO' *for switch AB is executed, control goes to the statement labelled PB. If T has the value 2, control goes to the statement labelled QB. If T has any other value, control goes to the statement following the* 'GO TO' *statement. When the* 'GO TO' *for switch AC is executed, control will go to statements labelled PC or QC if Y has the value one or two, respectively. If Y has the value three, then execution is equivalent to* 'GO TO' *AB[X]. If Y has any other value, control goes to the next sequential statement.*

'GO TO',
conditional designator

PURPOSE: *To interrupt the normal sequence of statement execution by causing control to be transferred to one of a number of possible statements; the statement chosen will depend on the value of a Boolean expression.*

FORM: 'GO TO' 'IF' *b* 'THEN' d_1 'ELSE' d_2

b: *Boolean expression*
d_1, d_2: *designational expression*

RULES:

1. *A designation expression* (d_1, d_2) *is any one of the following:*
   a. *Statement label*
   b. *Switch designator. This has the form sw[a], where sw represents a switch identifier and a represents an arithmetic expression.*
   c. *Conditional designator. This has the form*
      'IF' *b* 'THEN' *c* 'ELSE' *d*
      where b represents a Boolean expression;
      c may be either a statement label, a switch designator, or a conditional designator enclosed within parentheses;
      d may be either a statement label, a switch designator, or a conditional designator (not necessarily enclosed within parentheses).

2. *This statement operates as follows:*
   a. *The Boolean expression b is evaluated;*
   b. *If b is true, control is transferred as specified by* d_1*;*

c. *If the Boolean expression b is false, control is transferred as specified by* d_2.

3. *A* 'GO TO' *statement outside a* 'FOR' *statement may not refer to a label within that* 'FOR' *statement.*

4. *A* 'GO TO' *statement outside a compound statement may refer to a label within that compound statement.*

EXAMPLES:

1.	'GO TO' 'IF' A 'THEN' B 'ELSE' C[I]	*If the Boolean expression A is true, control goes to the statement labelled B. Otherwise, control goes to the statement referenced by the Ith item in the switch declaration defining C.*
2.	'GO TO' 'IF' BA 'THEN' LA 'ELSE' 'IF' BB 'THEN' LB 'ELSE' LC	*If the Boolean expression BA is true, control goes to the statement labelled LA. If expression BA is false and Boolean expression BB is true, control goes to the statement labelled LB. If both expressions BA and BB are false, control goes to the statement labelled LC. (Note:* d_1 *in this case is a statement label while* d_2 *is a conditional designator.)*

3. 'GO TO' 'IF' BA 'THEN' ('IF' BB 'THEN' LB 'ELSE' LC) 'ELSE' LA	*If both BA and BB are true, control goes to the statement labelled LB. If BA is true and BB is false, control goes to the statement labelled LC. If BA is false, control goes to the statement labelled LA. (Note: d_1 is a conditional designator and, therefore, must be enclosed in parentheses.)*

Procedure Statement

PURPOSE: *To call for the execution of a procedure defined by a* 'PROCEDURE' *declaration.*

FORM:

(1) *name*

(2) *name* $(a_1\ t\ a_2\ t\ \ldots\ t\ a_n)$

name: *procedure identifier*

$a_1, a_2, \ldots, a_n$: *actual parameter*

t: *separator*

RULES:

1. *A procedure statement may have no parameters as shown in FORM (1).*

2. *When there are parameters (FORM (2)), each separator t may be either "," or ")b:(" where b is only descriptive, i. e., it may be used as comments to describe actual parameters. b has no operational significance.*

3. *The procedure identifier must appear in a procedure declaration.*

4. *The number of actual parameters must be the same as the number of formal parameters in the procedure declaration. However, the method of parameter separation need not be the same in a procedure statement and the corresponding declaration. That is, where a comma was used in a procedure statement, the form ")b:(" may be used in the declaration and vice versa.*

5. *The actual parameters may be any one of the following:*
   a. *arithmetic expression*
   b. *Boolean expression*
   c. *string*
   d. *array identifier*
   e. *switch identifier*
   f. *procedure identifier*
   g. *designational expression*

6. *The correspondence between the actual parameters of the procedure statement and the formal parameters of the procedure declaration is by their appearance in the respective parameter lists. The two sets of parameters must have the same number of items.*

7. *The execution of a procedure statement is as follows:*
   a. *The formal parameters which appear in a value list of the procedure declaration are replaced by the values of the corresponding actual parameters.*
   b. *These actual parameters are evaluated from left to right according to their appearance in the parameter list.*
   c. *Formal parameters which are not part of a value list are replaced throughout the procedure by the corresponding actual parameters.*
   d. *If the identifier of an actual parameter and an identifier already in the procedure are the same, adjustments will automatically be made to the latter so that no conflicts occur.*
   e. *After the procedure has been modified as above, it is executed.*

8. *If an actual parameter is a string, it may only be used in a procedure written in non-ALGOL code. In an ALGOL procedure, a string may appear only as an actual parameter for a further procedure call.*

9. *An actual parameter corresponding to a formal parameter which appears on the left side of an assignment statement in the procedure must be a variable or a subscripted variable.*

10. *If a formal parameter is an array identifier, the corresponding actual parameter must also be an array identifier of the same dimension.*

11. *A switch identifier or string may not be an actual parameter corresponding to a formal parameter which is called by value. A procedure identifier may not be used as a value parameter unless it designates a function with no arguments.*

EXAMPLES:

1. HIGHVAL (Z, P**(P+1)/2 , V, I)

   The procedure which this statement calls is defined in the section 'PROCEDURE' *declaration, simple. In this procedure statement Z denotes the number of elements. The value of the largest element of Z will be found in V after the procedure call, and I will contain the value of the subscript of the largest element.*

2. SQUAREROOT (A↑2+B↑2, .000001, C)

The procedure which this statement calls is defined in the section 'PROCEDURE' *declaration, specification part. After this procedure statement is executed, C will contain the square root of* A^2+B^2 *with an accuracy of .000001.*

3. TOT (X, A, 1, N, 1/A×(A+1)

The procedure which this statement calls is defined in the section 'PROCEDURE' *declaration, value and specification part. This procedure statement will result in the following computation:*

$$X = \sum_{A=1}^{N} 1/A(A+1)$$

4. SUM←ADD (A, I, N) FUNCTION: (1/A×(A+1))

The procedure which this statement calls is defined in the section 'PROCEDURE' *declaration, function definition. This function call will result in the summation of example 3 in ADD and in SUM. The symbol FUNCTION is used as text and has no operational significance.*

5. SUM←ADD(P,Q,N×(N+1),
   ADD(Q,1,N,P/Q))

This statement results in the value of the following computation placed in ADD and in SUM:

$$\sum_{P=Q}^{N(N+1)} \sum_{Q=1}^{N} P/Q$$

This is an example of a recursive procedure call.

V. DECLARATIONS

'ARRAY' *Declarations*

PURPOSE: *To specify array identifiers, dimensions, bounds of subscripts and array types.*

FORM: *type* 'ARRAY' $a_1, a_2, \ldots, a_n$

type: *type word*

$a_1, a_2, \ldots, a_n$: *array specifier*

RULES:

1. *The type word may be any one of the following:*
   a. 'INTEGER'
   b. 'REAL'
   c. 'EXTENDED REAL'
   d. 'BOOLEAN'

2. *Type is optional. If it is not used,* 'REAL' *is assumed. The type is assigned to each array identifier in the declaration.*

3. *An array specifier may be either of the form b or b[c], where b represents an array identifier and c represents a dimension specifier. A dimension specifier has the form* d_1: e_1, d_2: $e_2, \ldots,$ d_n: e_n, *where each* d_i *and* e_i *may be an arithmetic expression. n is the number of dimensions.* d_i *and* e_i *represent the lower and upper subscript bounds of dimension i, respectively. The value of a lower bound may not exceed the value of an upper bound.*

4. *If an array identifier does not have a dimension specifier, the next dimension specifier is assigned. That is, the form* $b_1,b_2,\ldots,b_m$ $[d_1: e_1, d_2: e_2,\ldots,d_n: e_n]$ *is equivalent to the form* b_1 $[d_1: e_1, d_1: e_2,\ldots,d_n: e_n]$, b_2 $[d_1: e_1, d_2: e_2,\ldots,d_n: e_n]$, ... b_m $[d_1: e_1, d_2: e_2,\ldots,d_n: e_n]$.

5. *Lower and upper bounds will be evaluated from left to right. The bounds can only depend on variables and procedures which have been defined in a block enclosing the block for which the array declaration is valid. Consequently, in the outermost block of a program, only array declarations with constant bounds may be used.*

6. *The bounds will be evaluated each time the block is entered.*

7. *Every array used in a program must appear in an array declaration.*

8. *An array identifier may not appear with subscripts whose values do not lie within the bounds specified by the array declaration.*

EXAMPLES:

1. 'ARRAY' A[1:10]

   The array A is one-dimensional and has a lower subscript bound of 1 and an upper subscript bound of 10. A is assumed to be of 'REAL' *type.*

2. 'ARRAY' A,B [1:10,1:20]

Arrays A and B are two dimensional and have subscript bounds 1 and 10 and 1 and 20. The arrays are assumed to be 'REAL' *type.*

3. 'INTEGER' 'ARRAY' A[P:Q], B [1:2*P, 3:5, 1:5]

The array A is of 'INTEGER' *type and has subscript bounds P and Q. B is of* 'INTEGER' *type and is three dimensional. The bounds of the dimensions and 1 and 2*P, 3 and 5, and 1 and 5 respectively.*

'ARRAY',
'OWN'

PURPOSE: *To specify array identifiers, dimensions, bounds of subscripts and array types; also to specify the condition of arrays upon re-entry into a block.*

FORM: 'OWN' *type* 'ARRAY' $a_1, a_2, \ldots, a_n$

type: *type word*
$a_1, a_2, \ldots, a_n$: *array specifier*

RULES:

1. *The array specifiers may be in any of the forms permissible for the array declaration.*

2. *All the Rules which pertain to array declarations are valid for the* 'OWN' *array declaration except:*
   a. *On re-entry into the block in which the* 'OWN' *array declaration appears the array elements will have their previous values.*
   b. *The subscript bounds must be integer constants.*

3. *When exit is made from the block (by* 'END' *or by a* 'GO TO' *statement), the identifiers are inaccessible even though their values have been saved.*

EXAMPLE:

```
'OWN' 'BOOLEAN' 'ARRAY'
BA[1:20, 5:15, 1:10]
```

The array BA is three dimensional and is of 'BOOLEAN' *type. The bounds of the dimensions are 1 and 20, 5 and 15, and 1 and 10, respectively.*

'PROCEDURE' *Declarations*

PURPOSE: *To define a statement or series of statements as being associated with a procedure identifier; to provide a means by which a procedure may be executed any number of times in the course of a program although the steps of the procedure appear only once.*

FORM:

1) 'PROCEDURE' *name; s*
2) 'PROCEDURE' *name* $(a_1\ t\ a_2\ t\ \ldots\ t\ a_n)$; *s*

name: *procedure identifier*
$a_1, a_2, \ldots, a_n$: *formal parameter*
t: *separator*
s: *statement*

RULES:

1. *A procedure declaration may have no parameters as shown in FORM (1).*

2. *When there are parameters (FORM (2)), each separator t may be either "," or ")b:(" where b represents any sequence of letters. The function of b is only descriptive, i.e., it may be used as comments to describe actual parameters. b has no operational significance.*

3. *The formal parameters may be any of the following:*
   a. *variable*
   b. *array identifier*
   c. *switch identifier*
   d. *label*
   e. *procedure identifier*

4. *The formal parameters usually appear somewhere in statement s. They will be replaced by or assigned the values of the actual parameters of the particular procedure statement which calls the procedure.*

5. *Statement s may be*
   a. *a simple statement*
   b. *a compound statement*
   c. *a block*

6. *Identifiers which are not formal parameters may appear in s if either of the following conditions exists:*
   a. *s is in the form of a block and the identifiers are declared at the beginning of this block.*
   b. *the identifiers are declared in the block in which the procedure declaration appears.*

7. *Statement s always acts like a block insofar as the scope of its identifiers is concerned, i.e., a label appearing in s is not defined outside the procedure declaration.*

8. *The procedure specified may be executed anywhere in the block in which the declaration appears by writing a procedure statement containing the procedure identifier and the actual parameters, if any.*

EXAMPLE:

```
'PROCEDURE' HIGHVAL (A,N) ANS:(X,Y);
   'BEGIN'
      X←A[1]; Y←1;
      'FOR' I←2'STEP' 1 'UNTIL' N 'DO'
      'IF' A[I] 'GR' X 'THEN'
           'BEGIN'
              X←A[I]; Y←I
           'END'
   'END'
```

This procedure determines the largest element of an array. Input formal parameters are: array identifier A and number N of elements. Output formal parameters are: value X of largest element and value Y of subscript of largest element. The symbol ANS is used as text and has no operational significance.

PURPOSE: *To define a statement or series of statements as being associated with a procedure identifier; to provide a means by which a procedure may be executed any number of times in the course of a program although the steps of the procedure appear only once; to specify the kinds of quantities actual parameters may represent.*

FORM:

'PROCEDURE' *name* (a_1 *t* a_2 *t ... t* a_n)
sp list; sp list;...; sp list; s

name: *procedure identifier*
$a_1, a_2, \ldots, a_n$: *formal parameter*
t: *separator*
sp: *specifier*
list: *formal parameters separated by commas*
s: *statement*

RULES:

1. *Each separator t may be either "," or ")b:(" where b represents any sequence of letters. The function of b is only descriptive, i.e., it may be used as comments to describe actual parameters. b has no operational significance.*

2. *The formal parameters may be any of the following:*
   a. *variable*
   b. *array identifier*
   c. *label*
   d. *switch identifier*
   e. *procedure identifier*

3. *The formal parameters usually appear somewhere in statement s. They are replaced at the time of execution by the actual parameters of the procedure statement.*

4. *The specifiers may be any of the following:*

'ARRAY'
'BOOLEAN'
'BOOLEAN' 'ARRAY'
'BOOLEAN' 'PROCEDURE'
'EXTENDED REAL'
'EXTENDED REAL' 'ARRAY'
'EXTENDED REAL' 'PROCEDURE'
'INTEGER'
'INTEGER' 'ARRAY'
'INTEGER' 'PROCEDURE'
'LABEL'
'PROCEDURE'
'REAL'
'REAL' 'ARRAY'
'REAL' 'PROCEDURE'
'STRING'
'SWITCH'

5. *The specifiers indicate for the parameters in their "list" what form the corresponding actual parameters should take. (Note:* 'INTEGER', 'REAL', *and* 'EXTENDED REAL' *may be used interchangeably and the proper transformations will take place automatically.)*

6. *A formal parameter may appear in no more than one "list." However, a formal parameter need not appear in a "list," except for switches which must be specified.*

---

7. *Statement s may be*
   a. *a simple statement*
   b. *a compound statement*
   c. *a block*

8. *Identifiers which are not formal parameters may appear in s if either of the following conditions exists:*
   a. *s is a block and the identifiers are declared at the beginning of this block.*
   b. *the identifiers are declared in the block in which the procedure declaration appears.*

9. *Statement s always acts like a block insofar as the scope of its identifiers is concerned, i.e., a label appearing in s is not defined outside the procedure declaration.*

10. *The procedure specified may be executed anywhere in the block in which the declaration appears by writing a procedure statement containing the procedure identifier and the actual parameters.*

EXAMPLE:

```
'PROCEDURE' SQUAREROOT (X,E,S);
'REAL' X, E, S;
'BEGIN' 'REAL' SA;
   'IF' X 'LS' 0 'THEN'
   'BEGIN' S←-1; 'GO TO' B 'END';
   SA←1;
   A: S←(SA+X/SA)/2;
   'IF' ABS(SA-S) 'GR' E 'THEN'
      'BEGIN' SA←S; 'GO TO' A 'END';
B: 'END'
```

This procedure computes the square root. Input formal parameters are: number X whose square root is wanted and accuracy E. Output formal parameter is square root S of X.

'PROCEDURE' *declaration, value and specification part*

PURPOSE: *To define a statement or series of statements as being associated with a procedure identifier; to provide a means by which a procedure may be executed any number of times in the course of a program although the steps of the procedure appear only once; to specify which formal parameters are replaced by the value of the corresponding actual parameters; to specify the kinds of quantities actual parameters may represent.*

FORM:

'PROCEDURE' *name* (a_1 *t* a_2 *t* ... *t* a_n)
'VALUE' *list;*
sp list; sp list;...; sp list; s

name: procedure identifier
$a_1, a_2, \ldots, a_n$: formal parameter
t: separator
sp: specifier
s: statement
list: formal parameters separated by commas

RULES:

1. *Each separator t may be either "," or ")b:(" where b represents any sequence of letters. The function of b is only descriptive, i.e., it may be used as comments to describe actual parameters. b has no operational significance.*

2. *The formal parameters may be any of the following:*
   a. *variable*
   b. *array identifier*
   c. *label*
   d. *switch identifier*
   e. *procedure identifier*

3. *The formal parameters usually appear somewhere in statement s. They are replaced at the time the proceudre is called upon by the actual parameters of the procedure statement.*

4. *However those formal parameters which are listed in the* 'VALUE' *part of the declaration are assigned the current values of the corresponding actual parameters before statement s is executed. The order of assignment is from left to right according to the order of appearance in the formal parameter list.*

5. *The specifier may be any of the following:*

'ARRAY'	'INTEGER' 'ARRAY'
'BOOLEAN'	'INTEGER' PROCEDURE'
'BOOLEAN' 'ARRAY'	'LABEL'
'BOOLEAN' 'PROCEDURE'	'PROCEDURE'
'EXTENDED REAL'	'REAL'
'EXTENDED REAL' 'ARRAY'	'REAL' 'ARRAY'
'EXTENDED REAL' 'PROCEDURE'	'REAL' 'PROCEDURE'
'INTEGER'	'STRING'
	'SWITCH'

6. *The specifiers indicate, for the parameters in their list, what form the corresponding actual parameters should take. (Note:* 'INTEGER', 'REAL' *and* 'EXTENDED REAL' *may be used interchangeably and the proper transformations will be made automatically.)*

7. *A formal parameter may appear in no more than one specification list. However, a formal parameter need not appear in a list, except for switches which must be specified.*

8. *A formal parameter appearing in the* 'VALUE' *list must also appear in one of the specification lists.*

9. *Statement s may be:*
   a. *a simple statement*
   b. *a compound statement*
   c. *a block*

10. *Identifiers which are not formal parameters may appear in s if either of the following conditions exists:*
   a. *s is a block and the identifiers are declared at the beginning of this block.*
   b. *the identifiers are declared in the block in which the procedure declaration appears.*

11. *Statement s always acts like a block insofar as the scope of its identifiers is concerned, i.e., a label appearing in s is not defined outside the procedure declaration.*

12. *The procedure specified may be executed anywhere in the block in which the declaration appears by writing a procedure statement containing the procedure identifier and the actual parameters.*

EXAMPLE:

```
'PROCEDURE' TOT(T,K,L,M,U);
'VALUE' L,M; 'INTEGER' L,M;
'BEGIN'
   T←0;
   'FOR' K←L 'STEP' 1 'UNTIL' M 'DO'
   T←T+U
'END'
```

This procedure computes the sum of values of a function U between the limits of summation L and M. The function U may depend on the summation index K. The sum is generated in formal parameter T.

PURPOSE: *To define a statement or series of statements associated with a specific procedure identifier as being a function; to provide a means by which the appearance of the procedure identifier will cause the function to be performed and a value to be given to the identifier although the steps of the function appear only once.*

FORM:

(1) *type* 'PROCEDURE' *name; s*

(2) *type* 'PROCEDURE' *name* (a_1 *t* a_2 *t ... t* a_n)*; s*

(3) *type* 'PROCEDURE' *name* (a_1 *t* a_2 *t ... t* a_n)*;*
sp list; sp list;...; sp list; s

(4) *type* 'PROCEDURE' *name* (a_1 *t* a_2 *t ... t* a_n)*;*
'VALUE' *list;*
sp list; sp list;...; sp list; s

type:	*type word*
name:	*procedure identifier*
$a_1, a_2, \ldots, a_n$:	*formal parameter*
t:	*separator*
sp:	*specifier*
s:	*statement*
list:	*formal parameters separated by commas*

RULES:

1. *A procedure declaration may have no parameters as shown in FORM (1).*

2. *When there are parameters (FORM (2), (3), (4)), each separator t may be either "," or ")b:(" where b represents any sequence of letters. The function of b is only descriptive, i.e., it may be used as comments to describe actual parameters. b has no operational significance.*

3. *The type word may be any of the following:*
   a. 'INTEGER'
   b. 'BOOLEAN'
   c. 'REAL'
   d. 'EXTENDED REAL'
   The type word identifies the type of the procedure identifier.

4. *At some point in the procedure body, i.e., in statement s, the procedure identifier must appear on the left side of an assignment statement. When this statement is executed, the function receives a value, and it is this value which is used when the procedure identifier appears in an expression. The function receives a value according to the type specified by the type word.*

5. *The procedure identifier may appear on the left side of any number of assignment statements. It is the last one to be executed from which the function receives its value.*

6. *The formal parameters may be any of the following:*
   a. variable
   b. array identifier
   c. label
   d. switch identifier
   e. procedure identifier

7. *The formal parameters usually appear in statement s. They are replaced at the time the procedure is called upon by the actual parameters of the function call.*

8. *There may or may not be a* 'VALUE' *declaration in a function definition. If there is, the rules which apply are the same for all procedure declarations.*

9. *The specifiers which may be included, and the rules which apply are the same for all procedure declarations.*

10. *Statement s may be*
    a. *a simple statement*
    b. *a compound statement*
    c. *a block*

11. *Identifiers which are not formal parameters may appear in s if either of the following conditions exists:*
    a. *s is a block and the identifiers are declared at the beginning of this block.*
    b. *the identifiers are declared in the block in which the procedure declaration appears.*

12. *Statement s always acts like a block insofar as the scope of its identifiers is concerned, i.e., a label appearing in s is not defined outside the procedure declaration.*

13. *The function which this declaration defines may be executed anywhere in the block in which this declaration appears by writing in an arithemetic or Boolean expression the procedure identifier and the actual parameters, if any.*

EXAMPLES:

1.
```
'REAL' 'PROCEDURE' ADD(K,L,M,U);
'BEGIN' 'REAL' W;
   W←0;
   'FOR' K←L 'STEP' 1 'UNTIL'
   M 'DO'
        W←W+U;
   ADD←W
'END'
```

This function computes the sum of values of a function U between the limits of summation L and M. The function U may depend on the summation index K. Upon exit from the function, the sum is contained in ADD which is of type 'REAL'.

2.
```
'INTEGER' 'PROCEDURE' FACT(X);
'IF' X 'EQ' 1 'THEN' FACT←1 'ELSE'
     FACT←X* FACT(X-1)
```

This is an example of a recursive procedure declaration. Execution of FACT(2) causes FACT(1) to be executed because of the statement FACT←2 FACT(1). Then FACT will have the value 2*1. Execution of FACT(3) causes FACT to have the value 3*2*1. If this procedure is called n times, FACT will have the value n factorial.*

PURPOSE: *To provide a technique for communicating with separately compiled procedures.*

FORM:

(1) 'CODE'

(2) 'CODE' 'BEGIN' $d_1;d_2;\ldots;d_n$ 'END'

$d_1, d_2, \ldots, d_n$: *code declaration*

RULES:

1. *FORM (1) or FORM (2) above are to be used in a procedure declaration in place of statement s when it is desired to write a procedure outside an ALGOL program. The procedure may be written either as a separately compiled ALGOL program or as a procedure compiled in some other language (e.g., GMAP).*

2. *Each* d_i *may have any one of the following forms:*

   a. 'OWN' *type* 'ARRAY' $a_1, a_2, \ldots, a_n$

   where type and $a_1, a_2, \ldots, a_n$ *have the same meaning as described under Array declaration,* 'OWN'. *This code declaration declares* 'OWN' *arrays whose storage will be reserved in the declaring program but whose identifiers will be valid only in the separately compiled procedure.*

   b. 'OWN' *type* $v_1, v_2, \ldots, v_n$

   where type and $v_1, v_2, \ldots, v_n$ *have the same meaning as described under Type declaration,* 'OWN'. *This code declaration declares* 'OWN' *variables whose storage will be reserved with the declaring program but whose identifiers will be valid only in the separately compiled procedure.*

c. 'NONLOCAL' $a_1, a_2, \ldots, a_n$

where $a_1, a_2, \ldots, a_n$ *may be any of the following:*

1) *variable*
2) *procedure identifier*
3) *array identifier*
4) *switch identifier*
5) *label*

This code declaration makes the specified identifiers of the declaring procedure available to the separately compiled procedure.

3. *The procedure identifier of a separately compiled procedure and all the identifiers specified in a, b and c above must be unique in 6 characters. (A character is either a letter or a digit.)*

4. *For all procedures defined as* 'CODE', *a SYMREF will be produced in the declaring program.*

5. *SYMDEFS will be produced for all* 'OWN' *variables and arrays. In the case of an* 'OWN' *variable, the SYMDEF will point to the storage location for the variable; in the case of an* 'OWN' *array it will point to the first word of the alpha vector for the array.*

6. *There will be a SYMDEF associated with each entry in a* 'NONLOCAL' *list.*
   a. *For a procedure identifier, the SYMDEF will point to the entry location of the procedure.*
   b. *For a switch identifier, the SYMDEF will point to the entry location for the body of code which evaluates the switch.*

c. *For a variable identifier, the SYMDEF will define either the absolute location or the stack relative location of the variable, depending on whether the variable is non-procedural or procedural.*

d. *For a label, the SYMDEF will point to the location of the label.*

e. *For an array identifier, the SYMDEF will point to the first word in the alpha vector for the array. The pointer will be absolute or stack relative, depending on the point of definition of the array.*

7. *The user of a* 'CODE' *procedure is completely responsible for proper manipulation of the stack pointer, for setting of the available space pointer, and for correct usage of the various ALGOL constructs made available to him.*

8. *Details regarding Rules 4-7 may be found in ALGOL SSI.*

9. *It is possible to remap the internal name of a separately compiled procedure into a different set of 6 or fewer characters which will be used as its SYMREF. This is accomplished with the ALGOL word* 'RENAME' *followed by a string containing the desired external name. This construct follows the formal parameter list and precedes the word* 'CODE'. *The* 'RENAME' *string may consist of any combination of 6 or fewer characters and/or decimal points.*
Example: 'PROCEDURE' INPUT 0 (*a, string*); 'RENAME'".A0IPT\; 'CODE'

'SWITCH' *Declaration*

4. *When a* 'GO TO' *statement involving a switch designator is encountered in the program, the subscript of the switch designator is given an integral value. It is this value which determines which element of the list is referenced.*

5. *If the list item referenced is a conditional designator the* 'IF' *clauses are evaluated until a designational expression involving only a label or a switch designator is reached.*

6. *If the list element referenced is a label, it specifies directly the next statement to be executed.*

7. *If the element is a switch designator, it in turn references another* 'SWITCH' *declaration. The subscript of the switch designator is evaluated to locate the correct list element of the new* 'SWITCH' *declaration.*

8. *This process may be repeated through any number of* 'SWITCH' *declarations until reference is made directly to a statement label.*

9. *Each time an element in the list of a* 'SWITCH' *declaration is referenced, any expressions the element may contain are re-evaluated.*

EXAMPLE:

```
'SWITCH' BA←PA, 'IF' S 'THEN'
PB 'ELSE' PC, AC[X]
```

This switch may be called by a statement such as 'GO TO' *BA[D] which operates as follows: If D has the value 1, operation is equivalent to operation of* 'GO TO' *PA, where PA is a statement label. If D has the value 2, operation is equivalent to operation of* 'GO TO' 'IF' *S* 'THEN' *PB* 'ELSE' *PC, where S is a Boolean expression and PB and PC are statement labels. If D has the value 3, operation is equivalent to operation of* 'GO TO' *AC[X] where AC is a switch identifier and X is an arithmetic expression. If D has any other value, the statement following the* 'GO TO' *is executed next.*

Type Declarations

PURPOSE: *To specify which variables represent integer, real, extended real or Boolean quantities.*

FORM: *type* $v_1, v_2, \ldots, v_n$

type: *type word*
$v_1, v_2, \ldots, v_n$: *variable*

RULES:

1. *The type word may be one of the following:* 'REAL', 'EXTENDED REAL', 'INTEGER', *or* 'BOOLEAN'. *The type word specifies the type of the variables* $v_1, v_2, \ldots, v_n$.

2. *Each variable used in a program must be declared in a type declaration.*

3. *No variable may appear in more than one type declaration in a single block.*

4. *The type declaration is valid only for the block in which the declaration appears. Outside this block the identifiers may be used for other purposes.*

5. *The type declaration is valid for any blocks contained within the block containing the type declaration. However, variables may be redeclared in sub-blocks, in which case the previous declaration is superceded.*

6. *When exit is made from a block (by* 'END' *or by a* 'GO TO' *statement) all identifiers which were declared for the block are undefined.*

EXAMPLE:

```
'BEGIN' 'INTEGER' P,Q; 'INTEGER' 'ARRAY' S[1:5];
        P←3; Q←2;
        'BEGIN' 'REAL' P,R;
                R←Q;
                P←1;
                S[1]←P;
                S[2]←Q;
                S[3]←R
        'END';
        S[4]←P;
        S[5]←Q
'END'
```

These statements assign the numbers 1, 2, 2, 3, 2 in this order to elements of the array S.

PURPOSE: *To specify which variables represent integer, real, extended real, or Boolean quantities; to provide a means for retaining previous values of certain variables upon re-entry into a block.*

FORM: 'OWN' *type* $v_1, v_2, \ldots, v_n$

type: *type word*
$v_1, v_2, \ldots, v_n$: *variable*

RULES:

1. *The type word may be one of the following:* 'REAL', 'EXTENDED REAL', 'INTEGER', *or* 'BOOLEAN'. *The type word specifies the type of the variables* $v_1, v_2, \ldots, v_n$.

2. *Each variable used in a program must appear in a type declaration.*

3. *No variable may appear in more than one type declaration in a single block.*

4. *Only variables whose values are to be preserved for possible re-entry into a block should be specified by an* 'OWN' *type declaration. All other variables should be declared in a regular type declaration.*

5. *The variable identifiers declared in any type declaration are defined only for the block in which they appear. Outside the block the identifiers may be used for other purposes.*

6. *When an exit is made from a block (by* 'END' *or by a* 'GO TO' *statement) the identifiers are inaccessible although their values have been saved.*

EXAMPLE:

```
    A←6;
B:  'BEGIN' 'REAL' C; 'OWN' 'REAL' D;
            'IF' A 'EQ' 6 'THEN'
            'BEGIN'
                 C←7;
                 D←8;
                 A←9;
                 'GO TO' E
            'END';
            A←D-2
    'END';
E:  'IF' A 'NQ' 6 'THEN' 'GO TO' B
```

During the first execution of block B, 7 is assigned to C, 8 is assigned to D and 9 is assigned to A. Execution of the conditional statement labelled E causes block B to be executed again. During this execution, A is set to 6 because the previous value of 'OWN' *variable D is saved. However, variable C could not be used in this way because not being* 'OWN', *its value is not saved.*

VI. COMPOUND STATEMENTS AND BLOCKS

PURPOSE: *To permit a series of statements to be joined together in such a way as to act as a unit.*

FORM: 'BEGIN' $s_1;s_2;\ldots;s_n$ 'END'

$s_1, s_2, \ldots, s_n$: *statement*

RULES:

1. *A compound statement may have a label and may contain any number of statements* (s_i).

2. *Each statement* $s_1, s_2, \ldots, s_n$ *may be*
   a. *a simple statement*
   b. *a compound statement*
   c. *a block*

3. *Each statement may have a label.*

4. *A* 'GO TO' *statement may transfer control to a statement within a compound statement.*

EXAMPLES:

1.
```
I←1;
T: 'IF' I 'LQ' 10 'THEN'
'BEGIN'
   A[I]←I;
   I←I+1;
   'GO TO' T
'END'
```

These statements assign the numbers one to ten to elements of the array A. This example contains a compound statement as the true branch of a conditional statement.

2.
```
'FOR' I←1 'STEP' 1 'UNTIL' 10 'DO'
      'BEGIN'
      'FOR' J←1 'STEP' 1 'UNTIL' 10 'DO'
            'BEGIN'
            'IF' I 'EQ' J 'THEN'
                  'BEGIN'
                  B[I,J]←1; 'GO TO' S
                  'END';
            B[I,J]←0;
        S: 'END'
      'END'
```

These statements generate a ten by ten unit matrix in the array B. Each 'FOR' *statement has a compound statement as its object. Also, the true branch of the* 'IF' *statement is a compound statement.*

PURPOSE: *To permit statements and declarations to be grouped together in such a way as to be independent of other parts of a program. This permits labels and identifiers to be used in different sections of a program without conflicts.*

FORM: 'BEGIN' $d_1;d_2;\ldots;d_n;s_1;s_2;\ldots;s_m$ 'END'

$d_1, d_2, \ldots, d_n$: *declaration*
$s_1, s_2, \ldots, s_m$: *statement*

RULES:

1. *A block may have a label, and may contain any number of declarations and statements.*

2. *Each statement* $s_1, s_2, \ldots, s_m$ *may be*
   a. *a simple statement*
   b. *a compound statement*
   c. *a block*

3. *Each statement may have a label.*

4. *When a block is entered through* 'BEGIN', *the identifiers which are declared for the block are newly defined and lose any significance they may have had prior to entry.*

5. *All labels within a block are local to the block and may not be referred to from outside.*

6. *When exit is made from a block, all identifiers which were declared for the block are undefined and may be used for other purposes, including those declared as* 'OWN'.

7. *If a declaration is prefaced with* 'OWN', *the identifiers so defined will retain their previous values upon re-entry into the block. If* 'OWN' *is not specified, the values will be lost when exit is made from the block and will be undefined upon re-entry.*

8. *All identifiers used in a program must be declared in one of the blocks comprising the program. No identifier may be declared more than once in a single block.*

9. *If blocks are nested, a statement label has meaning only in the smallest block containing that statement.*

EXAMPLE:

```
'BEGIN' 'REAL' X,Y; 'ARRAY' A[1:5];
   X←1; Y←2;
   'BEGIN' 'REAL' X,Z;
           Z←Y;
           X←3;
           A[1]←X;
           A[2]←Y;
           A[3]←Z
   'END';
   A[4]←X;
   A[5]←Y
'END'
```

These statements assign the numbers 3,2,2,1,2 in this order to elements of the array A.

VII. INPUT/OUTPUT

INPUT/OUTPUT

The ALGOL language itself provides no input/output statements. However, the ALGOL compiler for the General Electric 625/635 contains within it a number of procedures which handle the I/O. All a programmer need do is to call the existing procedures using an ALGOL procedure statement, and through the procedure parameters, transmit the information required for the input and/or output process.

The procedure identifiers used by ALGOL are reserved and act as though declared in a block enclosing the program. If a programmer redeclares one of these identifiers in his program his declaration supersedes the standard definition. The procedures provided are listed below:

A. *Procedures pertaining to the layout of the I/O information on the external device:*

BAD DATA
FORMAT
FORMAT *n* (*n*=0,1,2,...,9)
HEND
HLIM
NO DATA
TABULATION
VEND
VLIM

B. *Procedures dealing with the actual transmission of data:*

INLIST
INPUT *n* (*n*=0,1,2,...,9)
OUTLIST
OUTPUT *n* (*n*=0,1,2,...,9)

C. *Procedures allowing finer control over the input and output processes:*

POSITION

SYSPARAM

D. *Primitive procedures:*

INSYMBOL

LENGTH

NAME

OUTSYMBOL

STRING ELEMENT

TYPE

Each procedure is discussed in detail on the following pages, and the form of the procedure call is given.

In addition, the user of these procedures needs to provide a list of the data items which are to be transmitted. This list is specified in a user declared procedure called a list procedure. The identifier for this procedure is not reserved by ALGOL, and thus any valid identifier may be chosen. The list procedure is discussed following the ALGOL procedures.

A. *Layout Procedures*

The procedures to be described in this section deal with the appearance of the data on an input or output device. All of the procedures describe a printed page. However the concepts may be generalized to include any external device.

Listed below are the physical characteristics of the I/O devices. The number of characters per line is referred to as P. The number of lines per page is referred to as P'.

Device	*P (characters)*	*P' (lines)*
Line Printer	*120*	*55*
Card Reader (binary)	*160*	*no limit*
Card Reader (decimal)	*80*	*no limit*
Card Punch (binary)	*160*	*no limit*
Card Punch (decimal)	*80*	*no limit*
Magnetic Tape, Disk, Drum	*120*	*no limit*

These device characteristics may be changed where applicable (e.g., number of characters per line for magnetic tape may be changed) by using the procedure SYSPARAM *described in part C of this section.*

The layout procedures are used to describe non-standard operations which are to take place during input and output. The procedures need not be called, in which case certain standard operations (described with each procedure) will be in effect. The technique for using the layout procedures is as follows:

Layout Procedures (contd)

*The programmer declares a set-up procedure containing any or all of the eight layout procedures (*FORMAT, HLIM, VLIM, HEND, VEND, NO DATA, TABULATION, BAD DATA*). At some point in the program there is a call to an I/O transmission procedure which has as one of its parameters the procedure identifier of this set-up procedure. At the time the I/O procedure is called it causes the set-up procedure to be executed thus establishing the non-standard operations. Each time a new I/O transmission is called, the standard layout operations will be resumed until changed by a new set-up procedure.*

PURPOSE: *To indicate the procedure which is to be called when a request is made for an item to be transmitted, and the item is incompatible with the format character.*

FORM: BAD DATA *(p)*

p: procedure identifier

RULES:

1. *This procedure applies only to input.*

2. *If a translated format (anything but* I, R, E *or* L*) is used and the referenced field is not compatible, control will be transferred to procedure p.*

3. *If* BAD DATA *is not used and the condition described in Rule 2 arises, control will be transferred to the end of the program as though a dummy label had been placed just before the final* 'END'.

EXAMPLES:

1. BAD DATA (CHECK) — *The procedure CHECK is used when incorrect data appears on the input device.*

2.
```
'BEGIN'
'PROCEDURE' REDO; OUTLIST (6,LAY,LIST);
...
BAD DATA (REDO);...
'END'
```

When an incompatibility occurs, control goes to procedure REDO which outputs an error message.

PURPOSE: *To describe the form in which data appears on the input device or is to appear on the output device.*

FORM: FORMAT *(string)*

string: *a string with a special form*

RULES:

1. *The format string is composed of a series of items separated by commas.*

2. *The string is interpreted from left to right in conjunction with a list of data items which are to be transmitted.*

3. *These data items usually appear in a separate procedure called a list procedure.*

4. *An item in the format string may describe a number, a string, or a Boolean quantity, or it may simply cause a title to be written or page alignment to take place.*

5. *The following rules describe the various kinds of format items.*

6. *Number formats*

   a. *Integers*

      1) *This format item consists of a series of* Z's, *a series of* D's, *or a series of* Z's *followed by* D's *each corresponding to a digit position of the number, and an optional sign.*

2) *The letter* D *is used to indicate a digit which is always to be printed.*
(ex. 385 when written with format DDDD *will appear externally as 0385.)*

3) *The letter* Z *is used to indicate that the corresponding digit is to be suppressed if it is a leading zero. In this case, a zero digit will be replaced by a blank space when all the digits to its left are zeros.*
(ex. 21 when written with format ZZZ *will appear externally as ⌀21.)*

4) *A series of* Z's *or* D's *may be written in a shorthand notation as follows:* nZ *or* nD *(where n is an integer) is equivalent to* ZZZ...Z *or* DDD...D *(n times).*
(ex. 3Z *and* ZZZ *are equivalent.* 4D *and* DDDD *are equivalent.)*

5) *An optional sign may precede or follow the* Z's *and* D's *of a number format.*
If no sign appears, the number is assumed to be positive.
Note: If a negative number is output with no sign position, the first digit position will print as ⌀,A,B,...,I representing the digits 0,1,1,...,9 respectively.
If a plus sign appears, the correct sign of the number appears on the external medium.
If a minus sign appears, positive numbers will be unsigned and negative numbers will have a minus sign on the external medium.

6) If a preceding sign is to appear externally with a number which has had leading zeros suppressed, the sign will be placed immediately to the left of the first non-zero digit.

7) The total number of positions which an integer occupies on the external medium is the sum of the Z's and D's (plus one if the optional sign appears). If the field width is insufficient to hold the complete number, the high order digits are transmitted and the leftmost digit position will be ↑,J,K,...,R according as the actual digit is 0,1,2,...,9. If, in addition to the above condition, the field is also unsigned and the number is negative, the leftmost position will be +,/,S,T, ...,Z representing the digits is 0,1,2,...,9 respectively.

8) Examples of integer formats:
If +ZZDDD is used with 2176, it appears as ⱷ+2176.
If -ZZZDD is used with 3, it appears as ⱷⱷⱷⱷ03.
If -DDDD is used with -45, it appears as -0045.
If ZZZ is used with 0, it appears as ⱷⱷⱷ.
If ZZD is used with 0, it appears as ⱷⱷ0.
If 2Z4D+ is used with 390, it appears as ⱷⱷ0390+.

b. Decimal Numbers

1) This format item consists of Z's and/or D's each corresponding to a digit position, a period (.) or the letter V to indicate the position of the decimal point, and an optional sign.

2) *The letter* Z *has the same function it did for integers and it may appear only to the left of the decimal point.*

3) *The letter* D *may appear on both sides of the point and has the same function as for integers.*

4) *If a . is used to indicate the decimal point position, it will appear on the external medium in that position. If the letter* V *is used it merely indicates where the decimal point should be, but no space is used on the external medium.*

5) *The sign part functions as it did for integers.*

6) *The total number of positions which a decimal number occupies on the external medium is the sum of the* Z's *and* D's *plus one for the sign, plus one if the point is indicated by a . in the format. If the field width is insufficient to hold the complete number the high order digits are transmitted and the leftmost digit position will be* $\uparrow, J, K, \ldots, R$ *according as the actual digit is* $0, 1, 2, \ldots, 9$. *If, in addition, the field is unsigned and the number is negative, the leftmost position will be* $+, /, S, T, \ldots, Z$ *representing the digits* $0, 1, 2, \ldots, 9$, *respectively.*

7) *Examples of decimal numbers:*
If ZZDD.DD *is used with 146.776, it appears as ƀ146.78.*
If -3D.D *is used with 1.2, it appears as ƀ001.2.*
If +3Z.3D *is used with .0042, it appears as ƀƀƀ+.004.*
If -ZZDVD *is used with -142.78, it appears as -1428.*
If ZZ4D.DD- *is used with -3394.7, it appears as ƀƀ3394.70-.*
If ZZD *is used with 29.756, it appears as ƀ30.*
If .3D- *is used with -.0254, it appears as .025-.*

c. *Decimal Numbers with Exponent*

1) *This format item is the same as that for a decimal number with the addition of an exponent part to indicate the power of ten to which the number must be raised to give the true decimal number.*

2) *The exponent part consists of an apostrophe (') to separate it from the decimal number followed by an optional sign, a series of* Z's *and/or a series of* D's.

3) *The ' will appear on the external medium in the proper position to separate the decimal number and its exponent.*

4) *The rules for the exponent part are the same as those for integers.*

5) *A number using this format will appear externally with its leading digit not zero. The exponent is adjusted accordingly. If the number is zero the exponent is also set to zero.*

6) *If a nonzero number has a zero exponent which is specified by* Z's *the* ' *and the exponent sign are also suppressed.*

7) *The total number of positions needed on the external medium is the sum of all the* Z's *and* D's *plus one for the sign, plus one for the exponent sign, plus one for the* ' *plus one for the decimal point (if* . *is specified).*

8) *Examples of decimal numbers with exponents:*
If 3D.DD'+DD *is used with 3075.2, it appears as* *307.52'+01.*
If D.DD'-ZZ *is used with 7.1, it appears as 7.10ϕϕϕϕ.*
If ZZD'+ZD *is used with .021758, it appears as* *218'ϕ-4.*
If DD'ZZ *is used with 35.649, it appears as 36ϕϕϕ.*
If .3D'+2D *is used with 917.2, it appears as .917'+03.*
If .DD'-ZZZ *is used with .000312, it appears as* *.31'ϕϕ-3.*

d. *Octal Numbers*

1) *The form of this item is* n0 *or* 00...0 *(n times) where n is an integer which specifies the number of digits in the octal field.*

2) *For output if n<12, the leftmost n digits will be transmitted; if n≥12, 12 digits will be transmitted followed by n-12 blanks.*

3) *For input if n<12, the next n characters are transmitted; if n≥12, the next 12 characters are transmitted.*

4) *Examples of octal numbers:*

If 5O *is used with 447521767511 on output, it appears as 44752.*

If 14O *is used with 712342165134 on output, it appears as 712342165134ØØ.*

If 15O *is used with 754162314321744 on input, it appears as 754162314321 internally.*

7. *Truncation for Number Formats*

a. *The integer or decimal number formats described above may be followed by the letter* T *to indicate that the output should be truncated instead of rounded. Rounding occurs when truncation is not specified.*

b. *Examples of truncation:*

If -2Z3D.2DT *is used with -12.719, it appears as* ØØ-012.71.

If 3ZDT+ *is used with 145.6, it appears as* Ø145+.

If -Z.DT'+ZZ *is used with .012537, it appears as* Ø1.2'Ø-2.

8. *Insertions in Number Formats*

a. *All of the number formats may have either blanks or strings inserted anywhere within the format item. The insertion will appear on the external medium.*

b. *A blank is denoted by the letter* B. *If more than one blank is desired it may be expressed by a series of* B's *or by the shorthand notation n*B *(n is an integer specifying the number of blanks.)* 3B *is equivalent to* BBB.

c. *A string which is to be inserted must be enclosed in string quotes (i.e. "string\). If the string is to be repeated it may appear as n"string\ where n is an integer specifying the number of times the string is to appear. The information in the string (not including the outermost quotes) is inserted in the corresponding place in the number.*

d. *Examples of insertions:*

If D2B3D *is used with 3972, it appears as 3ϕϕ972.*

If "ANS=\4D *is used with 271, it appears as ANS=0271.*

If "INTEGERϕPART\-4ZVB"FRACTION\B2D *is used with -195.7634, it appears as INTEGERϕPARTϕ-195ϕFRACTIONϕ76.*

If 2ZB2D.DBT'+DD *is used with 44865.5, it appears as 44ϕ86.5ϕ'+01.*

If "OCTALϕ\5O *is used with 112233445566, it appears as OCTALϕ11223.*

9. *Numbers for Input*

a. *Numbers which are input using the above format codes should, in general, appear the same as those which are output.*

b. *However, there are fewer restrictions on the form of input numbers.*

1) *Leading zeros may appear even if* Z's *are used in the format code. Leading blanks may appear even if* D's *are used.*

2) *If insertion strings or blanks are used in the format code the corresponding number of characters on the input device are skipped.*

3) *If a sign is specified at the left in the format code it may appear in any* Z *or* D *positions on the input device as long as it is to the left of the first digit. If the sign is specified at the right, it must appear exactly where it is indicated.*

10. *String Format*

a. *This format item is used to output string quantities. It may not be used for input. Alpha format must be used instead.*

b. *The form of this item is n*S *or* SS...S *(n times), where n is an integer which indicates the number of symbols in the string.*

1) *If the actual string is longer than the number of* S's *indicated, only the leftmost symbols are transmitted.*

2) *If the string is shorter, blank symbols are added to the right of the string.*

3) *Examples of string format:*
If S *is used with "A\, it appears as A.*
If 6S *is used with "TOTALS\, it appears as TOTALS.*
If SSS *is used with "ABC\, it appears as ABC.*
If 4S *is used with "PROGRAM\, it appears as PROG.*
If 5S *is used with "CAT\, it appears as CATØØ*

11. *Insertions in String Format*

a. *Blanks or strings may be inserted in the* S *format.*

b. *The rules are the same as described for number formats.*

c. *Examples:*
If B3SBB2S *is used with "12345\, it appears as Ø123ØØ45.*
If 2S"=\3SB *is used with "T1ANS\, it appears as T1=ANSØ.*

12. *Alpha Format*

a. *This format item is used to transmit ALGOL basic symbols. (see INTRODUCTION for a list of basic symbols.)*

b. 1) *The form of this item is the letter* A.

2) *The appearance of the letter* A *as a format item causes transmission of a single symbol from or to the data item specified in the list procedure.*

3) *The symbol will be stored as an integer.*

c. *It may be desired to work with symbols transmitted by the* A *format. Therefore, a function is provided which makes any ALGOL symbol type* 'INTEGER' *and causes the symbol to have the same value as if it had been read in using Alpha format.*

d. *The function is called* EQUIV. *Its argument must be an ALGOL basic symbol enclosed in string quotes, i.e.,* EQUIV("'BEGIN'\).

e. *Example:*
If A *format is used to read an "%" into variable ALG the statement* 'IF' ALG 'EQ' EQUIV ("%\) 'THEN' 'GO TO' GOOD *will check that "%" was in fact the symbol which was read in.*

13. *Boolean Format*

a. *This format item is used to transmit Boolean quantities.*

b. *The item may consist of the letter* P *or the letter* F.

c. *If* P *is used and the quantity is true, the number 1 is transmitted; if false, 0 is transmitted.*

d. *If* F *is used and the quantity is true the word* 'TRUE' *transmitted; if false the word* 'FALSE' *is transmitted.*

e. *Input must be in the form specified in c. and d.*

14. *Insertions in Boolean Format*

a. *Blanks or strings may be inserted in the Boolean format.*

b. *The rules are the same as described for number formats and for strings.*

c. *Examples:*
If BBPB *is used with a Boolean variable whose value is* 'TRUE', *it appears as* ØØ1Ø.
If "THEØRELATIONØIS\BF *is used with a Boolean variable whose value is* 'FALSE', *it appears as THEØRELATIONØISØ*'FALSE'.

15. *Standard Format*

a. *A number may be transmitted for input or output without specifying in a format item the exact form the number is to take. The number appears on the I/O device in "standard format."*

b. *If the letter* N *appears as a format item, it specifies that a number with standard format is to be transmitted.*

c. *Standard format for input may be defined as follows:*
1) *Any number of digits in any of the forms which are acceptable to integer or decimal number formats may be input.*

2) *The number must be terminated by an illegal character, i.e., one not normally permitted in a number, or by k blanks where k is a system parameter initially set at one. k may be changed by calling the system procedure* SYSPARAM *(described in Section C.).*

d. *If standard format is invoked, and the first line referenced contains any legal character for a number (i.e., digit, sign, decimal point or apostrophe) the right hand margin will terminate the number. If, however, the first line contains only nonlegal number characters, the subsequent lines will be searched until a legal number character is found. At this point the right hand margin is not significant, and only an illegal character or k blanks will terminate the number.*

e. *Standard format for output will appear as though the decimal number format* -.16D'+DD *had been invoked.*

f. *Standard format will be assumed if the end of a format string is reached while there are data items in the list procedure still to be transmitted. In this case all the remaining quantities will be transmitted with standard format.*

g. *If a list of variables is to be terminated but either*
1) no reference is made to a FORMAT *procedure, or*
2) the format call has the form FORMAT ("\)
the items will be transmitted according to standard format.

16. *Untranslated Format*

a. *If a quantity is to be transmitted using the internal machine notation, a format item may consist simply of an* I *an* R *an* E *or an* L.

b. *The letter to be used is determined as follows:*
I *for integers,*
R *for real numbers,*
E *for extended real numbers,*
L *for Boolean quantities.*

c. *Quantities which are written out using this format must be read in using the same format.*

17. *Alignment Marks*

a. *These are single characters which cause specific page operations to occur.*
The operations are:
/ *go to next line*
↑ *go to new page*
J *go to next tabulation position.*

b. *Alignment marks may appear as part of any format item. If they appear at the left of the item the actions take place before the format operation. If they appear at the right, they take place afterwards, i.e.,* /3S↑ *causes a skip to a new line before the string is transmitted and a skip to a new page after.*

c. *Alignment marks may also appear as separate format items simply by enclosing them in commas.*

d. *Any number of alignment marks may appear in succession, and this causes the specified action to be repeated as many times as it is indicated, i.e.,* ↑↑↑ *causes a page to be terminated and two pages to be skipped. Also any mark may be preceded by an integer n, where n indicates the number of times the action is to be done, i.e.,* 4J *causes a skip to the fourth tab position and is equivalent to* JJJJ.

18. *Title Format*

a. *This format item is used when it is desired to cause page alignment and/or the output of insertion strings without transmitting any ALGOL quantities.*

b. *This item consists entirely of insertions and alignment marks and refers to no data items.*

c. *On input this item causes characters to be skipped corresponding to the insertion strings and causes the desired alignment operations to be performed.*

d. *On output the insertion strings are transmitted and the alignment operations are performed.*

e. *Examples of title format:*
↑"SUMMARY\// *indicate a new page, an insertion, a line to be terminated and a line to be skipped.*
/"AMT\J"GROSS\J"NET\// *indicates a new line, an insertion, a tab, an insertion, a tab, an insertion, a line to be skipped.*

19. *All the format items listed above constitute a format string.*

20. *Any format item or any group of format items can be repeated any number of times by enclosing in parentheses those items to be repeated and preceding the parentheses by an integer n indicating the number of repetitions desired, i.e.,* 3(2Z.D) *causes 3 decimal numbers to be transmitted. If no integer precedes the parentheses an infinite number of repetitions is indicated.*

EXAMPLES:

1. FORMAT("4D.2D,2Z,/P,
"IS⌀THE⌀ANS\↑,A\)

This format string transmits a decimal number and an integer on one line; on the next line is a Boolean quantity specified by a 0 or a 1 followed by an insertion. Then a skip is made to a new page and an ALGOL symbol is transmitted.

2. FORMAT("7S,2(5Z.D'+ZZ,F),2J\)

A seven symbol string is transmitted followed by a decimal number, a Boolean quantity, a decimal number, a Boolean quantity. Then two tabulations occur.

3. FORMAT("(ZZ.BDT-,BBB+ZZD)\ )

A decimal number and an integer are transmitted an indeterminate number of times, i.e., until the list of data items is exhausted.

PURPOSE: *To describe the form in which data appears on the input device or is to appear on the output device; to permit certain elements of the format string to be variable and to have their values calculated at the time the* FORMAT *procedure is called.*

FORM: FORMAT *n(string,* $x_1,x_2,\ldots,x_n$*)*

n: *integer*
string: *string with a special form*
$x_1,x_2,\ldots,x_n$: *expression*

RULES:

1. *n may be* 0,1,2,...,9. *This value indicates the number of x's which appear following the format string.*
(Note: The form FORMAT *(string) as discussed previously is simply a special case of this format call in which n=0.)*

2. *The form of the string is the same as that discussed for the procedure call* FORMAT *(string), with certain additional features.*

3. *The string may contain the letter* X *in various format items. The values of the* x_i*'s which follow the format string will replace each* X *when the* FORMAT *procedure is called.*

4. *The letter* X *may appear in the format string as follows:*

   a. *In a Number Format:*

   Any Z *or* D *may be preceded by the letter* X *to indicate a variable number of repetitions of the* Z *or* D.

   Examples:

   XZXD - *variable integer size*

   ZZ.XD - *variable number of decimal places*

   .DDD'XD - *variable exponent size*

   b. *In an Insertion:*

   The letter B *may be preceded by an* X *to indicate a variable number of blank spaces on output or a variable number of ignored positions on input.*

   Example:

   2ZXB3D.D

   c. *In a String Format:*

   The letter S *may be preceded by the letter* X *to indicate a variable number of symbols in the string.*

   Examples:

   XS

   BXSB4S

   d. *With an Alignment Mark:*

   ↑,/ *or* J *may be preceded by the letter* X *to indicate a variable number of times the specified alignment action is to be taken.*

   Examples:

   XJDD.DD - *variable number of tabulations*

   3S2BX/ - *variable number of lines to be skipped*

5. *The* X's *may be used at most 9 times in a single format string. The integer n in the format call indicates the number of* X's *which appear in the string.*

6. *The* $x_1,x_2,\ldots,x_n$ *in the format call represent the integral values to be assigned to the* X's *in the string.* $x_1,x_2,\ldots,x_n$ *must be positive.* x_1 *is assigned to the first* X *which appears;* x_2 *to the second, etc.*

EXAMPLE:

```
FORMAT 3 ("ZZXD.D,XBXS\,2,A-5,B)
```

The decimal number will be transmitted as though it had been written as ZZ2D.D. A-5 blanks will precede the string which will contain B symbols.

PURPOSE: *To specify the procedures which are to be called when the end of a line is reached during input or output; to permit special action to be taken depending on what situation causes the end-of-line condition to occur.*

FORM: HEND *(p1,p2,p3)*

p1,p2,p3: procedure identifier

RULES:

1. *p1 is the name of the procedure to be called when a "/" appears in the format call. This indicates that a new line is to begin and is considered the normal case.*

2. *p2 is the name of the procedure to be called when a group of characters is to be transmitted or a tabulation is specified which would pass the right margin of the current line as specified by* HLIM.

3. *p3 is the name of the procedure to be called when a group of characters is to be transmitted or a tabulation is specified which would pass the physical end of the line due to the characteristics of the I/O device being used, but would not pass the right margin as set by* HLIM.
   Note: This physical end is specified by standard limits set within the system or a control card to the system, and may be altered by procedure SYSPARAM.

4. *If it is desired to take no special action when the end of a line is reached this procedure call may be omitted.*

5. *If action is desired for some but not all of the conditions, dummy procedure names may be used for those requiring no action.*

EXAMPLES:

1. HEND (NORM,OVER,END)

   a "/" in the format call causes control to go to Procedure NORM; if the right margin is reached control goes to OVER; if the physical end-of-line is reached control goes to END.

2. 'BEGIN'...'PROCEDURE' DUMMY;;...
   ...HEND (DUMMY,FIN,NEXT);...'END'

   Since Procedure DUMMY contains no statements, no special action will be taken when a "/" appears in the format call.

PURPOSE: *To specify the left and right margins of the input or output lines.*

FORM: HLIM *(left, right)*

left, right: arithmetic expression

RULES:

1. *The first parameter specifies the left margin.*
2. *The second parameter specifies the right margin.*
3. *There is a restriction that* $1 \leq left \leq right$.
4. *If this procedure call is not given, the left margin is set to one and the right margin is set to infinity.*

EXAMPLES:

1. HLIM (5,50)	*Left margin is 5, right margin is 50.*
2. HLIM (J-4,K)	*Left margin is value of J-4, right is value of K.*

PURPOSE: *To indicate the procedure which is to be called when a request is made for data on an input device but no more data remains.*

FORM: NO DATA *(p)*

p: procedure identifier

RULES:

1. *This procedure call applies only to input.*

2. *If input data is requested by a data transmission procedure when no data remains on the input device, control will be transferred to procedure p.*

3. *If* NO DATA *is not used and the condition described in Rule 2 arises, control will be transferred to the end of the program as though a dummy label had been placed just before the final* 'END'.

EXAMPLES:

1. NO DATA (EOF) — *The procedure EOF is used when no data exists on the input device.*

2.
```
'BEGIN'
'PROCEDURE' LAST; 'GOTO' FIND;
...
NO DATA (LAST);...
'END'
```

When no data is found on the input device, control goes to procedure LAST which sends control to the statement labelled FIND.

PURPOSE: *To set the width of the tabulation field of the I/O device; to permit the skipping of a fixed number of positions whenever the alignment mark* J *appears in a format call.*

FORM: TABULATION *(a)*

a: arithmetic expression

RULES:

1. *"a" specifies the number of characters of the foreign medium which constitute the tabulation field.*

2. *If the left margin is at position X, the tab positions for a line are:*

   X, X+a, X+2a, X+3a, ... , X+ka

   The last tab position occurs before or at the same point as the right margin as specified by HLIM, *or at the physical end of the line, whichever is smaller.*

3. *When a "J" appears in a format call, the I/O device is spaced to the next tab position.*

4. *If this procedure call is not given the tabulation spacing is one.*

EXAMPLES:

1. TABULATION (15)

A new tab position occurs every 15 spaces.

2. TABULATION (A↑2-B*C)

The value of A^2*-BC determines the tab spacing.*

PURPOSE: *To specify the procedures which are to be called when the end of a page is reached during input or output; to permit special action to be taken depending on what situation causes the end-of-page condition to occur.*

FORM: VEND *(p1,p2,p3)*

p1,p2,p3: procedure identifier

RULES:

1. *p1 is the name of the procedure to be called when a "↑" appears in the format call. This indicates that the subsequent information is to appear on a new page, and is considered the normal case.*

2. *p2 is the name of the procedure to be called when a group of characters is to be transmitted which would appear on the line after the one specified by* VLIM *as the bottom margin.*

3. *p3 is the name of the procedure to be called when a group of characters is to be transmitted which would pass the physical end of the page due to the characteristics of the I/O device being used, but would not pass the bottom margin set by* VLIM. *Note: This physical end is specified by standard limits set within the system or a control card to the system, and may be altered by procedure* SYSPARAM.

4. *If it is desired to take no special action when the end of a page is reached this procedure call may be omitted.*

5. *If action is desired for some but not all of the conditions, dummy procedure names may be used for those requiring no action.*

EXAMPLES:

1. VEND (NEW,PAGE 1, PAGE 2)

   Control goes to procedure NEW when a "↑" appears in the format call; to PAGE 1 when the bottom margin is reached and to PAGE 2 when the physical end of the page is reached.

2. 'BEGIN'...'PROCEDURE' EMPTY;;...
   ...VEND (OK,FIX,EMPTY);...'END'

   No action is taken if an attempt is made to write beyond the end of the page.

PURPOSE: *To set the vertical layout of a page; to specify how many lines on a page are to be used.*

FORM: VLIM *(top, bottom)*

top, bottom: arithmetic expression

RULES:

1. *The top line of the page has a value of 1, the second, 2, etc.*
2. *The first parameter indicates the first line to be used for transmission.*
3. *The second parameter indicates the last line to be used.*
4. *There is a restriction that* $1 \leq top \leq bottom$.
5. *If this procedure call is not given, the first line is set to one and the last line is set to infinity.*

EXAMPLES:

1. VLIM (10,50) — *Data transmission starts on line 10 and ends on line 50.*

2. VLIM (1, TOTAL)

Data transmission starts on the first line of a page, and ends on the line specified by the value of TOTAL.

Examples of Layout Procedures:

1.
```
'PROCEDURE' SET;
'BEGIN'
  FORMAT ("3D.2D\);
  'IF' A 'EQ' B↑2 'THEN'
  'BEGIN'
       FORMAT ("ZZZ\);
       TABULATION (5)
  'END';
  VLIM ('IF' A 'EQ' B↑2 'THEN' 5
       'ELSE' 10,50)
'END'
```

If $A=B^2$ the second format call will override the first, a TAB of 5 will be set and the vertical margins will be (5,50). If $A\neq B^2$ the first format will be in effect the TAB will be 1 and the vertical margins will be (10,50).

2.
```
'PROCEDURE' LAYOUT;
'BEGIN'
  FORMAT("↑,100(ZZD.D,BBD.D'DD),
        / \);
  HLIM(5,60);
  HEND(GOOD,OVER,OVER)
'END';
'PROCEDURE' GOOD; HLIM(5,60);
'PROCEDURE' OVER; HLIM(15,60)
```

Whenever line overflow occurs procedure OVER will change the horizontal margins. When the "/" in the format call is reached, procedure GOOD will restore the original margins.

B. *Data Transmission Procedures*

These procedures handle the actual transmission of data for input and output.

In calling these procedures it is necessary to specify the I/O device which is to be used for the transmission. For the GE 625/635 operating system a GECOS file control card is required to indicate the devices to be used.

Files used by ALGOL are restricted to the numeric file codes 01_{10} *to* 40_{10}. *05 is the standard input file and 06, the standard output file. These two files do not require file control cards in order to be used. Unless redefined, file 05 indicates GECOS file I*;06 indicates GECOS file P*. Error messages will thus be written on 06.*

The point in a program at which the actual I/O procedure is called is when the transmission of data occurs. Layout procedures, if any, and a list procedure, if any, will be called by the internal I/O procedures.

PURPOSE: *To indicate that data is to be transmitted for input; to specify the input device, the set-up procedure and the list procedure.*

FORM: INLIST (a_1,a_2,a_3)

a_1: *arithmetic expression*
a_2,a_3: *procedure identifier*

RULES:

1. a_1 *is the file number from the GECOS file card which indicates the specific input device to be used.*

2. a_2 *is the name of the set-up procedure containing the layout procedure calls.*

3. a_3 *is the name of the list procedure which contains the data items to be transmitted.*

4. *When* INLIST *is executed, it first calls the layout procedures, then transfers back and forth to the list procedure while the actual input is taking place. See Appendix 3 for a detailed explanation of* INLIST.

EXAMPLES:

1. INLIST (05, ABC, INPT)

This statement causes input to take place on I/O device 5 according to the layout procedures in procedure ABC and according to the list procedure INPT.

2.
```
'BEGIN' 'PROCEDURE' START;
   'BEGIN'
      FORMAT("↑,A,D.D'DD/,ZDD,P\);
      VLIM(2,50)
   'END';...
   'PROCEDURE' LIST (OK);
   'BEGIN'
   OK(ALPHA); OK(BOY); OK(COUNT);
   OK(BOOL)
   'END';...
   INLIST (7,START,LIST);...
'END'
```

This program transmits a symbol into ALPHA, a real number into BOY, an integer into COUNT and a 0 or 1 into BOOL.

PURPOSE: *To indicate that data is to be transmitted for input; to provide for data input without using layout procedures or a list procedure.*

FORM: INPUT *n* *(a, string, $e_1, e_2, \ldots, e_n$)*

n: *integer*
a: *arithmetic expression*
string: *format string*
$e_1, e_2, \ldots, e_n$: *variable or subscripted variable*

RULES:

1. *a is the file number from the GECOS file card which indicates the input device to be used.*

2. *The format string is in the same form as the format call* FORMAT *(string), i.e., no* X's *are allowed in the string.*

3. *$e_1, e_2, \ldots, e_n$ are the actual data items to be transmitted according to the format string given.*

4. *n may have the value* 0,1,2,...,9 *and indicates the number of data items.*

5. *The equivalent of this procedure call in terms of* INLIST *is as follows:*

```
'BEGIN' 'PROCEDURE' LAYOUT; FORMAT (string);
        'PROCEDURE' LIST (ITEM);
        'BEGIN' ITEM (e1); ITEM (e2);...;
                ITEM (en)
        'END';
         INLIST (a,LAYOUT,LIST)
'END'
```

6. *When the only layout procedure required is* FORMAT *and when there are nine or fewer items to be transmitted, this simpler input call may be used instead of* INLIST.

EXAMPLES:

1. INPUT 6 (05, "(ZD.D)↑\, A[1], A[2], A[3], A[4], A[5], A[6]) *This transmits 6 values according to the repeated format ZD.D*

2. INPUT 2 (07,"P,F\, B[1], B[2]) *This transmits 1 or 0 into* B_1 *and* 'TRUE' *or* 'FALSE' *into* B_2.

PURPOSE: *To indicate that data is to be transmitted for output; to specify the output device, the set-up procedure and the list procedure.*

FORM: OUTLIST (a_1, a_2, a_3)

a_1: *arithmetic expression*
a_2, a_3: *procedure identifier*

RULES:

1. a_1 *is the file number from the GECOS file card which indicates the specific output device to be used.*

2. a_2 *is the name of the set-up procedure containing the layout procedure calls.*

3. a_3 *is the name of the list procedure which contains the data items to be transmitted.*

4. *When* OUTLIST *is executed, it first calls the layout procedures then transfers back and forth to the list procedure while the actual output is taking place. See Appendix 3 for a detailed explanation of* OUTLIST.

EXAMPLES:

1.
```
OUTLIST (10,PAGE,LIST)
```

This statement causes output to take place on I/O device 10 according to the layout procedures in procedure PAGE and according to the list procedure LIST.

2.
```
'BEGIN' 'PROCEDURE' SET;
   FORMAT("3D.D,BZZD,2B3S/\);
   ...
   'PROCEDURE' OUT (A);
   'BEGIN'
      A(TOTAL);A(INTEGER);A("ANS\)
   'END';...
   OUTLIST(6,SET,OUT);...
'END'
```

This program causes the values of the two variables TOTAL and INTEGER and the string ANS to be written out on device 6.

PURPOSE: *To idicate that data is to be transmitted for output; to provide for data output without using layout procedures or a list procedure.*

FORM: OUTPUT *n* $(a, string, e_1, e_2, \ldots, e_n)$

n: *integer*
a: *arithmetic expression*
string: *format string*
$e_1, e_2, \ldots, e_n$: *arithmetic expression, Boolean expression or string*

RULES:

1. *a is the file number from the GECOS file card which indicates the output device to be used.*

2. *The format string is in the same form as the format call* FORMAT *(string), i.e., no* X's *are allowed in the string.*

3. $e_1, e_2, \ldots, e_n$ *are the actual data items to be transmitted according to the format string given.*

4. *n may have the value* 0,1,...,9 *and indicates the number of data items.*

5. *The equivalent of this procedure call in terms of* OUTLIST *is as follows:*

```
'BEGIN' 'PROCEDURE' LAYOUT; FORMAT (string);
        'PROCEDURE' LIST (ITEM);
        'BEGIN' ITEM (e1); ITEM (e2);...;
                ITEM (en)
        'END';
         OUTLIST  (a,LAYOUT,LIST)
'END'
```

6. *When the only layout procedure required is* FORMAT *and when there are nine or fewer items to be transmitted, this simpler output call may be used instead of* OUTLIST.

EXAMPLES:

1.
```
OUTPUT 3 (06,"3(2ZD.DD)\,A,B,C)
```
This statement will cause 3 values of A, B and C to be transmitted to device 6 according to the format given.

2.
```
OUTPUT 5 (09,"2(D.D'ZZ), 3S,
2BSS,I\, X↑2-3,Y↑2-3,"TOT\,
"A1\, COUNT)
```
This statement will cause 2 decimal numbers, 2 strings and an internal notation integer to be transmitted.

C. *Input/Output Control Procedures*

These procedures access system parameters and allow some control over the positioning of the I/O devices.

PURPOSE: *To position the specified file to the indicated page and line.*

FORM: POSITION (e_1, e_2, e_3)

e_1, e_2, e_3: *arithmetic expression*

RULES:

1. e_1 *represents the file from the GECOS file card.*
2. e_2 *is the page number.*
3. e_3 *is the line number.*
4. *This procedure may be used in conjunction with* SYSPARAM *to record information on a file and later make reference to it. At a particular point in a program, a call on* SYSPARAM *can be used to record the current position on a file. At a later time, if it is desired to return to that point in the file a call on* POSITION *giving the relevant page and line numbers for parameters* e_2 *and* e_3 *will reposition the file to the desired point. Note: Backpositioning on a unit record device is undefined; however, such positioning is meaningful for a unit record logical device which is assigned to a magnetic tape (other than* SYSOUT*).*

EXAMPLE:

```
POSITION(4,A-5,B)
```

Device 4 will be spaced so that it is prepared to access the line specified by the value of B on the page specified by the value of A-5.

PURPOSE: *To gain access to certain system parameters so that they may be modified.*

FORM: SYSPARAM (a_1, a_2, a_3)

a_1, a_2: *arithmetic expression*
a_3: *integer variable*

RULES:

1. *The system parameters which may be changed or read out are:*
   a. *The character, line and page pointers (p, p' and p") respectively.*
   b. *The "standard format" constant determining the number of spaces between items (k).*
   c. *The physical end of line (P) and the physical end of page (P') which are characteristic of the I/O decive.*

2. a_1 *is the file number from the GECOS file card specifying the I/O device concerned.*

3. a_2 *may have a value of* $1, 2, \ldots, 11$.
   a. *If the value of* a_2 *is* $1, 3, 5, 7, 9$ *or* 11, *the value of the system parameter in question is assigned to variable* a_3.
   b. *If the value of* a_2 *is* $2, 4, 6, 8$ *or* 10, *the value of* a_3 *becomes the new value of the system parameter.*

c. The action is as follows:

if $a_2 = 1$, $a_3 \leftarrow p$	if $a_2 = 2$, $p \leftarrow a_3$
if $a_2 = 3$, $a_3 \leftarrow p'$	if $a_2 = 4$, $p' \leftarrow a_3$
if $a_2 = 5$, $a_3 \leftarrow P$	if $a_2 = 6$, $P \leftarrow a_3$
if $a_2 = 7$, $a_3 \leftarrow P'$	if $a_2 = 8$, $P' \leftarrow a_3$
if $a_2 = 9$, $a_3 \leftarrow k$	if $a_2 = 10$, $k \leftarrow a_3$
if $a_2 = 11$, $a_3 \leftarrow p''$	

4. p and p' represent actual positions on the I/O device which are to be changed when $a_2 = 2$ and $a_2 = 4$.
   a. If $a_2 = 2$, p is tested to see if $p < a_3$. If it is, blanks are inserted until $p = a_3$. If $p \geq a_3$, a skip to the next line is performed, p is set equal to 0, and blanks are inserted until $p = a_3$.
   b. If $a_2 = 4$, p' is tested to see if $p' < a_3$. If it is, lines are advanced until $p' = a_3$. If $p' \geq a_3$, a skip is made to a new page, p' is set equal to 0, and lines are advanced until $p' = a_3$.

5. $a_2 = 6$ and $a_2 = 8$ change the physical limits of the I/O device (P and P') where this is possible (i.e., magnetic tape block length may be changed and unit record devices may have physical limits reduced, but not extended beyond the standard limits). If the limits cannot be changed and these actions are specified, the statement acts like a dummy statement.

6. *a_2 may also have a value of 21 or 22*
   a. *If the value of a_2 is 21, the file denoted by a_1 is defined as an input file.*
   b. *If the value of a_2 is 22, the file denoted by a_1 is defined as an output file.*
   c. *If the value of a_2 is 21 or 22, the value of a_3 is not significant.*

7. *The condition which requires a_2 = 21 or 22 only arises when the intended first action on a particular file uses a primitive procedure or procedure* SYSPARAM. *If this is the case, the system does not know the nature of the file and thus a call to* SYSPARAM *with a_2 = 21 or 22 would serve to define the file. e.g., If the first action with respect to file 6 is to read out the value of p by a call to* SYSPARAM *such as*

   SYSPARAM(06,1,CHAR)

   this call would have to be preceded by a call to SYSPARAM *defining 06 as an output file as follows:*

   SYSPARAM(06,22,0)

EXAMPLES:

1. SYSPARAM (8,3,LINENO) — *On device 8 the value of the line pointer is assigned to variable LINENO.*

2. SYSPARAM (5,10,3) — *For device 5 the value of k is changed to 3, i.e., 3 or more blanks must follow a number in standard format.*

D. *Primitive Procedures*

These procedures are included in the ALGOL language to allow the other Input/Output procedures to be written in ALGOL.

They are available for use by the programmer but are not intended to be general purpose routines.

PURPOSE: *To associate specific ALGOL symbols with specific integers; to read in a basic symbol from an external device as an integer.*

FORM: INSYMBOL *(e, s, v)*

e: arithmetic expression (called by value)
s: string
v: integer variable

RULES:

1. *The basic symbols contained in the string "s" are given integer values.*

2. *The symbols are assigned from left to right to the positive integers 1,2,3, etc.*

3. *This procedure acts as follows:*
   a. *It reads in the next symbol from the input device.*
   b. *If it is a basic symbol which appears in the string "s", the variable v will be assigned the integer value associated with this symbol.*
   c. *If it is a basic symbol which does not appear in the string "s", v will receive a value of 0.*
   d. *If the input symbol is not an ALGOL basic symbol, v will receive a value of minus one.*

e. *If there is no more data on the input device, v will receive a value of minus two.*

f. *If the string "s" is null, i.e.,* INSYMBOL *(e,"\,v), v will receive the standard system value for the basic symbol. (See Appendix 5).*

PURPOSE: *To calculate the length of a given string.*

FORM: LENGTH *(s)*

s: string

RULES:

1. *The result of this procedure is an integer.*

2. *It is equal to the number of basic symbols in the string "s" not including the outermost pair of string quotes.*

PURPOSE: *To permit the saving or "remembering" of labels and procedure identifiers.*

FORM: NAME (v_1, v_2, a, p)

v_1, v_2: *integer variable*
a: *statement label*
p: *procedure identifier*

RULES:

1. *If v_1 has a value of 1, the integer associated with a is assigned to v_2.*

2. *If v_1 has a value of 3, the integer associated with p is assigned to v_2.*

3. *If v_1 has a value of 2, control will be transferred to the label whose value is the same as that of v_2.*
   (Note: v_2 must have been assigned the value of a label by a previous NAME *statement.)*
   If $v_2 = 0$ the program will be terminated.

4. *If v_1 has a value of 4, control will be transferred to the procedure whose identifier has the same value as v_2.*
   (Note: v_2 must have been assigned the value of a procedure identifier by a previous NAME *statement.)*
   If $v_2 = 0$ the procedure will be a dummy procedure.

5. *The association of specific integers with labels and procedure identifiers holds only in the block in which the labels or identifiers are declared, i.e., the rules of scope for ALGOL block structure are obeyed.*

PURPOSE: *To associate ALGOL basic symbols with specific integers; to write out a basic symbol on an external device from an internally stored integer.*

FORM: OUTSYMBOL (e_1, s, e_2)

e_1, e_2: *arithmetic expression (called by value)*

s: *string*

RULES:

1. *The basic symbols in the string "s" are given integer values.*

2. *The positive integers 1, 2, 3, etc. are assigned to the symbols from left to right; leftmost = 1, next = 2, etc.*

3. *This procedure acts as follows:*
   a. *It evaluates e_2 and determines the integer which is closest to this value.*
   b. *If the value has an equivalent in string "s", the basic symbol corresponding to this value will be written on the output device.*
   c. *If the value has no equivalent in string "s" by being outside the bounds of the string, or if it is not a basic symbol, the symbol ∅ will be written on the output device.*
   d. *If the string "s" is null, i.e.,* OUTSYMBOL (e_1,"\",e_2), *the standard system values are used to determine the basic symbol which will be written on the output device. (See Appendix 5.)*

PURPOSE: *To enable the scanning of a given string (actual or formal) in a machine independent manner.*

FORM: STRING ELEMENT (s_1, v_1, s_2, v_2)

s_1, s_2: *string*
v_1, v_2: *variable*

RULES:

1. *Variable v_1 determines which symbol of s_1 is referenced, i.e., if $v_1 = 1$ it is the leftmost symbol; if $v_1 = 2$, the next, etc.*

2. *Once the symbol is chosen, its associated integer is assigned to variable v_2.*
   (Note: the associated integer is determined by encoding string s_2 as was done with the string in the procedure INSYMBOL.*)*

PURPOSE: *To determine the type of a number which is to be written out in standard format.*

FORM: TYPE (v_1,v_2)

v_1: *variable*
v_2: *variable or string*

RULES:

1. *If* v_2 *is a string,* v_1 *is set equal to 4.*

2. *If* v_2 *is a variable,* v_1 *is assigned a different value depending on the type of* v_2 *as follows:*
   a. *If* v_2 *is* 'INTEGER', $v_1 \leftarrow 1$.
   b. *If* v_2 *is* 'REAL', $v_1 \leftarrow 2$.
   c. *If* v_2 *is* 'BOOLEAN', $v_1 \leftarrow 3$.
   d. *If* v_2 *is* 'EXTENDED REAL', $v_1 \leftarrow 8$.

E. *List Procedure*

This procedure is written by the programmer to be used with the I/O procedures provided by ALGOL.

PURPOSE: *To list a sequence of quantities to be transmitted for input or output; this list is used in conjunction with the format items of a* FORMAT *call.*

FORM: 'PROCEDURE' *name (ident); s*

name: *procedure identifier*
ident: *identifier*
s: *simple statement, compound statement or block*

RULES:

1. *The formal parameter "ident" appears in the body of the list procedure as a procedure identifier.*

2. *Each item to be transmitted for input or output appears in the procedure body as the parameter for procedure ident.*
   Example:
   'PROCEDURE' A(X); 'BEGIN' X(M); X(N); X(P) 'END'
   M, N and P are transmitted.

3. *When the list procedure is called by a data transmission procedure (*INLIST *or* OUTLIST*), an internal system procedure (*INITEM *or* OUTITEM*) will be the actual parameter corresponding to the formal parameter "ident," and thus will be substituted for "ident" in the list procedure body.*

4. *Execution of the list procedure causes the internal system procedure (*INITEM *or* OUTITEM*) to be executed.* INITEM *or* OUTITEM *has as its parameter the item to be transmitted.*

5. *This parameter may be an arithmetic expression, Boolean expression or a string for output. However, the parameter may be only a variable or subscripted variable for input.*

6. *The item is called by name by the internal system procedure and its value is transmitted for input or output.*

7. *The sequence of statements in the list procedure body determines the sequence in which the items are transmitted for input or output.*

8. *All ALGOL statements are permissible in a list procedure including a call to one or more of the layout procedures.*

EXAMPLES:

1.
```
'PROCEDURE' LIST (NAME);
'BEGIN' NAME(X); NAME (Y↑3*Z);
NAME ("TOTAL\) 'END'
```

*The identifier NAME is replaced by a system procedure name when the list procedure is called. X, Y↑3*Z and "TOTAL\ are parameters to this system procedure and their values will be transmitted.*

2.
```
'PROCEDURE' MANY (ITEM);
'FOR' I←1 'STEP' 1 'UNTIL'
10 'DO' 'BEGIN' ITEM (A[I]);
ITEM (B[I]) 'END'
```

The items to be transmitted are $A_1, B_1, A_2, B_2, \ldots, A_{10}, B_{10}$.

APPENDIX 1

RESERVED IDENTIFIERS

The following list enumerates reserved identifiers. These identify functions and procedures which are available without explicit declarations. These functions and procedures are assumed to be declared in a block external to the program. However, a programmer may redeclare a reserved identifier, in which case the reserved meaning is superseded.

The reserved identifiers are as follows:

ABS
ARCTAN
BAD DATA
COS
ENTIER
EQUIV
EXP
FORMAT
FORMAT 0
FORMAT 1
FORMAT 2
FORMAT 3
FORMAT 4
FORMAT 5
FORMAT 6
FORMAT 7
FORMAT 8
FORMAT 9
HEND
HLIM
INLIST
INPUT 0
INPUT 1
INPUT 2
INPUT 3
INPUT 4
INPUT 5
INPUT 6
INPUT 7
INPUT 8
INPUT 9
INSYMBOL
LENGTH
LN
NAME
NO DATA
OUTLIST
OUTPUT 0
OUTPUT 1
OUTPUT 2
OUTPUT 3
OUTPUT 4
OUTPUT 5
OUTPUT 6
OUTPUT 7
OUTPUT 8
OUTPUT 9
OUTSYMBOL
POSITION
SIGN
SIN
SQRT
STRINGELEMENT
SYSPARAM
TABULATION
TYPE
VEND
VLIM

APPENDIX 2

MATHEMATICAL FUNCTIONS

Form	*Description*
ABS(*e*)	*absolute value of the expression e*
ARCTAN(*e*)	*principal value of the arctangent of e*
COS(*e*)	*cosine of e*
ENTIER(*e*)	*the integral part of e*
EXP(*e*)	*exponential function of e*
LN(*e*)	*natural logarithm of e*
SIGN(*e*)	*sign of e (+1 if e>0, 0 if e = 0, -1 if e<o)*
SIN(*e*)	*sine of e*
SQRT(*e*)	*square root of e*

These functions are available without explicit declarations. They are assumed to be declared in a block external to the program. However, a programmer may redeclare a mathematical function identifier, in which case the standard meaning is superseded.

These functions accept parameters of types 'REAL', 'EXTENDED REAL' *and* 'INTEGER'. *They all yield values of type* 'EXTENDED REAL', *except for* ENTIER(*e*) *and* SIGN(*e*) *which yield values of type* 'INTEGER'.

The parameters of these functions are treated as 'VALUE' *parameters.*

APPENDIX 3

DETAILED EXPLANATION OF INLIST

Let us assume:

1. INLIST *has been called.*

2. *Lines 1,2,...,p' of the current page have been read.*

3. *Characters 1,2..,p of the current line (line p' + 1) have been read.*

4. *At the beginning of the program p = p' = 0.*

5. *Symbols P and P' denote line size and page size respectively.*

6. *There are eight hidden variables H1, H2,...H8 which correspond to the eight layout procedures as follows:*

   H1 - FORMAT
   H2 - H LIM
   H3 - V LIM
   H4 - H END
   H5 - V END
   H6 - TABULATION
   H7 - NO DATA
   H8 - BAD DATA

7. *The left margin of* H LIM *is L.*
   The right margin of H LIM *is R.*
   The top margin of V LIM *is L'.*
   The bottom margin of V LIM *is R'.*

STEP 1. (Initialization)

The hidden variables are set to standard values:

H1 is set to the "standard" format.

H2 is set so that L = 1, R = ∞.

H3 is set so that L' = 1, R' = ∞.

H4 is set so that the three parameters are all effectively equal to the dummy procedure defined as follows: 'PROCEDURE' DUMMY;;.

H5 is set so that the three parameters are all effectively equal to the dummy procedure, DUMMY.

H6 is set so that TAB = 1.

H7 is set to terminate the program in case the data ends.

H8 is set to terminate the program if an unacceptable character is received for format translation.

STEP 2. (Layout)

The layout procedure is called; this may change some of the variables H1, H2, H3, H4, H5, H6, H7, H8. Set T to 'FALSE'. *(T is a Boolean variable used to control the sequencing of data with respect to title formats; T =* 'TRUE' *means a value has been requested of the procedure which has not yet been input.)*

STEP 3. (Communication with List Procedure)

The next format item of the format string is examined. (Note: after the format string is exhausted, "standard" format is used from then on until the end of the procedure. In particular, if the format string is "\, standard format is used throughout.) Now if the next format item is a title format, that is, requires no data item, we proceed directly to Step 4. If T = 'TRUE', *proceed to Step 4. Otherwise, the list procedure, is activated. This is done the first time by calling the list procedure, using as actual parameter a procedure named* IN ITEM.

This is done on all subsequent times by merely returning from the procedure IN ITEM *which will cause the list procedure to be continued from the latest* IN ITEM *call. (Note: the identifier* IN ITEM *has scope local to* IN LIST *so a programmer may not call this procedure directly.) After the list procedure has been activated in this way, it will either terminate or will call the procedure* IN ITEM. *In the former case, the input process is completed; in the latter case, T is set to* 'TRUE'. *Then any assignments to hidden variables that the list procedure may have invoked will cause adjustment to the variables H1, H2, H3, H4, H5, H6, H7, H8, (which are local to* IN ITEM*). We then continue at Step 4.*

STEP 4. (Alignment Marks)
If the next format item includes alignment marks at its left, remove them from the format and execute process A (a subroutine below) for each "/", process B for each "↑", and process C for each "J".

STEP 5. (Get within Margins)
Execute process G to ensure proper page and line alignment.

STEP 6. (Formatting for Input)
Take the next item from the format string.

NOTES:
In unusual cases, the list procedure or an overflow procedure may have called the descriptive procedure FORMAT *thereby changing the format string. In such cases, the new format string is examined from the beginning; and it is conceivable that the format items examined in Steps 3, 4, and 6 might be three different formats. But at this point the current format item is effectively removed from the format string and copied elsewhere so that the format string itself, possibly changed by further calls of* FORMAT, *will not be interrogated until the next occurrence of Step 3.*

Alignment marks at the left of the format item are ignored. If the format item is not composed only of alignment marks and insertions, the value of T is examined. If T = 'FALSE', *undefined action takes place (the programmer has substituted a nontitle format for a title format in an overflow procedure, and this is not allowed). Otherwise, T is set to* 'FALSE'. *If the format item is "A" or "N", set s = 1 and go to Step 7; otherwise, the number of characters, s, needed to input the format item for the present medium is determined, and it is assumed that the same number of character positions will be used in the input medium for this item.*

STEP 7. (Check for Overflow)
If the present item uses "N" format, the character positions p + 1, p + 2,... are examined until either a proper termination of the number has been found, or position min (R,P) has been reached with no sign, digit, decimal point, or "'" encountered. In the former case, set s to the number of character positions occupied by the number, including preceding and embedded blanks and the termination character, and then go to Step 9; in the latter case, go to Step 8 with p = min (R,P).

If the present item uses "A" format, the character position p + 1 is examined, if it contains "γ", set p = min (R,P) and go to Step 8, otherwise input characters starting from position p + 1 until a basic symbol has been input. Set s to the number of characters denoting the basic symbol and go to Step 9. Finally, if neither "N" nor "A" format is used, go to Step 8 or Step 9 according as p + s > min (R,P) or not.

STEP 8. *(Processing of Overflow)*

Perform process H (p + s). Then proceed as follows:

"N" format: Input characters until either finding a number followed by a proper termination (go to Step 9) or until reaching position min (R,P). In the latter case, a partial number may have been examined; repeat Step 8 until a number properly terminated has been input. In the former case, set s to the number of positions occupied by that portion of the number lying to the right of p, including embedded blanks and the termination character, then go to Step 9.

"A" format: Input characters as with "N" format until a basic symbol has been input. (This basic symbol necessarily takes several character positions on the medium.)

Other: If p + s < R and p + s ≤ P, go to Step 9; otherwise input k = min (R,P) - p characters, set p = min (R,P), decrease s by k, and repeat this step.

STEP 9. *(Finish the Item)*

If neither "A" nor "N" format is being used, input s characters. Determine the value of the item that was input here, or Steps 7 and 8 in case of "A" or "N" format, using the rules of format. Assign this value to the actual parameter of IN ITEM *unless a title format was specified. Increase p by s.*

Any alignment marks at the right of the format item now cause activation of process A for each "/", process B for each "↑", and process C for each "J". Return to Step 3.

PROCESS A. *("/" Operation)*

Check page alignment with process F, then execute process D and call procedure p1 of H END.

PROCESS B. *("↑" Operation)*

If p > 0, execute process D and call procedure p1 of H END. *Then execute process E and call procedure p1 of* V END.

PROCESS C. *("J" Operation)*

Check page and line alignment with process G. Then let k = ((p - L + 1)% TAB + 1) x TAB + L - 1 (the next "tab" setting for p), where TAB is the "tab" spacing for this channel. If k > min (R,P), perform process H(k); otherwise skip over character positions until p = k.

PROCESS D. *(New Line)*

Skip the input medium to the next "line," set p = 0, and set p' = p' + 1.

PROCESS E. *(New Page)*

Skip the input medium to the next "page," and set p = 0.

PROCESS F. *(Page Alignment)*

If p' + 1 < L', execute process D until p' = L' - 1.

If p' + 1 > R', execute process E, call procedure p2 of V END *and repeat process F.*

If p' + 1 > P', execute process E, call procedure p3 of V END *and repeat process F.*

This process must terminate because 1 ≤ L' ≤ R' and 1 ≤ L' ≤ P'. If a programmer chooses a value of L' > P', L' is set equal to 1.

PROCESS G. *(Page and Line Alignment)*

Execute process F. Then,

If p + 1 < L, skip over character positions until p + 1 = L.

If p + 1 > R or p + 1 > P, perform process H (p + 1).

This process must terminate because 1 ≤ L ≤ R and 1 ≤ L ≤ P. If a programmer chooses a value of L > P, L is set equal to 1.

PROCESS H(k). *(Line Overflow)*

Perform process D. If k > R, call procedure p2 of H END*; otherwise call p3. Then perform process G to ensure page and line alignment.*

Note: Upon return from any of the overflow procedures, and assignments to hidden variables that have been made by calls on descriptive procedures will cause adjustment to the corresponding variables H1, H2, H3, H4, H5, H6, H7, H8.

EXAMPLE:

Notice that the programmer has the ability to determine the presence of absence of data on a card when using standard format, because of the way overflow is defined. The following program, for example, will count the number n of data items on a single input card and will read them into A[1], A[2],...,A[n]. (Assume unit 5 is a card reader.)

```
'PROCEDURE' LAY; H END (EXIT, EXIT, EXIT);
'PROCEDURE' LIST (ITEM); ITEM (A[N+1]);
'PROCEDURE' EXIT; 'GO TO' L2;
N←0; LI: INLIST (5, LAY, LIST);
N←N + 1; 'GO TO' LI;
L2:;
```

DETAILED EXPLANATION OF OUTLIST

Let us assume:

1. OUTLIST *has been called.*

2. *Lines* $1,2,\ldots,p'$ *of the current page have been completed.*

3. *Characters* $1,2,\ldots,p$ *of the current line (line* $p' + 1$*) have been completed.*

4. *At the beginning of the program* $p = p' = 0$.

5. *Symbols* P *and* P' *denote the line size and page size respectively.*

6. *There are eight hidden variables* $H1,H2,\ldots,H8$ *which correspond to the eight layout procedures as follows:*

   H1 - FORMAT
   H2 - H LIM
   H3 - V LIM
   H4 - H END
   H5 - V END
   H6 - TABULATION
   H7 - NO DATA
   H8 - BAD DATA

7. *The left margin of* H LIM *is* L.
   The right margin of H LIM *is* R.
   The top margin of V LIM *is* L'.
   The bottom margin of V LIM *is* R'.

STEP 1. *(initialization)*

The hidden variables are set to the following standard values:

H1 is set to the "standard" format.

H2 is set so that L = 1, R = ∞.

H3 is set so that L' = 1, R' = ∞.

H4 is set so that the three parameters are all effectively equal to the dummy procedure defined as follows: 'PROCEDURE' DUMMY;;.

H5 is set so that the three parameters are all effectively equal to the dummy procedure, DUMMY.

H6 is set so that TAB = 1.

STEP 2. *(Set-Up)*

The set-up procedure is called; this may change some of the variables H1, H2, H3, H4, H5, H6. Set T to 'FALSE'. *(T is a Boolean variable used to control the sequencing of data with respect to title formats; T =* 'TRUE' *means a value has been transmitted to the procedure which has not yet been output.)*

STEP 3. *(Communication with List Procedure)*

The next format item of the formt string is examined. (Note: after the format string is exhausted, "standard" format is used from then on until the end of the procedure. In particular, if the format string is "\, standard format is used throughout.) Now if the next format item is a title format, that is, requires no data item, we proceed directly to Step 4. If T = 'TRUE' *proceed to Step 4. Otherwise, the list procedure is activated; this is done the first time by calling the list procedure, using as actual parameter a procedure named* OUT ITEM; *this is done on subsequent times by merely returning from the procedure* OUT ITEM, *which will cause the list procedure to be continued from the latest* OUT ITEM *call.*

(Note: the identifier OUT ITEM *has scope local to* OUT LIST*, so a programmer may not call this procedure directly.) After the list procedure has been activated in this way, it will either terminate or will call the procedure* OUT ITEM*. In the former case, the output process is completed; in the latter case, T is set to* 'TRUE' *and any assignments to hidden variables that the list procedure may have invoked will cause adjustment to the variables H1, H2, H3, H4, H5, H6 (which are local to* OUT ITEM*) and we then continue to Step 4.*

STEP 4. (Alignment Marks)
If the next format item includes alignment marks at its left remove them from the format and execute process A (a subroutine below) for each "/", process B for each "↑", and process C for each "J".

STEP 5. (Get Within Margins)
Execute process G to ensure proper page and line alignment.

STEP 6. (Formatting the Output)
Take the next item from the format string.

NOTES:
In unusual cases, the list procedure or an overflow procedure may have called the descriptive procedure FORMAT*, thereby changing the format string. In such cases, the new format string is examined from the beginning, and it is conceivable that the format items examined in Steps 3, 4, 6 might be three different formats. But at this point the current format item is effectively removed from the format string and copied elsewhere, so that the format string itself, possibly changed by further calls of* FORMAT*, will not be interrogated until the next occurrence of Step 3.*

Alignment marks at the left of the format item are ignored. If the format item is not composed only of alignment marks and insertions, the value of T is examined. If T = 'FALSE', undefined action takes place (the programmer has substituted a nontitle format for a title format in an overflow procedure, and this is not allowed). Otherwise, the output item is evaluated and T is set to 'FALSE'. Now the rules of format are applied, and the characters $X_1X_2...X_s$ which represent the formatted output on the external medium are determined. (Note that the number of characters, s, may depend on the value being output, using "A" or "S" format, as well as on the output medium.)

STEP 7. (Check for Overflow)
If $p + s \leq R$ and $p + s \leq P$, where s is the size of the item as determined in Step 6, the item will fit on this line, so go on to Step 3. Otherwise, if the present item uses "A" format, output a special symbol "γ" which is recognizably not a basic symbol; this is done to ensure the input will be inverse to output. Go to Step 8.

STEP 8. (Processing of Overflow)
Perform process H (p + s). Then, if $p + s \leq R$ and $p + s \leq P$, go to Step 9; otherwise let $k = min (R,P) - p$. Output $X_1X_2...X_k$, set $p = min (R,P)$ and then let $X_1X_2...X_{s-k} = X_{k+1} + X_{k+2}...X_s$. Decrease s by k and repeat Step 8.

STEP 9. (Finish the Item)
Output $X_1X_2...X_s$, and increase p by s. Any alignment marks at the right of the format item now cause activation of process A for each "/", process B for each "↑", and process C for each "J". Return to Step 8.

PROCESS A. *("/" Operation)*

Check page alignment with process F, then execute process D and call procedure p1 of HEND.

PROCESS B. *("↑" Operation)*

If p > 0, execute process D and call procedure p1 of HEND. *Then execute process E and call procedure p1 of* VEND.

PROCESS C. *("J" Operation)*

Check page and line alignment with process G. Then let k = ((p-L+1) % TAB + 1) x TAB + L - 1 (the next "tab" setting for p), where TAB is the "tab" spacing for this channel. If k ≥ min (R,P), perform process H(k); otherwise effectively insert blanks until p = k.

PROCESS D. *(New Line)*

Skip the output medium to the next "line," set p = 0, and set p' = p' + 1.

PROCESS E. *(New Page)*

Skip the output medium to the next "page," and set p' = 0.

PROCESS F. *(Page Alignment)*

If p' + 1 < L' execute process D until p' = L' - 1. If p' + 1 > R', execute process E, call procedure p2 of V END, *and repeat process F. If p' + 1 > P', execute process E, call procedure p3 of* V END *and repeat process F.*

This process must terminate because 1 ≤ L' ≤ R' and 1 ≤ L ≤ P'. If a programmer chooses a value of L' > P', L' is set equal to 1.

PROCESS G. *(Page and Line Alignment)*

Execute process F. Then if p + 1 < L, effectively output blank spaces until p + 1 = L.

If p + 1 > R or p + 1 > P, perform process H (p + 1).

This process must terminate because 1 ≤ L ≤ R and 1 ≤ L ≤ P. If a programmer chooses a value of L > P, L is set equal to 1.

PROCESS H(k). *(Line Overflow)*

Perform process D. If k > R, call procedure p2 of H END*; otherwise, call procedure p3 of* H END*. Then perform process G to ensure page and line alignment. Note: upon return from any of the overflow procedures, any assignments to hidden variables that have been made by calls on descriptive procedures will cause adjustment to the corresponding variables H1, H2, H3, H4, H5, H6.*

APPENDIX 4

PROCEDURES FOR PREPARING ALGOL PROGRAMS FOR COMPILATION AND EXECUTION

An ALGOL compilation will consist of either a block or a procedure declaration. In the first case what is produced is a free-standing program which may call external procedures but which is assumed to operate otherwise as a free-standing program. In the second case the result is a separately compiled procedure which may be called by another program.

In either case, the program is keypunched and submitted to the 625/35 computer following a control card of the form:

col. 1 8 16

$ ALGOL OPTIONS

where the following options are allowed

LSTIN	An input listing will be furnished
NLSTIN	No input listing will be furnished
DECK	A binary program deck will be output
NDECK	No binary program deck will be output
COMDK	A comdeck of the source program will be output
NCOMDK	No comdeck of the source program will be produced

where the underlined options are assumed in the absence of information to the contrary.

For the case in which a procedure is being compiled by itself, it is possible to redefine the procedure name for purposes of external reference. This is accomplished by using the ALGOL word 'RENAME' followed by a string of six or fewer characters which defines the desired external name or SYMDEF. The rename string may consist only of alphabetics, numerics and the decimal point. This construct, if used, must immediately follow the formal parameter list.

EXAMPLE:

```
col. 1      8         16
     $      ALGOL     OPTIONS
        'PROCEDURE' INPUT 0(unit, string); 'RENAME' ".A0IPT ;
           'VALUE' unit; 'INTEGER' unit;
           'BEGIN'
```

The above example defines the beginning of the job deck for a procedure, INPUT 0, *being compiled by itself. Within this procedure all references to itself, as in recursive calls or passage as an actual parameter, would be to* INPUT 0. *The symbolic for a SYMREF in any other program desiring to reference this procedure would have to be .A0IPT.*

To run an ALGOL execution activity the following deck setup is required:

```
     $      OPTION   ALGOL, options
          { binary decks or ALGOL compilations
            as defined above
     $      EXECUTE
    { $     FFILE                                 }
    { $     < Physical device assignment >        }
```

The $ OPTION card with option ALGOL is required for every execution activity containing at least one deck produced by the ALGOL compiler. It must be the first card of the execution activity. Other options, as desired, may be used on this card but ALGOL is required.

The $ FFILE and < Physical device assignment > cards are enclosed in braces to indicate they may or may not be required for a particular activity. Cards of the form $ TAPE, DISC, PRINTER (as desiribed in the GECOS manual) define physical devices which are to be associated with files referenced in the ALGOL program through calls on the input output data transmission procedures. A card of this type is required for every referenced file other than 05 and 06 and input files produced with the $ DATA card.

The $ FFILE card, as described in the GECOS manual, provides fine control over the characteristics of each logical field. With respect to an ALGOL activity, the option DSTCOD should be considered. It is of the form:

DSTCOD/XXX

where XXX may be any of the following:

Mnemonic	*Device*
PRNTR	*Line Printer*
BCRDR	*Card Reader (Binary)*
DCRDR	*Card Reader (Decimal)*
BCPNCH	*Card Punch (Binary)*
DCPNCH	*Card Punch (Decimal)*
MTAPE	*Magnetic Tape*
DISC	*Disk*
DRUM	*Drum*

The destination code subfield (DSTCOD) defines the type of logical device which is to be associated with a file, independent of the physical device on which the file may reside. In this way the system limits, i.e., P and P' for a file are defined. For example, to produce a listing file which must be saved on tape for future reference a $ TAPE card would provide the physical assignment and $ FFILE nn, DSTCOD/PRNTR would define the output as destined for a line printer. In the absence of the FFILE card or the DSTCOD subfield the logical device will be assumed the same as the physical device.

APPENDIX 5

BASIC SYMBOLS WITH EQUIVALENT INTERNAL INTEGER VALUES

SYMBOL	*VALUE*	*SYMBOL*	*VALUE*
A	*32*	'GQ'	*163*
B	*33*	'GR'	*164*
C	*34*	'NQ'	*159*
D	*35*	'EQV'	*154*
E	*36*	'IMP'	*155*
F	*37*	'OR'	*156*
G	*38*	'AND'	*157*
H	*39*	'NOT'	*158*
I	*40*	.	*511*
J	*41*	,	*172*
K	*42*	:	*178*
L	*43*	;	*176*
M	*44*	(	*152*
N	*45*	)	*174*
O	*46*	[	*153*
P	*47*	]	*173*
Q	*48*	"	*182*
R	*49*	\	*183*
S	*50*	'	*510*
T	*51*	←	*144*
U	*52*	⍬	*181*
V	*53*	'ARRAY'	*134*
W	*54*	'BEGIN'	*128*
X	*55*	'BOOLEAN'	*133*
Y	*56*	'CODE'	*140*
Z	*57*	'COMMENT	*180*
0	*0*	'DO'	*148*
1	*1*	'ELSE'	*151*
2	*2*	'END'	*175*
3	*3*	'EXTENDED REAL'	*131*
4	*4*	'FOR'	*143*
5	*5*	'GO TO'	*142*
6	*6*	'IF'	*149*
7	*7*	'INTEGER'	*132*
8	*8*	'LABEL'	*138*
9	*9*	'NONLOCAL'	*141*
'TRUE'	*509*	'OWN'	*129*
'FALSE'	*510*	'PROCEDURE'	*135*
+	*165*	'REAL'	*130*
-	*167*	'RENAME'	*184*
×	*168*	'STEP'	*145*
/	*169*	'STRING'	*139*
%	*170*	'SWITCH'	*136*
↑	*171*	'THEN'	*150*
'LS'	*160*	'UNTIL'	*146*
'LQ'	*161*	'VALUE'	*137*
'EQ'	*162*	'WHILE'	*147*

INDEX

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