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A Translator System for the EULER Programming Language

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Abstract

A Translator System for the EULER Programming Language.

EULER is a generalization of the ALGOL programming language, combining the ALGOL capabilities with many features similar to McCarthy's LISP language. In this paper, a new syntax is presented for EULER, together with a notation that specifies how EULER is translated. A fast, pushdown-automaton model was used as a basis for designing the translator system, and the design methods used for a portion of the translator are presented. Syntactic methods of machine-independent optimization of the translated language are discussed, and a syntactic notation for designing "extendible compilers" in terms of the EULER language is introduced.

The second section of the report is a documentation of the intermediate language into which the EULER is translated. Algorithms for executing the commands of this intermediate language are described, and versions of the programmed algorithms, rewritten in a subset of EULER, are presented.

The appendices contain listings of the actual translator and intermediate language interpreter for the EULER system. These listings consist of FORTRAN IV-MAP programs written for the IBM 7094 computer.

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Part I. The EULER Translator

Introduction

In a previous paper (7), we introduced methods of designing programming language translators using a pushdown automaton model and a notation for specifying how the language of the translator is mapped into its translation. In that paper, a very small programming language was used in the design of a small translator system for purposes of demonstration. This paper will present a much expanded example of translator design based on the EULER programming language of Wirth and Weber (11). Much of the discussion in this paper will draw upon results and notation used in the previous paper.

Our first order of business is a syntax of EULER. Readers of the Wirth and Weber paper will note that the original EULER grammar was written in a very stylized fashion with many extra symbols introduced in order to fit the grammar into the framework of the Wirth and Weber translation algorithm. The EULER syntax to be presented in this report has been rewritten, not for the purpose of conforming to another translation algorithm, but to show that a more nearly transparent syntax can still yield an acceptable translator. In fact, the original EULER syntax would also "work" in our system, and the new version of the EULER syntax might be thought of as an exercise in aesthetics.

During the writing of the EULER translator system, an idea began to take shape concerning simple and clever methods for extending the EULER language and for using syntactic methods for the purpose of producing partially optimized code from the translator. These methods will be discussed in the following sections that deal with optimizations and methods of extending the system.

Readers interested in learning how to use the EULER language are referred to the extremely well written presentation in the original EULER paper (11). That paper contains examples of EULER programs, a few of which have typographic errors that the careful reader can use to test his knowledge of the language. Because the EULER report deals only with the reference language (i.e., had numerous symbols not available on many card-punch machines), an appendix is included with this paper to indicate the programming conventions used with the University of Maryland EULER system. This appendix might also be a useful first guide to EULER for programmers who know some ALGOL.

An EULER Translation Grammar

The notation for the following grammar is an extension of the notation used in the previous report. In this notation, syntactic rules specifying the programming language are paired with rules of translation that specify how the language is translated, as in the following example:

Syntactic Rule	Rule of Translation
<sum> → <term>	I
| +<term>	<term>
| -<term>	<term>.NEG.
| <sum>+<term>	<sum><term>+
| <sum>-<term>	<sum><term>-

In this example, sequences of symbols are rearranged in the process of translation. Thus, the infix addition of "<sum>+<term>" is translated into the reverse Polish addition of "<sum><term>+". The unary plus sign in the sequence "+<term>" is discarded in the translated sequence for <term>. When the <term> stands by itself as a descendant of a <sum>, no symbols are added or deleted in the translation (hence, the notation used is I for Identity Translation).

In the rules of translation for the full grammar, there are certain sequences of symbols whose meaning may not seem obvious on a first reading. For example, to understand why the EULER statement

"A=B*C+D.IN..,"

is translated into the sequence

".VRBL.A .VRBL.B .IN. .VRBL.C .IN.* .VRBL.D.IN..IN.+=.,"

it is well to know something about how pointers to data are manipulated in the EULER reverse POLISH string interpreter. This interpreter is described in the next section. To understand why the EULER statement

".IF.A.AND.B..THEN.C.ELSE.D.,"

is translated into the sequence

".VRBL.A.IN..FAND..VRBL.B.IN..SAND..IF..VRBL.C.IN..SWCH..THEN..NOT..IF..
VRBL.D..IN..SWCH..THEN..,.,"

it is well to read the following section on syntactic methods of producing optimized translations as well as the interpreter description. The descriptions of EULER programming in this paper and in the Wirth and Weber article will also be quite useful.

The full EULER grammar follows. A comparison of this grammar with the original one will satisfy the interested reader that the languages are virtually identical, although the grammars are different in form.

The Grammar

Syntactic Rule	Rule of Translation
<program>→.ENTRY<block>.EXIT.	<block>
<block>→<blockhead><body>.END	I
<blockhead>→.BGIN.	I
|<blockhead><labeldec>.,	<blockhead><labeldec>
|<blockhead><vardec>.,	<blockhead><vardec>
<vardec>→.NEW.<name>	.NEW.<name>
|<vardec>,<name>	<vardec>.NEW.<name>
<labeldec>→.LABL.<name>	.LABL.<name>
|<labeldec>,<name>	<labeldec>.LABL.<name>
<body>→<body>.,<stat>	I
|<stat>	I
<stat>→<labeldef><stat>	I
|<expr>	I
<labeldef>→<name>..	.LBDF.<name>
<expr>→<block>	I
|<disj>	I
|<var>=<expr>	<var><expr>=
|.GOTO.<prim>	<prim>.GOTO.
|.OUT.<prim>	<prim>.OUT.
|<condition><consequence><alternative>	I
<condition>→.IF.<expr>	<expr>.IF.
<consequence>→.THEN.<expr>	<expr>.SWCH..THEN..NOT..IF.
<alternative>→.ELSE.<expr>	<expr>.SWCH..THEN..,
<disj>→<conj>	I
|<disj>.OR.<conj>	<disj>.FSOR.<conj>.SCOR.
<conj>→<neg>	I
|<conj>.AND.<neg>	<conj>.FAND.<neg>.SAND.
<neg>→<relation>	I

Syntactic Rule	Rule of Translation
|.NOT.<relation>	<relation>.NOT.
<relation>→<sum>	I
|<sum>(1)<relop><sum>(2)	<sum>(1)<sum>(2)<relop>
<relop>→{.EQ.|.NEQ.|	
.GT.|.GEQ.|.LT.|.LEQ.}	I
<sum>→<term>	I
|+<term>	<term>
|-<term>	<term>.NEG.
|<sum>{+|-}<term>	<sum><term>{+|-}
<term>→<factor>	I
|<term>{*|/|./.|.MDLO.}<factor>	<term><factor>{*|/|./.|.MDLO.}
<factor>→<catena>	I
|<factor>**<catena>	<factor><catena>**
<catena>→<prim>	I
|<catena>.CNCT.<prim>	<catena><prim>.CNCT.
<prim>→.UNDF.	I
|<var>	<var>.IN.
|<label>	<label>.IN.
|(<expr>)	<expr>
|<procdef>	I
|<referenceprim>	I
|<listprim>	I
|<numberprim>	I
|<logicalprim>	I
|.TAIL.<prim>	<prim>.TAIL.
|<var><list>	<var>.LSCL.<list>
|<symbolprim>	I
<label>→<name>	.VRBL.<name>
<var>→<name>	.VRBL.<name>
|<var>.IN.	<var>.IN.
|<var>(<sum>)	<var><sum>)
<referenceprim>→.AT.<var>	<var>
<listprim>→<list>	I

Syntactic Rule	Rule of Translation
|.LIST.<sum>	<sum>.LIST.
<list>→<listhead>).	I
|<listhead><expr>).	I
<listhead>→.(	I
<listhead><expr>,	I
<numberprim>→<number>	.NMBR.<number>
|.REAL.<disj>	<disj>.REAL.
|.LNGT.<catena>	<catena>.LNGT.
|.ABST.<sum>	<sum>.ABST.
|.INTG.<sum>	<sum>.INTG.
<logicalprim>→.TRUE.	I
|.FLSE.	I
|.LGCL.<sum>	<sum>.LGCL.
|<typeinquiry><var>	<var><typeinquiry>
<typeinquiry>→{.ISNU.| .ISLO.|.ISLA.|.ISLI.|.ISPR.| .ISRE.|.ISSY.|.ISUN.}	I
<symbolprim> →.* <6-symbolstring>	I
<procdef>→<prochead><expr>$.	I
<prochead>→.$	I
|<prochead><formaldec>.,	<prochead><formaldec>
<formaldec>→.FRML.<name>	.FRML.<name>
|<formaldec>,<name>	<formaldec>.FRML.<name>
<6-symbolstring> → {<letter>|<digit>|<blank> |,|.|$\|*\|?\|=\|+\|-\|)\|(}^{6} (i.e., 6 characters)	I
<name>→{<letter>{<letter>|<digit>}^{k}, k=0,1,...,5} (i.e., a name is a letter followed by up to five letters or digits.)	I
<number>→<integer>	TEMP(1)
|<integer>$^{(1)}$.<integer>$^{(2)}$	TEMP(1)+SCALExTEMP(2)
<integer>→<digit>	SCALE←0.1; TEMP(i)←value.(<digit>).;

Syntactic Rule	Rule of Translation
|<integer><digit>	TEMP(i)←10xTEMP(i)+value.(digit).; SCALE 0.1xSCALE;
<digit>→{0|1|...|9}	I
<letter>→{A|B|...|Z}	I

Syntactic Methods for Optimizing Expressions

At two points in the grammar above, the rules of translation specify translated sequences of symbols that are not in reverse Polish. The motivation for doing this in the grammar is to provide a framework for executing the resulting expressions so as to skip over redundant portions of the translated string. One of the instances of this translated structure is the rule

<disj>→<disj>.OR.<conj>.

In ordinary Polish notation, the rule of translation would be the sequence

<disj><conj>.OR.

However, this translation does not take into account the fact that, if the <disj> is .TRUE., there is no need to evaluate the <conj> in the expression.

It was decided instead to write the rule of translation as follows:

<disj>.FSOR.<conj>.SCOR.

When this translated expression is executed, the .FSOR. operator is read immediately after the <disj> portion of the expression is evaluated. The effect of executing .FSOR. is to cause the interpreter to skip over the <conj> when the <disj> is evaluated as .TRUE. . In order to skip over the segment of program between .FSOR. and .SCOR., the interpreter routine treats the program text as though it were a table of labels, and scans ahead until it encounters an .SCOR. that matches the .FSOR. by which the routine was activated. Thus, the .SCOR. operator is not executed by the interpreter, but is used as a place marker in the translated program.

The syntactic rule <conj>→<conj>.AND.<neg>
is matched with the translation rule

<conj>.FAND.<neg>.SAND.

for the same reason as given above. In this case, if <conj> has logical value .FLSE., the translated program segment between .FAND. and .SAND. is skipped over by the interpreter routine.

A similar rationale was used in determining the rules of translation used for conditional statements. In this case, it was decided to break down EULER conditional statements from the form

".IF.<expr>$^{(1)}$.THEN.<expr>$^{(2)}$.ELSE.<expr>$^{(3)}$.,"

into the form ".IF.<expr>$^{(1)}$.THEN.<expr>$^{(2)}$

.IF..NOT.<expr>$^{(1)}$.THEN.<expr>$^{(3)}$.,".

In order to avoid evaluating <expr>(1) twice in the translated program, the following strategy was developed:

At run time, the EULER Polish interpreter stores the values of evaluated expressions in sequence on top of a stack of operands. It is therefore possible to retain the value of <expr>(1) for re-use in the translated program. Thus, the actual translation of the conditional statement above is the following sequence:

"<expr>(1) .IF.<expr>(2) .SWCH..THEN..NOT..IF.<expr>(3) .SWCH..THEN..,.,"

Here, the .IF. command leaves the value of <expr>(1) in place on the operand stack. If <expr>(1) is true, <expr>(2) is evaluated, and, by the EULER conventions, <expr>(2) will also reduce to a single value. When <expr>(2) is completed, the operand stack will contain the sequence

value.(<expr>(1))., value.(<expr>(2)).

as the two topmost operands. It is then only necessary to switch these two operands (using the .SWCH. command), negate the topmost operand (using .NOT.), and skip over <expr>(3) to the .THEN. that matches the .IF. operator. The extra semicolon after the .THEN. place marker serves to unstack the value of .NOT.<expr>(1) at the end of the conditional statement. Thus, in this case also, the use of a placemarker known to the interpreter facilitates skipping over redundant portions of the translated program.

Some Syntactic Methods of Extending the EULER Language

After developing the appropriate techniques for breaking down conditional statements and for optimizing logical expressions, the next question concerns using these syntactic tricks to provide extended facilities in the EULER language. The extensions to be described in what follows have not yet been programmed into the system, there being a minor obstacle of time and money presently obstructing progress.

The introduction of full string-processing facilities into the EULER system is the first example to be considered. Without altering the EULER interpreter, and with very little reprogramming of the translator, we can effect the following

improvement:

Syntactic Rule	Rule of Translation
<prim> → <stringprim>	I
<stringprim>→<stringhead>/.	<stringhead>).
<stringhead>→./	.(
|<stringhead><symbol>	<stringhead>.*<symbol>,

Here, a string of arbitrary length is translated into a list whose cells store the symbols of the string one symbol to the cell in sequence. With this arrangement, it is possible to manipulate strings using the list concatenation operator, the .TAIL. operator, and using EULER subroutines for performing tests for list equality and containment.

The second example involves the addition of facilities for reading in data at run time within the framework of the EULER system. In this case, additional structures must be provided in the EULER Polish string interpreter. These facilities would take the form of routines for converting numbers into their internal representation and for packing string data. The added syntax might resemble the following rule system:

Syntactic Rule	Rule of Translation
<program>→.ENTRY<block>.EXIT.	<block>
|.ENTRY<data>.,<block>.EXIT.	<data><block>
<data>→<datahead>.END.	I
<datahead>→.DATA.<item>	I
|<datahead>.,<item>	I
<item>→<number>	I
|<stringprim>	I
|<datalist>	I
<datalist>→<datalisthead>).	I
<datalisthead>→.(<item>	I
|<datalisthead>,<item>	I

With this program structure, the <data> portion could be read in by a subroutine that leaves the <data> in a pre-arranged location in memory. The interpreter routine could then be read in on top of the data subroutine, and the translated

program would be executed. A statement of the form ".READ. prim " would then store an appropriate link to some segment of the read-in data on top of the operand stack of the interpreter.

The third example involves the use of a syntactic notation to expand the EULER Language into a self-extendible programming language similar to MAD/1 (4) and ALGOL 68 (10). By an extendible programming language, people currently mean the following two things:

(a) A language in which the programmer can specify new data types and data structures composed of novel configurations of data elements.

(b) A language in which the programmer is able to reorder the priorities of expression operators and is able to specify arbitrary new operations at will.

In EULER, there already exists a very general mechanism for allowing programmers to manipulate data structures, namely, the list mechanism. EULER lists can be constructed from arbitrary combinations of data elements. However, EULER only has eight data types with no facilities for extending their ranges. Such range-extension facilities depend on the machine on which the language is implemented, and algorithms for specifying such things as numbers of arbitrary precision must be written for the machine in question. Hence, our example will concentrate on the machine-independent problem of specifying new operators in programs.

Any reasonable programming language must presuppose the existence of a standard set of expression operators before provision is made for allowing programs to expand this set of operators. With each standard operator will be associated a standard precedence level, and the operators to be introduced by the programmer must also have precedence levels. As the term is currently used, operator precedence (or priority) is a measure of how expression operators compare in binding power. For example, exponentiation is said to have a lower precedence than addition, because exponentiation is performed before addition in arithmetic expressions. Thus, precedence imposes on the operations of a language. This ordering is reflected in the ordering of syntax rules in programming language grammars. In the EULER grammar above, rules are ordered so that list concatenation is performed first, then exponentiation, and so on, until the operation of value assignment. From concatenation to assignment of value there are nine levels of precedence.

Our approach in providing for the programming of new operations is to assign these operations to one of nine classes of operators, reflecting the nine levels in the original grammar. We accomplish this by adding an operator declaration to the language, and by permitting the programmer to define new operators and rearrange their precedences at will. The rules for permitting this in our system are as follows:

Syntactic Rule	Rule of Translation
<expr>→<var><opname><expr>	.(<var>,.$<expr>$.)..CALL.<opname>
|<disj>	I
<disj>→<disj><opname><conj>	.(.$<disj>$.,.$<conj>$.).CALL.<opname>
|<conj>	I
⋮	⋮
<catena>→<catena><opname><prim>	.(.$<catena>.,$<prim>$.)..CALL.<opname>

<blockhead>→	
<blockhead><operatordec>.,	<blockhead><operatordec>
<operatordec>→.OPRT.<opname>	.OPRT.<opname>
|<operatordec>,<opname>	<operatordec>.OPRT.<opname>

(Programs now have operator, data variable, and label declarations. Procedures may then have operators global to them, but may not have operators passed to them as parameters of procedure calls.)

Syntactic Rule	Rule of Translation
<numberprim>→.PREC.<opname>	I
(.PREC. inquires about the precedence of the following <opname>.)	
<expr>→<opname>=<opdef>	.OP.<opname><opdef>=
(Definition of new operators and redefinition of old ones.)	

Syntactic Rule	Rule of Translation
<opdef> → <defhead><expr>$.	I
<defhead> → <formalpart><precedencepart>	I
<formalpart> → .$.FRML.<name>.,	.$.FRML.<name>
|.$.FRML.<name>,<name>.,	.$.FRML.<name>.FRML.<name>
<precedencepart> → RANK=<digit>.,	RANK.NMBR.<digit>=.,
<opname> → {=|+|-|*|...|.CNCT.	
|.{<letter>|<digit>}^{4}.}	I

In the syntax above, the <opname> in each rule is translated into a procedure call, with parameters consisting of the operands associated with each <opname>. These procedure calls either refer to the "standard" operator associated with a particular precedence level or refer to the translated <opdef>'s introduced into the program. It is assumed that the translator will automatically enclose each translated program with an extra outer block containing the procedure definitions of the standard operators. In this way, the standard operators can be redefined within a particular program, but will regain their usual meaning upon exit from the block in which the redefining statement occurred.

A certain amount of optimization is still possible within the framework of this extendible translator. As an example, suppose we write the following routine as the procedure corresponding to the standard operator for logical conjunction:

```
.AND.= .$.FRML.X,Y.,RANK=7.,
     .BGIN..NEW.Z.,Z=X.,
     .IF.Z.THEN.
        .IF.ISLO.Y.THEN.Y.ELSE..GOTO.ERROR
     .ELSE. Z .END.$.
```

The actual parameters in the procedure call for .AND. are subexpressions surrounded by .$ and $. . Thus, the effect of the statement

"Z=X.,"

is to evaluate the X parameter only once and not to evaluate the Y parameter unless Z is .TRUE. .

Other possible extensions to the EULER language include the addition of ALGOL-like iteration statements, as well as more rapid FORTRAN-style iterations. In both these cases, the additions can be made easily by incorporating a little extra syntax into the translator, and by having the language of that syntax translate into appropriate procedure calls to global "system" procedures.

How a Section of the Translator Was Designed--An Example

It is assumed that readers of this section will have some familiarity with the translator example in the previous paper (8) on this subject. In order to simplify the programming of the translator, it was decided to have the reserved words of the language perform as many functions as possible in the translation. Thus, the reserved words actually appear in translations as commands for the interpretive system where appropriate, and are stored on the pushdown store of the translator in place of the "nonterminal symbols" of the normal-form version of the grammar. For example, in the normal-form grammar for EULER, the rule

<expr> $\rightarrow X_1$ <alternative>
$X_1 \rightarrow X_2$ <consequence>
$X_2 \rightarrow$ <condition>

By letting X_1 be .THEN. and X_2 be .IF. in the translator, the coding is greatly simplified, and no ambiguities are introduced, since the X_i can be treated as "new and distinct" symbols. The flowchart of Figure 1, showing the transitions to and from the box corresponding to <expr>, illustrates how the EULER translator given in Appendix was programmed.

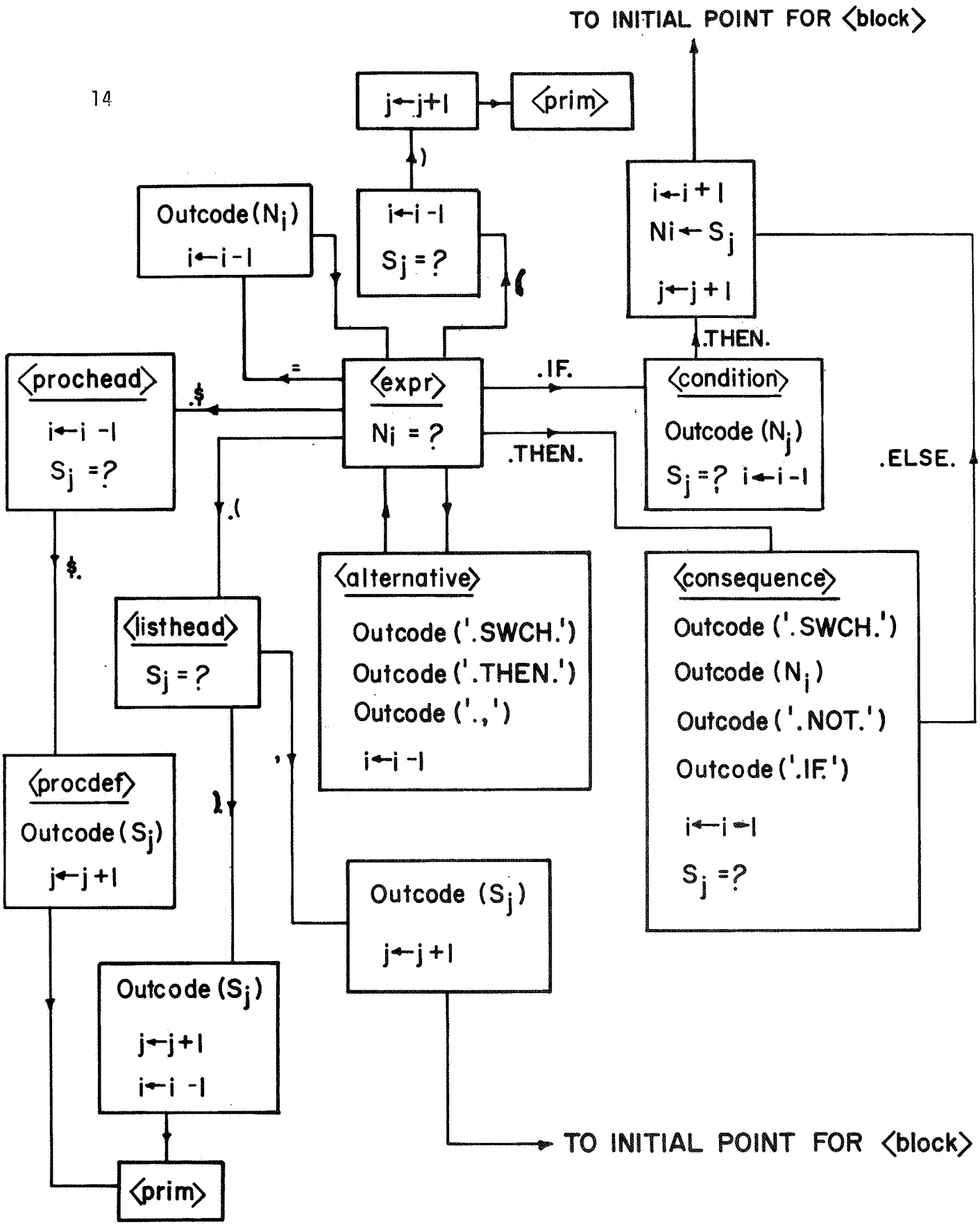

Figure 1. A Portion of the EULER Translator

Error Messages and Error Scans in the Translator

In the flowchart segment of Figure 1, no error exits are indicated. This is because, with this translator-design algorithm, error exits are implied; i.e., when the appropriate combination of program and pushdown-store symbols are not read at some stage of the computation, a syntactic error in the program is indicated. Rather than halt the processing of an input program at this point, it was decided to provide a full error scan, one that points out the location of each error as it occurs.

The error-scanning mechanism is based on the following observation concerning the EULER syntax: The <body> of a program consists of sequences of the form

<body>.,<stat>

where the <stat> may be some additional sequence of statements surrounded by .BGIN. and .END. . Thus, it is possible to treat this level of the programming language as a synchronizable encoding (7) in which the decoding process can be resumed after an error occurs because the decoding algorithm does not "know" the difference between an input sequence of the form

"<stat>$^{(1)}$.,<stat>$^{(2)}$.,<stat>$^{(3)}$.,"

and one of the form

"<stat>$^{(1)}$.,<stat>$^{(3)}$.,".

Because of this property of the grammar, a scanning routine can be constructed so that, whenever the translator finds a program error, the routine scans forward in the program until it encounters the first semicolon or .END. following the error. This routine then resets the translator so that translation resumes at the program location following the semicolon or .END. . If a semicolon is encountered, the translator resumes translation at its initial point; if an .END. is encountered, the translator resumes translation in the section corresponding to <body>.

It is conjectured here, but not proved, that this error-scanning mechanism will never permit the printing out of a translated program containing an error. The reason for this conjecture is that the syntax-checking mechanism of the translator is critically sensitive to the balancing of .BGIN.'s and .END.'s, left-and right parentheses, etc., in a program. Thus, when an error is discovered in a program, some extra symbol will remain on the pushdown store, and this symbol will ultimately cause an error message when

the .EXIT. command of the program is read. With an error message at this point in the program, it is a very simple matter to suppress the punching out of the translated program. So far, experience with the translator has borne out this conjecture.

A Missing Feature of the Translator

In section 4.7.3.3 of the revised ALGOL report (14), the following description of procedure calls appears:

> ...If the procedure is called from a place outside the scope of any nonlocal quantity of the procedure body the conflicts between the identifiers inserted through this process of body replacement and the identifiers whose declarations are valid at the place of the procedure statement...will be avoided through suitable systematic changes of the latter identifiers.

The meaning of this condition can be seen in terms of the following EULER programming example:

```
.ENTRY.BGIN..NEW.A,B.,
      A=2.,
      B=.$A$..,
       .BGIN. .NEW.A.,A=5.,
       .OUT.B.END..,
       .OUT.B .END. .EXIT.
```

Following the dictates of the ALGOL report, the number 2 would be written out twice by the program above. This is because the variable A is global to the definition of procedure B, and hence, some translation routine would have to rename A so that the translated program would be similar to what would appear if the above program had originally been written in the following way:

```
.ENTRY  .BGIN. .NEW.Z,B.,
     Z=2.,
     B=.$Z$..,
     .BGIN..NEW.A.,A=3.,
     .OUT.B.END..,
     .OUT.B.END..EXIT.
```

Although this ALGOL principle is not directly stated in the EULER report, there is an indication that variables in procedures are bound to the block in which they occur. Thus, something like section 4.7.3.3 must have been part of the original EULER.

In our EULER translator, the effect of executing the program example above would be to write out the number 5 followed by the number 2. Thus, section 4.7.3.3 has not yet been implemented for our system, although the programming involved is fairly straightforward. At present, the second program above must be submitted to obtain the correct results, and so the programmer must rename his program variables rather than have the translator perform the renaming.

Translation Times and Memory Requirements

The present EULER translator programmed in FORTRAN IV on the IBM 7094 machine takes approximately 5600 words of memory, including FORTRAN system routines and space for 500 packed words of EULER program to be translated. At present, 500 words of translated program output are obtained in about .06 minutes of execution time, and times for smaller programs are somewhat better, although difficult to measure.

Part II. The EULER Interpretive System

Introduction

This section consists of a description of how the EULER interpreter works. The structures used by the system and the commands that manipulate these structures are described, and algorithms written in a subset of EULER depict what happens when the commands are used. It is intended that these descriptions and algorithms, together with the actual FORTRAN IV version of the system given at the end of this report, will give the reader two somewhat different viewpoints of how the interpretive system functions.

This section of the report could also be considered an advanced manual for programming in the EULER reverse Polish language, although it is intended that the EULER translator be used for "writing" the programs used by the interpreter. It should be noted that the interpreter system now in use accepts programs written on punched cards, with the commands and data punched between columns 7 and 72 of the cards. Individual commands are punched left-justified into separate fields six columns in length. Thus, a total of eleven commands and data items can appear on one card. The EULER translator receives programs punched "free format" between columns 7 and 72 of cards and translates these programs into the interpreter notation, properly spaced and justified on punched cards.

Structures within the EULER Polish Interpreter

The following are the stacks and computer words used by the processor that executes the translated EULER code:

CODE - The array in which the translated EULER program is stored.

I - The index of CODE, pointing to the translated instruction currently being executed.

IDNTLS - The table of names, types and values used to implement dynamic storage allocation of variables.

T - The index of IDNTLS, pointing to the location of the most recently declared variable name in a program being executed.

OPRND - The stack of intermediate values and links stored in the process of executing a program.

IOPRND - The stack of data types associated with the values and links stored in OPRND.

IK - The index of OPRND and IOPRND.

STORAJ - The stack of locations in the IDNTLS name table where storage of names begins for each block.

BLKNUM - The index of STORAJ that records the dynamic block number at each point in the program being executed.

JUMPBK - The stack of procedure return addresses used in execution of recursive and nonrecursive procedure calls.

PRAMLS - The stack of pointers to parameter lists of procedures called during program execution.

JMPRTN - The index of JUMPBK and PRAMLS, giving the level of nesting of procedure calls at any point in a program.

LAVS - Array name used for setting up the pool of linked list cells used by the interpreter's list-processing routines.

AVSL - The machine word containing pointers to the beginning and end of LAVS.

LSTRTN - A stack used for reading out the contents of lists that contain sublists during execution of a program.

LSTCNT - The index of LSTRNTN, indicating the depth of the sublist currently being read using LSTRTN.

The following description of the EULER interpreter commands consists largely of algorithms written in a subset of EULER. It was felt that these algorithms can be concisely written and are intelligible to anyone familiar with ALGOL, and possibly to some familiar with MAD or FORTRAN as well. Appendix 4 is the actual interpreter program, and is written in FORTRAN IV. By comparing the EULER algorithms with the corresponding FORTRAN, it will be noted that the function JUMPTO.(.*DUMMY)., where .*DUMMY is some chosen operator, corresponds to several slightly different FORTRAN routines used for scanning forward in the interpreted program without executing the segment of CODE that is thereby bypassed.

Typing and Storage of Data

Data appears in IDNTLS, the interpreter name table, as triples of Computer words. The first word in each triple is the program-declared name, the second word contains a data type code, and the third word contains the actual datum. Since the index of IDNTLS is T, this means that IDNTLS(3*T-2) is an alphanumeric word, IDNTLS(3*T-1) contains the type, and IDNTLS(3*T) contains the datum. Data is also stored on the operand stack OPRND. Here, OPRND(IK) denotes some value or linkage, and IOPRND(IK) is the integer type code of the datum in OPRND(IK).

The other important structures in which data can be stored and manipulated are list cells drawn from LAVS. Each list cell consists of a pair of adjacent computer memory words, in the manner of SLIP list cells (11). The SLIP conventions regarding fields within a computer word are used here: That is, a given word is divided into two address-sized fields, called the LNKL and LNKR fields, and a smaller ID field. The datum is stored in the second cell of each word pair, and the typing information for that datum appears in the ID field of the first cell of the pair. To maintain a semblance of consistency within the interpreter routines, each pair of words IDNTLS(3*T-1) and IDNTLS(3*T) is made to resemble a list cell in that the typing information for the datum in IDNTLS(3*T) is stored in the ID field of IDNTLS(3*T-1). In Appendix 2 is a brief description of the SLIP routines used in this paper to describe EULER.

At present, there are eight data types manipulated by the EULER system: numerical constants and variables, logical constants and variables, labels, lists, references or pointers, procedures, alphanumeric symbols, and a last category of undefined data. The type coding mechanism works as follows: If the ID field of IDNTLS(3*T-1) is all zero, or if IOPRND(IK) is an integer zero, the associated datum is a floating-point number. If the code is an integer one, the associated datum is logical. If the code is two, the datum is a label whose location in the CODE array is stored as a floating point number. If the ID code is three, the associated datum is an integer link to a list stored in the LNKR field of the datum word. If the ID code is four, the associated datum is called undefined. If the ID code is five, the associated datum is an integer pointer to some other datum. This link is likewise stored in the LNKR field, and is a reference to either the first word of a list cell or to IDNTLS(3*T'-1) for some T'. If the ID code is six, the datum is the location of the first command of a procedure somewhere in the CODE array, and this location is stored in floating point. Finally, if the ID code is seven, the corresponding datum contains six alphanumeric symbols, including blanks (for the IBM 7094 machine).

The following operators exist for testing the type of an operand during execution of a program. These operators check the type code of the topmost operand on the OPRND stack.

.ISNU.(isnumber) - Changes OPRND(IK) to true if IOPRND(IK) is 0. Otherwise OPRND(IK) becomes false. IOPRND(IK) becomes 1 (logical type).

.ISLO.(islogical)

.ISLA.(islabel)

.ISLI.(islist)

.ISUN.(isundefined) — All defined analogously to .ISNU.

.ISRE.(isreference)

.ISPR.(isprocedure)

.ISSY.(issymbol)

The following two operators exist to perform type conversions between numbers and logical values. They permit a certain flexibility in the use of arithmetic expressions or logical expressions in "unorthodox" computations:

.LGCL.(logical type conversion)	LOGCAL:.IF.IOPRND(IK).NEQ.0.THEN. .GOTO.ERROR .ELSE.IOPRND(IK)=1;.GOTO. CYCLE;
.REAL.(number type conversion)	TOREAL:.IF.IOPRND(IK).NEQ.1.THEN..GOTO. ERROR.ELSE.IOPRND(IK)=0;.GOTO.CYCLE;

Insertion of Data

At the present time, the interpreter does not use tables of numerical and logical constants. Instead, such data is passed to the interpreter at each point of occurrence in the translated program. Numbers are passed in the form of octal representations of floating point numbers, and are stored in two consecutive six-character words. The operator .NMBR. signals to the interpreter that the following two words in CODE are a number, and a machine-language subroutine packs this number into OPRND(IK), after IK has first been incremented and IOPRND(IK) set to zero. Another operator .* signals to the interpreter that the following word in CODE consists of six alphanumeric characters. Index IK is incremented, IOPRND(IK) is set to 7, and the six-character word is stored in OPRND(IK).

Logical truth and falsity are presented to the interpreter as .TRUE. and .FLSE. respectively. For each of these operands, IK is first incremented and IOPRND(IK) set to 1. If the operand is .TRUE., OPRND(IK) is set to 1, otherwise 0. Finally, it is possible to insert .UNDF. (an undefined constant) on the operand stack. In this case also, IK is incremented. IOPRND(IK) is then set to 4, and OPRND(IK) is set to zero.

The Basic Interpretive Cycle

Several of the basic interpreter commands have already been discussed. These commands and the remaining ones to be presented in this report are all executed by a basic interpretive cycle that reads commands from the translated EULER program and passes control to routines that execute these commands. This interpretive cycle can be described in the following steps:

I. Initialization of interpreter indices:
   I=0; IK=0; BLKNUM=0; T-0; JMPRTN=0;

II. Creation of the LAVS pool of linked list cells:
   INITAS.(.AT.AVSL,.AT.LAVS,2000).;

III. Reading of the next command of the translated EULER program:
   CYCLE: I=I+1; EXECUTE.(CODE(I)).; .GOTO.CYCLE;

Arithmetic and Logical Operations in the Interpreter

The following segmented table indicates in the left column the operator in CODE(I) to be executed and in the right column the corresponding interpretation algorithm:

I. Unary Operators

.NEG. (unary minus sign)	NEGATE: .IF. IOPRND(IK).NEQ.0.THEN. .GOTO. ERROR .ELSE. OPRND(IK))=-OPRND(IK); .GOTO.CYCLE;
.ABST. (Take absolute value) .INTG. (Truncate to an integer)	Defined analogously to unary negation.
.NOT. (logical negation)	NOT:.IF. IOPRND(IK) .NEQ.1.THEN..GOTO. ERROR.ELSE.OPRND(IK)=1-OPRND(IK); .GOTO. CYCLE;

II. Binary Operators

+(addition)	ADD:.IF. IOPRND(IK).NEQ.0 .OR. IOPRND(IK-1) .NEQ. 0 .THEN. .GOTO. ERROR .ELSE. .BGIN. OPRND(IK-1) = OPRND(IK-1)+OPRND(IK); IK=IK-1; .GOTO. CYCLE .END.
- (subtraction) * (multiplication) / (division) ./. (integer division) .MDLO. (modulo) ** (exponentiation)	Defined analogously to addition.
.EQ. (test for equality)	ISSAME:.IF. IOPRND(IK) .NEQ. 0 .OR. IOPRND(IK-1) .NEQ. 0 .THEN. .GOTO. ERROR .ELSE. .BGIN. OPRND(IK-1)= .IF. OPRND(IK-1) .EQ. OPRND(IK) .THEN. 1.0.ELSE.0.0.END. ;IK=IK-1; IOPRND(IK) =1; .GOTO. CYCLE;
.NEQ. (test for inequality) .GT. (test for >) .LT. (test for <) .GEQ. (test for ≥) .LEQ. (test for ≤)	Defined analogously to the test for equality.

III. Logical Operators Modified for Increased Execution Speed

.FAND. (logical conjunction) (Note: This is an optimized conjunction that is executed like an ALGOL conditional statement.)	.IF. IOPRND(IK) .NEQ.1.THEN. .GOTO. ERROR .ELSE..IF.OPRND(IK) .EQ. 0 .THEN. I=JUMPTO.(.*.SAND.)..ELSE. IK=IK-1;.GOTO.CYCLE;
.FSOR. (logical disjunction) (Note: This is an optimized disjunction that is executed like an ALGOL conditional statement.)	.IF. IOPRND(IK) .NEQ.1 .THEN. .GOTO. ERROR .ELSE. .IF. OPRND(IK) .EQ.1 .THEN. I=JUMPTO.(.*.SCOR.)..ELSE. IK=IK-1; .GOTO.CYCLE;
.SAND. (end label of a logical conjunction) .SCOR. (end label of a logical disjunction)	.IF. IOPRND(IK) .NEQ.1 .THEN..GOTO.ERROR .ELSE..GOTO.CYCLE;
.IF. (the test operator in a conditional statement.)	.IF.IOPRND(IK).NEQ.1.THEN. .GOTO.ERROR.ELSE..IF.OPRND(IK) .EQ.0.THEN.I= JUMPTO.(.*.THEN.)..ELSE..UNDF.; .GOTO.CYCLE;
.THEN.	.GOTO. CYCLE;
.SWCH. (Exchange the two topmost operands during a conditional statement having an alternative.)	DATUM=OPRND(IK);TYPE= IOPRND(IK); OPRND(IK)=OPRND(IK-1); IOPRND(IK)=IOPRND(IK-1); OPRND(IK-1)=DATUM; IOPRND(IK-1)=TYPE;

Block Structure and Declarations

Since EULER is a language having nested block structure and requiring that all program variables and labels be declared, appropriate commands exist for executing these functions. For the most part, these commands manipulate the IDNTLS table of declared names and the STORAJ stack of pointers to where the names of each currently active block are stored.

In this EULER system, the JUMPBK stack is the mechanism that implements returns of control from subroutines being executed. The stacking of subroutine return addresses permits recursive procedure calls to be executed in this system at the same speed and efficiency as non-recursive procedure calls. If a procedure leaves a value on the operand stack, that value is not destroyed by the procedure return mechanism. Thus, no extra mechanisms are necessary to implement procedures that return function values, and both types of procedures are treated alike.

There are two sequences of commands that initiate procedure calls in the EULER system. The sequence

".VRBL.<name>.IN.",

where name corresponds to a procedure variable, is used for calling those procedures that have no formal parameters. The sequence

".VRBL.<name>.LSCL..(<paramlist>)."

is used for calling procedures that have formal parameters. The actual parameters in the procedure call are put onto a list, and, when the command). is interpreted, the link to this list is put on top of the PRAMLS stack before control is transferred to that subroutine. A description of the .IN. command is given in the following section, .LSCL. is discussed in the section on transfers of control, and .(and). are described in the section on list operations. The following list of commands and algorithms includes those commands that are interpreted when a procedure is executed by the system.

```
.BGIN.
(beginning of a
program block)
.$
(beginning of a
 procedure definition)
```

```
BEGIN:BLKNUM=BLKNUM+1;
   STORAJ(BLKNUM)=T+1;
   .GOTO.CYCLE:
PROCHD:IK=IK+1;OPRND(IK)=I;
   IOPRND(IK)=6;
   I=JUMPTO.(.*$.    ).;
   .GOTO.CYCLE;
```

```
.NEW.
 (variable
  declaration)
```

```
NEW:I=I+1; T=T+1; IDNTLS(3*T-2)=
   CODE(I);SETDIR.(4,0,BLKNUM,
   IDNTLS(3*T-1)).;IDNTLS(3*T)=0;
   .GOTO.CYCLE.
```

```
.LABL.
 (label
  declaration)
```

```
LABEL:I=I+1;T=T+1;IDNTLS(3*T-2)=
   CODE(I);SETDIR.(2,0,BLKNUM,
   IDNTLS(3*T-1)).;=
   SETDIR.(0,BLKNUM,LOCATE.(CODE(I)).,
   IDNTLS(3*T)).;.GOTO.CYCLE;
```

```
.LBDF.(label of definition)
```

```
LABDEF:I=I+1;.GOTO.CYCLE;
```

```
.FRML.
 (formal parameter
  declaration in
  procedure)
```

```
FORMAL:I=I+1;T=T+1;IDNTLS(3*T-2)=
   CODE(I);LINK=LNKR.(PRAMLS
   (JUMPRTN)).;.IF.LINK.EQ.0.THEN.
   .BGIN.IDNTLS(3*T)=0;
   SETDIR.(4,0,0,IDNTLS(3*T-1)).
   .END..ELSE..BGIN.TEMP=
ID.(INHALT.(LINK).).;.IF.TEMP.EQ.
  2.OR.TEMP.EQ.5.THEN.
  SETDIR.(-1,-1,LNKL.(INHALT.(LINK+1).).
  ,IDNTLS(3*T-1))..ELSE..UNDF.;
  PRAMLS(JUMPRTN)=INHALT.(LINK).;
  IDNTLS(3*T)=INHALT.(LINK+1).;
  .GOTO.CYCLE;
```

```
., (semicolon)
```

```
SEMCLN:.IF.IOPRND(IK).EQ.3
.THEN..BGIN.LLNK=LNKR.(
OPRND(IK)).;.IF.LNKL.(INHALT.(
LLNK).)..EQ.0.THEN.ERASE.(
LLNK)..ELSE..UNDF..END.
.ELSE..UNDF.;IK=IK-1;.GOTO.
CYCLE;
```

```
.END.                                  END:INDEX=STORAJ(BLKNUM);
 (end of a                               .IF.T.GEQ.INDEX.THEN.
  program block)                         LOOP:.BGIN..IF.ID.(IDNTLS(3*T-1)).
                                         .EQ.3.THEN.ERASE.(LNKR.(
                                         IDNTLS(3*T))..ELSE..UNDF.;
                                         T=T-1;.IF.T.GEQ.INDEX
                                         .THEN..GOTO.LOOP.ELSE..UNDF.
                                         .END..ELSE..UNDF.;BLKNUM=
                                         BLKNUM-1;.IF.BLKNUM.GT.0
                                         .THEN..GOTO.CYCLE.ELSE.
                                         .GOTO.HALT;
$.                                     PRCEND:I=JUMPBK(JMPRTN);
(end of a procedure)                   JMPRTN=JMPRTN-1;.GOTO.END;
```

Pointer Variables and Transfer of Data

In the EULER language, a limited use of indirect addressing exists in the form of variables of type reference. The value associated with a reference variable is either the machine address of IDNTLS(3*T'-1), for some T', or the machine address of the first word of some list cell. As an example, we could write the following fragment of a valid EULER program:

```
...A=2; V=.AT.A;
   V.IN.=V.IN.+1....
```

Here, A is a variable of type number, and V becomes a reference to A. The last command in the fragment causes A to acquire a numerical value of 3.

On a statement-by-statement basis, the program fragment would have been translated into the following fragment: (Note that .AT. is not translated directly.)

```
.VRBL.A     .NMBR.202400000000=
.,    .VRBL.V     .VRBL.A     =
.,    .VRBL.V     .IN.  .VRBL.V
.IN.  .IN.  .NMBR.201400000000+
```

The effect of the command .VRBL. is to fetch a pointer to the variable name that follows it in the translated program. Thus, the effect of executing the sequence

```
.VRBL.V     .VRBL.A     =
```

is to take the pointer for A and store it in IDNTLS as the datum for V. The effect of the command .IN. is to replace a pointer to some datum by the datum itself. Hence, the use of

```
.VRBL.V     .IN.  .IN.
```

in the translated program. Here, the datum acquired by the first use of .IN. is itself a pointer to another datum. The second use of .IN. finally captures that indirectly referenced datum. Thus, the effect of an .AT. in a program is the suppression of an .IN. in the translation.

The following list of commands presents the algorithms that are used to interpret references and assignments of value in this version of EULER. Note that error exits occur whenever some variable global to a program block is assigned as a reference to a variable local to that block.

.VRBL.
(fetches a pointer to a variable name)

```
VARIBL:I=I+1;IVRBL=CODE(I);
ITEMP=T;LOOP1:.IF.IDNTLS(3*T-2)
.NEQ.IVRBL.THEN..BGIN.ITEMP=ITEMP-1;
.IF.ITEMP.EQ.0.THEN..GOTO.ERROR
.ELSE..GOTO.LOOP1.END..ELSE..BGIN.
IK=IK+1;IOPRND(IK)=5;
SETDIR.(0,LNKR.(IDNTLS(3*ITEMP-1)).,
MADOV.(IDNTLS(3*ITEMP-1)).,OPRND(IK)).;
.GOTO.CYCLE.END.
```

.IN.
(fetches the datum referenced by a pointer; initiates procedure calls.)

```
INSIDE:ITYPE=ID.(CONT.(LNKR.(
OPRND(IK)).).).;IOPRND(IK)=ITYPE;
.IF.ITYPE.NEQ.6.THEN..BGIN.OPRND(IK)=
CONT.(LNKR.(OPRND(IK)).+1).;.GOTO.CYCLE
.END..ELSE..BGIN.IK=IK-1;JMPRTN=
1+JMPRTN;JUMPBK(JMPRTN)=I;
BLKNUM=1+BLKNUM;
STORAJ(BLKNUM)=1+T;
I=CONT.(LNKR.(OPRND(IK)).+1).;
.IF.CODE(I+1).EQ..*.FRML..THEN..GOTO.
```

```
                    ERROR.ELSE..GOTO.CYCLE.END.
=                   ASSIGN:.IF.IOPRND(IK-1).NEQ.5.THEN.
                    .GOTO.ERROR.ELSE..BGIN.TYPE=IOPRND(IK);
                    LRNK=LNKR.(OPRND(IK)).;LINK=
                    LNKR.(OPRND(IK-1)).;.IF.TYPE.EQ.5.OR.
                    TYPE.EQ.3.THEN..IF.LNKL.(OPRND(IK)).
                    .GT.LNKL.(OPRND(IK-1))..THEN..GOTO.ERROR
                    .ELSE..UNDF..ELSE..IF.TYPE.EQ.3.AND.
                    LRNK.GT.0.THEN..BGIN.SETIND.(-1,
                    LNKL.(CONT.(LRNK).)+1,-1,LRNK).;
                    SETDIR.(0,0,-1,OPRND(IK))..END..ELSE..UNDF.
                    ;.IF.ID.(CONT.(LINK).)..EQ.3.AND.LNKR.(
                    CONT.(LINK+1).)..GT.0.THEN.
                    ERASE.(CONT.(LINK+1).)..ELSE..UNDF.;
                    SETIND.(TYPE,-1,-1,LINK).;OPRND(IK)=
                    CONT(LINK+1);OPRND(IK-1)=OPRND(IK);
                    IOPRND(IK-1)=IOPRND(IK);IK=IK-1;.GOTO.CYCLE;
```

Transfers of Control Within a Program

Transfers of control in a programming language are both implicit and explicit. An explicit transfer is caused by a .GOTO. command. The .LSCL. command is implicit, since it does not appear in EULER programs, but is used by the translator system for transferring control to subroutines that have parameters. Note that .LSCL. only serves to find the location in the program of the procedure. The actual transfer of control takes place when). is read.

```
.GOTO.              JUMP:.IF.IOPRND(IK).NEQ.2.THEN.
                    .GOTO.ERROR.ELSE..BGIN.I=LNKR.(
                    OPRND(IK)).-1;JMPRTN=JMPRTN
                    +LNKL.(OPRND(IK)).-BLKNUM;.IF.
                    JMPRTN.LT.0.THEN.JMPRTN=0.ELSE.
                    .UNDF.;.GOTO.CYCLE.END.
```

```
.LSCL.                          LSCALL:LINK=LNKR.(OPRND(IK)).;
                                .IF.ID.(CONT.(LINK).)..EQ.6.THEN.
                                .BGIN.IOPRND(IK)=6;OPRND(IK)=
                                CONT.(LINK+1).;.GOTO.CYCLE.END.
                                .ELSE..GOTO.ERROR;
```

List Operations and String Processing

The EULER system has facilities for constructing and concatenating lists, for taking the suffix of a list, and for finding subscripted list elements. Moreover, each list call can store data of any legal type, including procedure, reference, label, etc. Thus, it is possible to execute a program by simply naming the elements of a list of procedures in order. Or, we can obtain the effect of an ALGOL switch by constructing a list of labels and writing .GOTO. followed by a subscripted list reference. Since characters can be stored on lists, it is possible to compare long character strings by writing procedures for testing two lists for equality, containment, etc.

The command .LIST. constructs an empty list whose length is given by the numerical value of the topmost operand on the OPRND stack. The commands .(and). construct a list out of data elements that occur between them separated by commas. The subscripting command) is evaluated one subscript level at a time and takes its information from the two topmost elements of the OPRND stack. The concatenation operator .CNCT. creates a copy of the two lists whose pointers are the topmost operands of the OPRND stack. Finally, the suffix operator .TAIL. finds the link to a list on top of the OPRND stack and replaces that link by a link to the following cell of that list.

The following example illustrates a distinction that should be understood when programming EULER: If A and B are lists in a program, then the two statements

C=.(A,B).; and C=A.CNCT.B;

do not have the same effect. In the first case, C is a list of two elements which point to A and B as sublists. In the second case, C is a list consisting of a copy of A joined to a copy of B.

The following table of commands and algorithms further describes the results produced by the list manipulation operators:

.LIST.

```
LIST:.IF.IOPRND(IK).NE.0.THEN.
.GOTO.ERROR.ELSE..BGIN.IOPRND(IK)
=3;INDEX=OPRND(IK);.IF.INDEX
.EQ.0.THEN..BGIN.OPRND(IK)=0;
.GOTO.CYCLE.END..ELSE..UNDF.;
IVRBL=NUCELL;.IF.INDEX
.EQ.1.THEN..GOTO.OUTPUT.ELSE.LLCELL=
IVRBL;LOOP2:INDEX=INDEX-1;.IF.
INDEX.LT.1.THEN..GOTO.OUTPUT.ELSE.
.BGIN.LRCELL=NUCELL;SETIND.(4,
-1,LRCELL,LLCELL).;LLCELL=LRCELL;
.GOTO.LOOP2.END.;OUTPUT:SETDIR.(0,
0,IVRBL,OPRND(IK)).;
```

.(

```
LISTHD:IK=IK+1;IOPRND(IK)=3;
OPRND(IK)=.*.(    ;.GOTO.CYCLE;
```

,

(stores topmost OPRND in a list cell and replaces this operand with a link to the cell.)

```
COMMA:IKK=IOPRND(IK);IJJ=LNKR.(
OPRND(IK)).;
.IF.IKK.EQ.3.AND.IJJ.GT.0.THEN.
SETIND.(-1,LNKL.(CONT.(IJJ).).+1,-1,IJJ).;
.ELSE..UNDF.;TEMP=NUCELL;
SETIND.(IKK,0,0,ITEMP);STRIND.(
OPRND(IK),ITEMP+1).;OPRND(IK)=TEMP;
IOPRND(IK)=3;.GOTO.CYCLE;
```

).

```
LSTEND:.IF.OPRND(IK).EQ..*.(    .THEN.
.BGIN.OPRND(IK)=0;.GOTO.CYCLE.END.
.ELSE.EXECUTE.(COMMA).;LOOP3:.IF.
OPRND(IK-1).NEQ..*.(    .THEN..BGIN.
SETIND.(-1,0,LNKR.(OPRND(IK)).,LNKR
.(OPRND(IK-1)).).;IK=IK-1;.GOTO.LOOP3
.END..ELSE..IF.OPRND(IK-1).NEQ.6.THEN.
.GOTO.CYCLE.ELSE..BGIN.JMPRTN=1+
JMPRTN;JUMPBK(JMPRTN)=I;T=T+1;
PRAMLS (JMPRTN)=IDNTLS(3*T)=OPRND(IK);
SETDIR.(3,1,0,IDNTLS(3*T-1)).;I=OPRND(IK-1;
IK=IK-2;.GOTO.BEGIN;
```

```
)                          RSBSCP:INDEX=OPRND(IK);IK=IK-1;
(subscript operator)       .IF.INDEX.LEQ.0.THEN..GOTO.CYCLE
                           .ELSE.LINK=LNKR.(CONT.(1+LNKR.(
                           OPRND(IK)).).;.IF.LINK.GT.0.THEN.
                           .BGIN.LOOP4:INDEX=INDEX-1;.IF.INDEX
                           .GT.0.THEN..BGIN.LINK=LNKR.(CONT.(
                           LINK).).;.GOTO.LOOP4.END..ELSE..BGIN.
                           SETDIR.(-1,-1,LINK,OPRND(IK)).;.GOTO.CYCLE
                           .END..END..ELSE..GOTO.ERROR;
.TAIL.                     TAIL: TEMP=LNKR.(OPRND(IK)).;.IF.
 (list suffix)             IOPRND(IK).NE.3.OR.TEMP.EQ.0.THEN.
                           .GOTO.ERROR.ELSE.TEMP=LNKR.(CONT
                           .(TEMP).);.IF.TEMP.EQ.0.THEN..GOTO.
                           ERROR.ELSE..BGIN.OPRND(IK)=TEMP;
                           SETIND.(-1,1+LNKL.(CONT.(TEMP).).,-1,TEMP).;
                           .GOTO.CYCLE.END.;
.CNCT.                     CONCAT:.IF.IOPRND(IK).NE.3.OR.
 (concatenation)           IOPRND(IK-1).NE.3.THEN..GOTO.
                           ERROR.ELSE..BGIN.COPY.(LNKR.(OPRND(IK)).,
                           JTOP,JBOT).;COPY.(LNKR.(OPRND(IK-1)).,
                           ITOP,IBOT).;SETIND.(-1,-1,JTOP,IBOT).;
                           IK=IK-1;OPRND(IK)=ITOP;.GOTO.CYCLE
                           .END.
.LNGT.                     LENGTH:.IF.IOPRND(IK).NE.3
 (List length)             .THEN..GOTO.ERROR.ELSE.BGIN.COUNT=0;
                           TEMP=LNKR.(OPRND(IK)).;IOPRND(IK)=0;
                           LOOPS:.IF.TEMP.EQ.0.THEN..BGIN.OPRND(IK)
                           =COUNT;.GOTO.CYCLE.END..ELSE..BGIN.
                           COUNT=1+COUNT;TEMP=LNKR.(CONT
                           .(TEMP).).;.GOTO.LOOPS.END.
```

Reusage of Discarded List Cells by the System

The EULER programmer will not usually concern himself with the problem of "garbage collection" of discarded list cells in his programs, since garbage collection is automatic in EULER. This collection occurs at three points in EULER programs: at the .END. command of a block, at an assignment statement when the = command is executed, and between statements when the ; command is executed. At the end of a block, all lists local to the block are linked one after another to the last cell in the LAVS list. When an assignment statement assigns a new value to a variable that was formerly a list, that list is checked to see if its first cell only has one name. If that list only has one name, it is linked to the last cell of LAVS. When a semicolon is encountered in the translated program, the top of the OPRND stack is checked to see if it contains a link to some list having no name (such as would be left there if something like .OUT..( ). were the preceding statement). If there is a link to an anonymous list on the OPRND stack, then this link is removed from OPRND, and the list is joined to the end of LAVS.

As in the SLIP system (a part of which is used in our implementation of EULER), sublists of lists are joined to the end of LAVS only when the NUCELL routine encounters them in the process of fetching list cells from the top of LAVS. In this case, the sublists are only considered to be reusable if they are sublists of no more than one list (in this case, they are sublists of LAVS). More information on this garbage collection technique can be found in the original SLIP paper. (11)

Communication of Data

The EULER language allows simple variables and lists to be printed out at execution time. A program statement such as

```
.OUT.V;
```

is translated into the sequence

```
.VRBL.V     .IN.  .OUT. ;
```

If V is a list, then the entire list, including sublists will be printed out. If V is a variable, then just that variable's value will be printed out. If V is a procedure, reference, or label, then PROCDR, REFRNC, or LABEL will be the appropriate "values" to be printed by the .OUT. operator.

As a further example, we might have the following statement in an EULER program:

```
.OUT. .(.*  N=  ,3.2,.*THIS I,.*S A LI,.*ST WIT,
      .*H SUBL,.*ISTS. ,.(.$3$.,.AT.N,.(2,3).).).;
```

When the corresponding statement in the translated program is executed, the following printed output will result:

```
(    N=        3.2000,THIS IS A LI
ST WITH SUBLISTS. ,   (  PROCDR,REFRNC,
(      2.0000,    3.0000   )     )     )
```

Note that commas are suppressed between list elements containing characters. A discussion of how one might extend the printing facilities of EULER can be found in the section entitled "Improvements and Extensions of EULER".

There are no facilities for reading data in the EULER language. The original EULER paper suggests that data be translated with the program, since translation can be a very rapid process. Perhaps a better suggestion, and one that we hope to implement, is to allow a list-structured input of data similar to the one used with the .OUT. command. The "Improvements and Extensions" Section of this paper has more to say on this matter.

The following algorithm implements list and variable printing as described above. The OUTPUT subroutine prints one datum for each call, and an index is used by the subroutine to position the datum on a printed line. Note that the LSTRTN stack facilitates writing out of sublists.

```
.OUT.       OUT: TYPE=IOPRND(IK);.IF.TYPE.NEQ.3
            .THEN..BGIN.INDEX=1; OUTPUT.(TYPE,OPRND(IK),
            .AT.INDEX).;.GOTO.CYCLE.END..ELSE..IF.LNKR.(
            OPRND(IK))..EQ.0.THEN..BGIN.INDEX=1;
            OUTPUT.(7,.* (  ) ,.AT.INDEX);.GOTO.CYCLE.END.
            .ELSE..BGIN.
            LSTCNT=INDEX=0;OUTPUT.(7,.*   (  ,.AT.INDEX).
            ;LINK=LNKR.(OPRND(IK)).;LOOP6:CTLNIK=CONT.(
            LINK).;.IF.ID.(CTLNIK)..EQ.3.THEN..BGIN.
            LSTCNT=1+LSTCNT;LSTRTN(LSTCNT)=LINK;
            LINK=LNKR.(CONT.(LINK+1).).;OUTPUT.(7,.*   (  ,
            .AT.INDEX).:.GOTO.LOOP6.END.
```

```
.ELSE..BGIN.OUTPUT.(ID.(CTLINK).,CONT.(LINK+1).,
.AT.INDEX).;.IF.ID.(CTLINK)..NEQ.7.AND.
LNKR.(CTLINK)..GT.O.THEN.OUTPUT.(7,  ,   ,
.AT.INDEX)..ELSE..UNDF..END.;
.IF.LNKR.(CTLINK)..GT.O.THEN..BGIN.LINK=
LNKR.(CTLINK).;.GOTO.LOOP6.END..ELSE.
.BGIN.LOOP7:OUTPUT.(7,.*  )    ,.AT.INDEX).;.IF.
LSTCNT.EQ.O.THEN..GOTO.CYCLE
.ELSE..BGIN.LINK=LNKR.(CONT.(LSTRTN(LSTCNT)).).
;LSTCNT=LSTCNT-1;.IF.LINK.EQ.O.THEN.
.GOTO.LOOP7.ELSE..BGIN.OUTPUT.(7,.*  ,   ,.AT.
INDEX).;.GOTO.LOOP6.END..END.
.END.
```

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Appendix 1. Features of the EULER Language

EULER is a nested block-structure language, similar to ALGOL. Thus, every block, consisting of a sequence of statements surrounded by .BGIN. and .END. parentheses, can be treated as a single statement in ALGOL fashion. An EULER program consists of an EULER block preceded by .ENTRY and followed by .EXIT..

In EULER, there are three declarations, one category for data variables, one for program labels, and one for formal parameters of procedures. In the program

```
".ENTRY .BGIN. .NEW.X,Y.,.LABL.Z.,
      Z..X=Y .END. .EXIT."
```

X and Y will store data, and Z will be a label preceding some statement.

Assigning a data type to a declared variable is accomplished by writing an assignment statement with data of the appropriate type on the right-hand side of the assignment. Thus, typing of variables in EULER is dynamic, since any assignment statement can change the data type stored in a variable. And, data typing is implicit, since there are no declarations like real, integer, etc., as appear in ALGOL. The following is a list of the eight EULER data types:

I. Number - In the EULER system, all numbers are assumed to be floating point numbers. The assignment statement

```
"V=E.,"
```

with E a numerical expression or number, causes variable V to become a numerical variable.

II. Symbol - In this EULER implementation, an assignment statement such as

```
"V=.*ALPHAN.,"
```

causes the six characters "ALPHAN" to be stored in the location named by variable V.

III. Logical - The logical constants are .TRUE. and .FLSE., standing respectively for logical truth and falsehood. The assignment statement,

```
"V=L.,"
```

with L a logical constant or logical expression, causes variable V to become a logical variable.

IV. Label - It will be recalled that EULER programs declare .NEW. variables as well as .LABL. statement labels. Interestingly enough, if V is a variable in some EULER program, and V is not in a block global to the block of label L, then the assignment statement

"V=L.,"

causes V henceforth to be of type label, and to be interchangeable with L in .GOTO. statements.

V. Reference - In EULER, if V1 is a variable not in a block global to the block of variable V2, then the assignment statement

"V1=.AT.V2.,"

makes V1 a pointer to the data stored in V2. After V1 is turned into such a pointer, the two statements

"V2=V2+1.,"

and "V1.IN.=V1.IN.+1.,"

will have exactly the same effect of manipulating whatever data is stored in V2.

VI. Procedure - An assignment statement of the form

"V1=.$<expr>$..,"

causes V1 to become the name of a parameterless procedure call with body given by <expr>. As a programming example, we might consider the following EULER block:

```
".BGIN..NEW.X,Y ., X=2;
      Y=.$.FRML.Z., X=X+Z$..,
      .OUT.Y.(5)..END."
```

When Y.(5). is operated on by the .OUT. operator, the value 7.0000 will be written out.

VII. List - In EULER, lists can be constructed in three distinct ways:

(a) On command: "V1=.LIST.300.,"

This statement creates a list of 300 cells and makes V1 their name.

(b) By explicit notation: "V2=.(1,.(2,3).,4)..,"
This statement creates a list consisting of two numbers and a sublist and makes V2 the name of that list.

(c) By concatenation: "V1=V1.CNCT.V2.,"
Using the concatenation operator, small lists can be joined together into larger ones. In addition, lists can be subscripted in the same way as ALGOL arrays, and each element of a list can be any EULER data type, including label, reference, and procedure. The following EULER block is an example of the generality of the list notation:

```
.BGIN..NEW.X,Y.,.LABL.Z.,
    Y=.(2,.$.BGIN.X=X+1.,Y(X).END.$.,
        .$.OUT.X$.,Z)..,
    X=Y(1).,Y.(X)..,.GOTO.Y(4).,
    Z...OUT..*FINISH.END.
```

With this program segment, first 3.0000, then FINISH, will be written out by the executed program.

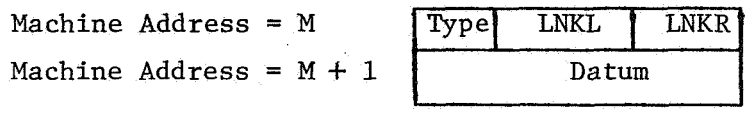
VIII. Undefined - Every variable declared by .NEW. in an EULER program is initially of type .UNDF.(undefined). In addition .UNDF. is used as a data constant occasionally and as an empty option in conditional statements, such as:

"V=.IF.L1.THEN..(1,5)..ELSE..UNDF..,"

For more details on EULER programming the reader is referred to the Wirth and Weber EULER paper (11).

Appendix 2. The SLIP Routines Used in Implementing EULER

The current EULER implementation uses lists whose cells consist of pairs of memory words having the following format:



The LNKR field of word M stores the machine address of the first word of the next cell in a list. If LNKR = 0, then that cell is the last cell of some list. The LNKL field stores a count of how many program names refer to a cell; i.e., the LNKL measures how many times a programmer has made that cell the head of a list. The type field, of course, stores the type code of the datum or link contained in word M + 1.

In the EULER algorithms describing the commands of the reverse Polish interpreter system, the following subroutines are used for list manipulation:

I. INITAS.(.AT.AVSL,.AT.LAVS,2000).

This routine passes pointers from the word AVSL and the 200 word array LAVS to a subroutine that organizes LAVS into a pool of list cells. A pointer to the first cell of this pool is stored in the LNKR field of AVSL, and the LNKL field of AVSL stores a pointer to the last cell of the LAVS pool.

II. ID.(WORD)., LNKL.(WORD)., LNKR.(WORD).

These functions perform appropriate masking and shifting of the contents of the <name> WORD, and return as values the ID, LNKL, and LNKR fields of WORD, respectively.

III. CONT.(ADDRESS).

This function returns the datum stored in the memory word with location given by ADDRESS.

IV. SETDIR.(ID,LNKL,LNKR,NAME).

Packs the value of ID into the ID field, LNKL into the LNKL field, and LNKR into the LNKR field of the word NAME. If any of the first three parameters of SETDIR is -1, the corresponding field of NAME is left unchanged.

V. SETIND.(ID,LNKL,LNKR,ADDRESS).

Similar to SETDIR above, except that ADDRESS is the machine address of some word in memory.

VI. MADOV.(NAME).

This function returns the machine address of the word containing the data stored in NAME.

VII. NUCELL

This parameterless function returns a link to the first free list cell in the LAVS pool. NUCELL also resets the LNKR field of the AVSL word to point to the new head of LAVS, and NUCELL initiates garbage collection of any unused sublists that it encounters.

```
$EXECUTE        IBJOB
$ID             SCHNEIDER,VICTOR B.*001/68/799*5M*50P*100C*BINARY$
$IBJOB          GO
$IBFTC TRANSL
C      NAMING AND TYPING OF STRUCTURES IN THE EULER TRANSLATOR.
           LOGICAL UNSAME,NOTIDT
           DIMENSION IDNTLS(1000),INPUT(3000),OUTPUT(1000),N(300),
     1          STORAJ(200)
           EQUIVALENCE (INPUT(501),OUTPUT(1)),(INPUT(1501),IDNTLS(1)),
     1          (INPUT(2501),N(1)), (INPUT(2801),STORAJ(1))
       INTEGER OUTPUT,PROCHD,PRCEND,BEGIN,TRMNAT,SEMCLN,COLON,ASSINE,
     1     OUT,TEST,SWITCH,THEN,ELSE,OR, FRSTOR,SCNDOR,AND,FSTAND,SCNAND,
     2     GREATR,GRATEQ,PLUS,ADD,SUBTRC,FLTDIV,EXPNNT,CONCAT,UNDFND,
     3     RTPREN,TAIL,FORMAL,COMMA,VARIBL,AT,TOREAL,TOABSL,TOINTG,TRUTH,
     4     FALSTY,SYMBOL,BLKNUM,STORAJ
       DATA KBGIN,KEND/6H.ENTRY,6H.EXIT./
       DATA IBLANK,NUMBER,LENGTH,LOGCAL/
     1     1H0,6H.NMBR.,6H.LNGT.,6H.LGCL./
       DATA ISNMBR,ISLGCL,ISLABL,ISLIST,ISUNDF,ISRFRN,ISPRCD,ISYMBL/
     1     6H.ISNU.,6H.ISLO.,6H.ISLA.,6H.ISLI.,6HCISUN.,6H.ISRE.,
     2     6H.ISPR.,6H.ISSY./
       DATA NEW,LABEL,JUMP,NEGATE,LABDEF,ISSAME,NOTSAM/
     1     5H.NEW.,6H.LABL.,6H.GOTO.,5H.NOT.,6H.LBDF.,4H.EQ.,5H.NEQ./
       DATA LESSTN,LESSEQ,NEG,MODULO,MLTPLY,INTDIV/
     1     4H.LT.,5H.LEQ.,5H.NEG.,6H.MDLO.,1H*,     3H././
       DATA INSIDE,LFPREN,LSCALL,LIST,LISTHD,LSTEND,LSBSCP/
     1     4H.IN.,1H(,6H.LSCL.,6H.LIST.,2H.(,2H).,4H((../
       DATA PROCHD,PRCEND,BEGIN,TRMNAT,SEMCLN,COLON/
     1     2H.$,2H$.,6H.BGIN.,5H.END.,2H.,,2H../
       DATA ASSINE,OUT,TEST,SWITCH,THEN/
     1     1H=,5H.OUT.,4H.IF.,6H.SWCH.,6H.THEN./
       DATA GREATR,GRATEQ,PLUS,ADD,SUBTRC,FLTDIV,EXPNNT/
     1     4H.GT.,5H.GEQ.,6H.PLUS.,1H+,1H-,1H/,2H**/
       DATA ELSE,OR,FRSTOR,SCNDOR,AND,FSTAND,SCNAND/
     1     6H.ELSE.,4H.OR.,6H.FSOR.,6H.SCOR.,5H.AND.,6H.FAND.,6H.SAND./
       DATA CONCAT,UNDFND,RTPREN,TAIL,FORMAL,COMMA,VARIBL/
     1     6H.CNCT.,6H.UNDF.,1H),6H.TAIL.,6H.FRML.,1H,,6H.VRBL./
       DATA AT,TOREAL,TOABSL,TOINTG,TRUTH,FALSTY,SYMBOL/
     1      4H.AT.,6H.REAL.,6H.ABST.,6H.INTG.,6H.TRUE.,6H.FLSE.,2H.*/
C
C INITIALIZATION--IT INDEXES IDNTLS, JK INDEXES INPUT, LL INDEXES OUTPUT
C AND IK INDEXES N, BLKNUM INDEXES STORAJ.  MARK IS USED IN WRITING OUT
C TRACES FOR BAD PROGRAMS.
C
           IT=0
           JK=1
           LL=0
           IK=0
           BLKNUM=0
           MARK=1
          CALL EDITOR(INPUT)
           WRITE(6,4)
    4      FORMAT(1H1)
C
C      INITIAL POINT FOR TRANSLATION
C
           IF(UNSAME(INPUT(JK),KBGIN)) GO TO 8000
           CALL STORE(KBGIN,N,IK,JK)
C
C      INITIAL POINT FOR BLOCK.
C
```

```
  100     ICODE=INPUT(JK)
          IF(UNSAME(ICODE,ISNMBR).AND.UNSAME(ICODE,ISLGCL).AND.
     1      UNSAME(ICODE,ISLABL).AND.UNSAME(ICODE,ISLIST).AND.
     2    UNSAME(ICODE,ISUNDF).AND.UNSAME(ICODE,ISRFRN).AND.
     3      UNSAME(ICODE,ISPRCD).AND.UNSAME(ICODE,ISYMBL)) GO TO 110
          CALL STORE(ICODE,N,IK,JK)
          GO TO 200
C      200 IS INITIAL POINT OF PRIMARY.
  110     IF(UNSAME( ICODE,LISTHD)) GO TO 120
          CALL OUTCOD(LISTHD,OUTPUT,LL)
          CALL STORE( LISTHD,N,IK,JK)
          GO TO 100
  120     IF(UNSAME(ICODE,BEGIN).AND.UNSAME(ICODE,PROCHD)) GO TO 130
          BLKNUM=BLKNUM+1
          STORAJ(BLKNUM)=IT+1
          CALL OUTCOD(ICODE,OUTPUT,LL)
          CALL STORE(ICODE,N,IK,JK)
          GO TO 100
  130     IF(UNSAME(ICODE,ADD)) GO TO 140
          CALL STORE(PLUS,N,IK,JK)
          GO TO 100
  140     IF(UNSAME(ICODE,SUBTRC)) GO TO 150
          CALL STORE(NEG,N,IK,JK)
          GO TO 100
  150     IF(UNSAME(ICODE,TAIL).AND.UNSAME(ICODETOUT).AND.UNSAME(ICODE,
     1       NOT).AND.UNSAME(ICODE,TEST).AND.UNSAME(ICODE,THEN).AND.
     2      UNSAME(ICODE,ELSE).AND.UNSAME(ICODE,LIST).AND.UNSAME(ICODE,
     3      LOGCAL).AND.UNSAME(ICODE,TOREAL).AND.UNSAME(ICODE,LENGTH)
     4      .AND.UNSAME(ICODE,AT).AND.UNSAME(ICODE,TOINTG).AND.UNSAME(
     5      ICODE,TOABSL).AND.UNSAME(ICODE,LIST).AND.UNSAME(ICODE,JUMP))
     6     GO TO 160
          CALL STORE(ICODE,N,IK,JK)
          GO TO 100
  160     IF(UNSAME(ICODE,NEW).AND.UNSAME(ICODE,FORMAL).AND.
     1     UNSAME(ICODE,LABEL)) GO TO 200
          CALL STORE(ICODE,N,IK,JK)
C
C      INITIAL POINT FOR PRIMARY.
C
  200     ICODE=INPUT(JK)
          IF(UNSAME(ICODE,SYMBOL)) GO TO 210
          CALL OUTCOD(SYMBOL,OUTPUT,LL)
          JK=JK+1
          CALL OUTCOD(INPUT(JK),OUTPUT,LL)
          JK=JK+1
          GO TO 300
  210     IF(UNSAME(ICODE,NUMBER)) GO TO 220
          CALL OUTCOD(NUMBER,OUTPUT,LL)
          CALL OUTCOD(INPUT(JK+1),OUTPUT,LL)
          CALL OUTCOD(INPUT(JK+2),OUTPUT,LL)
          JK=JK+3
          GO TO 300
  220     IF(UNSAME(ICODE,TRUTH).AND.UNSAME(ICODE,FALSTY).AND.UNSAME(
     1      ICODE,UNDFND)) GO TO 230
          CALL OUTCOD(ICODE,OUTPUT,LL)
          JK=JK+1
          GO TO 300
  230     IF(NOTIDT(ICODE)) GO TO 8230
          IF(UNSAME(INPUT(JK+1),COLON)) GO TO 235
          CALL OUTCOD(LABDEF,OUTPUT,LL)
          CALL OUTCOD(ICODE,OUTPUT,LL)
```

```
          JK=JK+2
          GO TO 100
  235     JK=JK+1
          NOFIK=N(IK)
          IF(UNSAME(NOFIK,FORMAL)) GO TO 250
          ITEMP=FORMAL
          CALL OUTCOD(FORMAL,OUTPUT,LL)
          CALL OUTCOD(ICODE,OUTPUT,LL)
          IT=IT+1
          IDNTLS(IT)=ICODE
          IK=IK-1
          ICODE=INPUT(JK)
          IF(UNSAME(ICODE,COMMA)) GO TO 240
          CALL STORE(ITEMP,N,IK,JK)
          GO TO 200
  240     IF(UNSAME(ICODE,SEMCLN)) GO TO 8240
          JK=JK+1
          IF(UNSAME(N(IK),PROCHD)) GO TO 8241
          GO TO 100
  250     IF(UNSAME(NOFIK,NEW).AND.UNSAME(NOFIK,LABEL)) GO TO 260
          ITEMP=NOFIK
          CALL OUTCOD(ITEMP,OUTPUT,LL)
          CALL OUTCOD(ICODE,OUTPUT,LL)
          IT=IT+1
          IDNTLS(IT)=ICODE
          IK=IK-1
          ICODE=INPUT(JK)
          IF (UNSAME(ICODE,COMMA)) GO TO 255
          CALL STORE(ITEMP ,N,IK,JK)
          GO TO 200
  255     IF(UNSAME(ICODE,SEMCLN)) GO TO 8255
          JK=JK+1
          IF(UNSAME(N(IK),BEGIN)) GO TO 8256
          GO TO 100
C     ICODE IS STILL THE IDENTIFIER IN QUESTION.
  260     ITEMP=IT
  261     IF(.NOT.UNSAME(IDNTLS(ITEMP),ICODE)) GO TO 265
          ITEMP=ITEMP-1
          IF(ITEMP) 8261,8261,261
  265     CALL OUTCOD(VARIBL,OUTPUT,LL)
          CALL OUTCOD(ICODE,OUTPUT,LL)
C
C     266 IS THE LABEL VARIABLE IN THE FLOWCHARTC
C         JK WAS INCREMENTED AT LABEL 235.ICODE WAS THEN INPUT(JK-1).
C
  266     ICODE=INPUT(JK)
          IF(UNSAME(ICODE,INSIDE)) GO TO 269
          CALL OUTCOD(INSIDE,OUTPUT,LL)
          JK=JK+1
          GO TO 266
  269     IF(UNSAME(ICODE,ASSINE)) GO TO 275
  270     CALL STORE(ICODE,N,IK,JK)
          GO TO 100
  275     IF(UNSAME(ICODE,LISTHD)) GO TO 277
          CALL OUTCOD(LSCALL,OUTPUT,LL)
          CALL OUTCOD(LISTHD,OUTPUT,LL)
          GO TO 270
  277     IF(UNSAME(ICODE,LFPREN)) GO TO 280
          CALL STORE(LSBSCP,N,IK,JK)
          GO TO 100
  280     NOFIK=N(IK)
```

```
      IF(UNSAME(NOFIK,AT)) GO TO 285
      IK=IK-1
      GO TO 300
285   IF(UNSAME(NOFIK,ISNMBR).AND.UNSAME(NOFIK,ISLGCL).AND.
     1   UNSAME(NOFIK,ISLABL).AND.UNSAME(NOFIK,ISLIST).AND.
     2   UNSAME(NOFIK,ISUNDF).AND.UNSAME(NOFIK,ISRFRN).AND.
     3   UNSAME(NOFIK,ISPRCD).AND.UNSAME(NOFIK,ISYMBL)) GO TO 295
      CALL OUTCOD(NOFIK,OUTPUT,LL)
      IK=IK-1
      GO TO 300
295   CALL OUTCOD(INSIDE,OUTPUT,LL)
C
C     300 IS THE LABEL OF PRIMARY.
C
300   NOFIK=N(IK)
      IF(UNSAME(NOFIK,TAIL)) GO TO 305
      CALL OUTCOD(NOFIK,OUTPUT,LL)
      IK=IK-1
      GO TO 300
305   IF(UNSAME(NOFIK,JUMP).AND.UNSAME(NOFIK,OUT)) GO TO 310
      CALL OUTCOD(NOFIK,OUTPUT,LL)
      IK=IK-1
      GO TO 1000
C     1000 IS THE LABEL OF EXPRESSION.
310   IF(UNSAME(NOFIK,CONCAT)) GO TO 400
C     400 IS THE LABEL OF CATENA.
      CALL OUTCOD(NOFIK,OUTPUT,LL)
      IK=IK-1
C
C     400 IS THE LABEL OF CATENA.
C
400   IF(UNSAME(INPUT(JK),CONCAT)) GO TO 410
      CALL STORE(CONCAT,N,IK,JK)
      GO TO 100
410   NOFIK=N(IK)
      IF(UNSAME(NOFIK,LENGTH)) GO TO 420
      CALL OUTCOD(LENGTH,OUTPUT,LL)
      IK=IK-1
      GO TO 300
420   IF(UNSAME(NOFIK,EXPNNT)) GO TO 500
      CALL OUTCOD(EXPNNT,OUTPUT,LL)
      IK=IK-1
C
C     500 IS THE LABEL OF FACTOR.
C
500   IF(UNSAME(INPUT(JK),EXPNNT)) GO TO 520
      CALL STORE(EXPNNT,N,IK,JK)
      GO TO 100
520   NOFIK=N(IK)
      IF(UNSAME(NOFIK,MLTPLY).AND.UNSAME(NOFIK,INTDIV).AND.
     1   UNSAME(NOFIK,FLTDIV).AND.UNSAME(NOFIK,MODULO)) GO TO 600
      CALL OUTCOD(NOFIK,OUTPUT,LL)
      IK=IK-1
C
C     600 IS THE LABEL OF TERM.
C
600   ICODE=INPUT(JK)
      IF(UNSAME(ICODE,MLTPLY).AND.UNSAME(ICODE,INTDIV).AND.
     1   UNSAME(ICODE,FLTDIV).AND.UNSAME(ICODE,MODULO)) GO TO 610
      CALL STORE(ICODE,N,IK,JK)
      GO TO 100
```

```
  610     NOFIK=N(IK)
          IF(UNSAME(NOFIK,PLUS).AND.UNSAME(NOFIK,NEG).AND.UNSAME(NOFIK,
     1      ADD).AND.UNSAME(NOFIK,SUBTRC)) GO TO 700
          CALL OUTCOD(NOFIK,OUTPUT,LL)
          IK=IK-1
C
C     700 IS THE LABEL OF SUM.
C
  700     ICODE=INPUT(JK)
          IF(UNSAME(ICODE,ISSAME).AND.UNSAME(ICODE,NOTSAM).AND.
     1      UNSAME(ICODE,LESSTN).AND.UNSAME(ICODE,LESSEQ).AND.
     2     UNSAME(ICODE,GREATR).AND.UNSAME(ICODE,GRATEQ).AND.
     3     UNSAME(ICODE,ADD).AND.UNSAME(ICODE,SUBTRC)) GO TO 710
          CALL STORE(ICODE,N,IK,JK)
          GO TO 100
  710     NOFIK=N(IK)
          IF(UNSAME(NOFIK,TOINTG).AND.UNSAME(NOFIK,TOABSL).AND.
     1      UNSAME(NOFIK,LOGCAL).AND.UNSAME(NOFIK,LIST))GO TO 720
          CALL OUTCOD(NOFIK,OUTPUT,LL)
          IK=IK-1
          GO TO 300
  720     IF(UNSAME(NOFIK,ISSAME).AND.UNSAME(NOFIK ,NOTSAM).AND.
     1      UNSAME(NOFIK,LESSTN).AND.UNSAME(NOFIK,LESSEQ).AND.
     2      UNSAME(NOFIK,GREATR).AND.UNSAME(NOFIK,GRATEQ)) GO TO 730
          CALL OUTCOD(NOFIK,OUTPUT,LL)
          IK=IK-1
          GO TO 800
  730     IF(UNSAME(NOFIK,LSBSCP)) GO TO   800
          IK=IK-1
          IF(UNSAME(INPUT(JK),RTPREN)) GO TO 8730
         CALL OUTCOD(RTPREN,OUTPUT,LL)
          JK=JK+1
          GO TO 266
C
C     800 IS THE LABEL OF RELATION.
C
  800     IF(UNSAME(N(IK),NEGATE))GO TO 850
          CALL OUTCOD(NEGATE,OUTPUT,LL)
          IK=IK-1
C
C     850 IS NEGATION.
C
  850     IF(UNSAME(N(IK),AND)) GO TO 870
          CALL OUTCOD(SCNAND,OUTPUT,LL)
          IK=IK-1
C
C     870 IS THE LABEL OF DISJUNCTION
C
  870     IF(UNSAME(INPUT(JK),AND)) GO TO 880
          CALL STORE(AND,N,IK,JK)
          CALL OUTCOD(FSTAND,OUTPUT,LL).
          GO TO 100
  880     IF(UNSAME(N(IK),OR)) GO TO 900
          CALL OUTCOD(SCNDOR,OUTPUT,LL)
          IK=IK-1
C
C     900 IS THE LABEL OF CONJUNCTION.
C
  900     IF(UNSAME(INPUT(JK),OR)) GO TO 910
          CALL STORE(OR,N,IK,JK)
          CALL OUTCOD(FRSTOR,OUTPUT,LL)
```

```
          GO TO 100
  910     IF(UNSAME(N(IK),TOREAL)) GO TO1000
          CALL OUTCOD(TOREAL,OUTPUT,LL)
          IK=IK-1
          GO TO 300
C      1000 IS THE LABEL OF EXPRESSION.
 1000     NOFIK=N(IK)
          IF(UNSAME(NOFIK,ASSINE)) GO TO 1010
          CALL OUTCOD(ASSINE,OUTPUT,LL)
          IK=IK-1
          GO TO 1000
 1010     IF(UNSAME(NOFIK,LFPREN)) GO TO 1020
          IK=IK-1
          IF(UNSAME(INPUT(JK),RTPREN)) GO TO 9010
          JK=JK+1
          GO TO 300
 1020     IF(UNSAME(NOFIK,TEST)) GO TO 1030
          CALL OUTCOD(TEST,OUTPUT,LL)
          IK=IK-1
          IF(UNSAME(INPUT(JK),THEN)) GO TO 9020
          CALL STORE(THEN,N,IK,JK)
          GO TO 100
 1030     IF(UNSAME(NOFIK,THEN)) GO TO 1040
          CALL OUTCOD(SWITCH,OUTPUT,LL)
          CALL OUTCOD(      THEN,OUTPUT,LL)
          CALL OUTCOD(NEGATE,OUTPUT,LL)
          CALL OUTCOD(TEST,OUTPUT,LL)
          IF(UNSAME(INPUT(JK),ELSE)) GO TO 9030
          N(IK)=ELSE
          JK=JK+1
          GO TO 100
 1040     IF(UNSAME(NOFIK,ELSE)) GO TO 1050
          CALL OUTCOD(SWITCH,OUTPUT,LL)
          CALL OUTCOD(THEN,OUTPUT,LL)
          CALL OUTCOD(SEMCLN,OUTPUT,LL)
          IK=IK-1
          GO TO 1000
 1050     IF(UNSAME(NOFIK,LISTHD)) GO TO 1060
          IK= IK-1
          IF(UNSAME(INPUT(JK),LSTEND)) GO TO 1055
          CALL OUTCOD(LSTEND,OUTPUT,LL)
          JK=JK+1
          GO TO 300
 1055     IF(UNSAME(INPUT(JK),COMMA)) GO TO 9055
          CALL OUTCOD(COMMA,OUTPUT,LL)
          CALL STORE(LISTHD,N,IK,JK)
          GO TO 100
 1060     IF(UNSAME(NOFIK,PROCHD)) GO TO 1100
          IK=IK-1
          IF(UNSAME(INPUT(JK),PRCEND)) GO TO 9060
          JK=JK+1
          CALL OUTCOD(PRCEND,OUTPUT,LL)
          GO TO 300
C
C      1100 IS THE LABEL OF STATEMENT.
C
 1100     IF(UNSAME(N(IK),SEMCLN)) GO TO 1110
          IK=IK-1
 1110     ICODE=INPUT(JK)
          IF(UNSAME(ICODE,SEMCLN)) GO TO 1120
          CALL OUTCOD(SEMCLN,OUTPUT,LL)
```

```
          CALL STORE(SEMCLN,N,IK,JK)
          GO TO 100
 1120     IF(UNSAME(ICODE,TRMNAT)) GO TO 9120
 1121    CALL OUTCOD(TRMNAT,OUTPUT,LL)
          JK=JK+1
          IF(UNSAME(N(IK),BEGIN)) GO TO 9121
          IT=STORAJ(BLKNUM)-1
          BLKNUM=BLKNUM-1
          IK=IK-1
          IF(IT.LT.0) GO TO 9121
C
C      1200 IS THE LABEL OF BLOCK.
C
 1200     IF(UNSAME(N(IK),KBGIN)) GO TO 1000
          IF(UNSAME(INPUT(JK),KEND)) GO TO 9200
          IIK=LL+1
          DO 1210 IKK=IIK,1000
 1210     OUTPUT(IKK)=IBLANK
          IIK=0
 1220     IIK=IIK+1
          IKK=11*IIK
          ITT=IKK-10
          IF(IKK.GT.1000)IKK=1000
          IF(IKK.EQ.1000.OR.OUTPUT(IKK+1).EQ.IBLANK) GO TO 1240
 1230     WRITE(7,1235)(OUTPUT(NOFIK),NOFIK=ITT,IKK)
          GO TO 1220
 1240     WRITE(7,1245)MLTPLY,(OUTPUT(NOFIK),NOFIK=ITT,IKK)
 1235     FORMAT(6X,11A6,8X)
 1245     FORMAT(A1,5X,11A6,8X)
          STOP
 6000     WRITE(6,6080)
 6080    FORMAT(1H0,82HTHE FOLLOWING IS A TRACE OF THE PORTION OF YOUR
     1PROGRAM THAT CONTAINED THE ERROR.      ,/,56HTHE LAST WORD CAUSED
     2THIS ERROR MESSAGE TO BE WRITTEN.              )
 6020     WRITE(6,6050)(INPUT(MM),MM=MARK,JK)
 6050     FORMAT(1H ,12A6)
          WRITE(6,6060)
 6060     FORMAT(1H0,25HTHE ERROR SCAN CONTINUES.////////)
 6090     JK=JK+1
         IF(JK.GT.500) GO TO 9500
          ICODE=INPUT(JK)
          IF(UNSAME(ICODE,SEMCLN)) GO TO 6095
          JK=JK+1
          MARK=JK
          GO TO 100
 6095    IF(UNSAME(ICODE,TRMNAT)) GO TO 6090
          MARK=JK
         JK=JK+1
         GO TO 1110
 8000     WRITE(6,4000)
 4000     FORMAT(1H0,50HIMPROPER CONTROL SYMBOL AT BEGINNING OF PROGRAM.
     1    )
         JK=JK+1
         GO TO 100
 8230     WRITE(6,4230)
 4230     FORMAT(1H0,50HILLEGAL OR MALFORMED IDENTIFIER. PROGRAM INVALID
     1.   )
          GO TO 6000
 8240     WRITE(6,4240)
 4240     FORMAT(1H0,60HILLEGAL PUNCTUATION IN FORMAL DECLARATION. INVAL
     1ID PROGRAM.    )
```

```
      GO TO 6000
8241  WRITE(6,4241)
4241  FORMAT(1H0,60HFORMAL DECLARATION IN NONPROCEDURE BLOCK. INVALI
     1D PROGRAM.     )
      GO TO 6000
8255  WRITE(6,4255)
4255  FORMAT(1H0,70HILLEGAL PUNCTUATION IN DECLARATION PART OF BLOCK
     1. INVALID PROGRAM.       )
      GO TO 6000
8256  WRITE(6,4256)
4256  FORMAT(1H0,67HDECLARATION ATTEMPT AT WRONG POINT IN PROGRAM.
     1INVALID PROGRAM.    )
      GO TO 6000
8261  WRITE(6,4261)
4261  FORMAT(1H0,60HATTEMPTED USE OF UNDECLARED IDENTIFIER. INVALID
     1PROGRAM.       )
      GO TO 6000
8730  WRITE(6,4730)
4730  FORMAT(1H0,60HUNBALANCED SUBSCRIPTING PARENTHESES. INVALID
     1PROGRAM.       )
      GO TO 6000
9010  WRITE(6,5010)
5010  FORMAT(1H0,67HUNBALANCED PARENTHESES AROUND AN EXPRESSION. INV
     1ALID PROGRAM.       )
      GO TO 6000
9020  WRITE(6,5020)
5020  FORMAT(1H0,60HMISSING THEN** IN CONDITIONAL STATEMENT. INVALID
     1 PROGRAM.      )
      GO TO 6000
9030  WRITE(6,5030)
5030  FORMAT(1H0,60HMISSING *ELSE* IN CONDITIONAL STATEMENT. INVALID
     1PROGRAM.       )
      GO TO 6000
9055  WRITE(6,5055)
5055  FORMAT(1H0,41HMISSING *COMMA* IN LIST. INVALID PROGRAM.     )
      GO TO 6000
9060  WRITE(6,5060)
5060  FORMAT(1H0,60HMISSING $. TO END A PROCEDURE DEFINITION. INVALI
     1D PROGRAM.     )
      GO TO 6000
9120  WRITE(6,5120)
5120  FORMAT(1H0,70HNO SEMICOLON** OR *END* AT END OF A STATEMENT.
     1INVALID PROGRAM.                                          )
      GO TO 6000
9121  WRITE(6,5121)
5121  FORMAT(1H0,60H*BEGINS* AND *ENDS* DO NOT BALANCE. INVALID
     1PROGRAM.       )
      GO TO 6000
9200  WRITE(6,5200)
5200  FORMAT(1H0,67HIMPROPER CONTROL CARD SYMBOLS. *$.* IS MISSING
     1AT END OF PROGRAM.       )
      GO TO 6000
9500  WRITE(6,6050)(OUTPUT(IKK),IKK=1,500)
      STOP
      END
$IBFTC STOREX
      SUBROUTINE STORE(ITEM,INPLAC,INDEXI,INDEXJ)
      DIMENSION INPLAC(300)
      INDEXI=INDEXI+1
      INPLAC(INDEXI)=ITEM
      INDEXJ=INDEXJ+1
```

```
          RETURN
          END
$IBFTC OUTCDX
      SUBROUTINE OUTCOD(ITEM,INPLAC,INDEXL)
          DIMENSION INPLAC(1000)
          INDEXL=INDEXL+1
          INPLAC(INDEXL)=ITEM
          IF(INDEXL+1.GT.1000) GO TO 5
          RETURN
    5     WRITE(6,10)(INPLAC(INDEXL),INDEXL=1,1000)
   10     FORMAT(1H0,5X,12A6)
          WRITE(6,11)
   11     FORMAT(1H0,5X,31HPROGRAM TOO LARGE TO TRANSLATE.)
          STOP
          END
$IBFTC NOTIDX
      LOGICAL FUNCTION NOTIDT(NAME)
           LOGICAL LETTER
          IF(.NOT.LETTER(ISHIFT(FSTSYM(NAME)))) GO TO 5
      NOTIDT=.FALSE.
      RETURN
    5     NOTIDT=.TRUE.
          RETURN
          END
$IBFTC EDITX
      SUBROUTINE EDITOR(INPUT)
C      INITIALIZATION
         LOGICAL DIGIT,LETTER
          INTEGER STRGHD
          DATA STRGHD/2H.*/
        INTEGER SEMCLN,PROCHD,PRIOD5,SPACE,BLANK,PERIOD,ASTRSK
        DATA ICOMMA,NUMBER/2H0,,6H.NMBR./
        DATA SEMCLN,PROCHD,LISTHD,PRIOD5/2H.,,2HC$,2H.(,2H0./
        INTEGER ZERO,ONE,TWO,THREE,FOUR,FIVE,SIX,SEVEN,EIGHT
         DIMENSION INPUT(3000)
         DATA ZERO,ONE,TWO,THREE,FOUR,FIVE,SIX,SEVEN,EIGHT,NINE/
     1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
        DATA IBLANK,ASTRSK/2H0 ,1H*/
        DATA BLANK,PERIOD,IPLUS,IMINUS,IASIGN,IFLDIV,IDOLAR,
     1IRPREN,IASTRK/1H ,1H.,2H0+,2H0-,2H0=,2H0/,2H0$,2H0),2H0*/
        DATA ILPREN,IEXPNT/2H0(,2H**/
          DO 10 KK=1,46
          LM=66*KK
          LL=LM-65
          IF(LM.GT.3000) LM=3000
          READ(5,11)MARKER,(INPUT(KL),KL=LL,LM)
          IF(ISHIFT(MARKER).EQ.IASTRK) GO TO 13
   10     CONTINUE
   11     FORMAT(A1,5X,66A1,8X)
   12     FORMAT(1H ,80A1)
   13    KK=0
         WRITE(6,12)(INPUT(KL),KL=1,LM)
         KL=0
   15    KK=KK+1
         IF(KK.GT.3000)GO TO 80
        ICODE=ISHIFT(INPUT(KK))
        IF(ICODE.EQ.IBLANK)GO TO 15
        IF(ICODE.EQ.PRIOD5)GO TO 20
        IF(ICODE.EQ.IPLUS.OR.ICODE.EQ.IMINUS.OR.ICODE.EQ.IASIGN.OR.
     1  ICODE.EQ.ICOMMA.OR.ICODE.EQ.IFLDIV.OR.ICODE.EQ.ILPREN)GO TO 25
        IF(ICODE.EQ.IDOLAR.OR.ICODE.EQ.IRPREN)GO TO 30
```

```
      IF(ICODE.EQ.IASTRK)GO TO 35
      IF(DIGIT(INPUT(KK)))GO TO 45
      IF(LETTER(ICODE))GO TO 40
      GO TO 15
C     RESERVED WORK BEGINNING WITH PERIOD
   20  KL=KL+1
      KK=KK+1
      ICODE=ISHIFT(INPUT(KK))
      IF(ICODE.NE.                ICOMMA)GO TO 21
      INPUT(KL)=SEMCLN
      GO TO 15
   21 IF(ICODE.NE.                  IDOLAR)GO TO 22
      INPUT(KL)=PROCHD
      GO TO 15
   22 IF(ICODE.NE.                  ILPREN)GO TO 23
      INPUT(KL)=LISTHD
      GO TO 15
   23   IF(ICODE.EQ.IASTRK) GO TO 200
        INPUT(KL)= SPACE(0,PERIOD)
      LL=1
   24 INPUT(KL)=IPACK(INPUT(KL),       SPACE(6*LL,INPUT(KK)))
      KK=KK+1
      ICODE=ISHIFT(INPUT(KK))
      IF(ICODE.EQ.IBLANK)GO TO 4
      LL=LL+1
      IF(ICODE.EQ.PRIOD5)GO TO 3
      IF(LL.LT.6) GO TO 24
      KK=KK-1
      GO TO 15
    3 INPUT(KL)=IPACK(INPUT(KL),      SPACE(6*LL,PERIOD))
    4 LL=LL+1
      DO 5 LLL=LL,5
    5 INPUT(KL)=IPACK(INPUT(KL),       SPACE(6*LLL,BLANK))
      GO TO 15
C   SINGLE CHARACTER OPERATOR
   25  KL=KL+1
       INPUT(KL)=INPUT(KK)
       GO TO 15
C   FIRST CHARACTER OF OPERATOR WITH PERIOD AS SECOND CHARACTER
   30   KL=KL+1
      IF(ISHIFT(INPUT(KK+1)).NE.PRIOD5)GO TO 31
      INPUT(KL)=IPACK(SPACE(0,INPUT(KK)),PRIOD5)
      KK=KK+1
       GO TO 15
   31 INPUT(KL)=INPUT(KK)
       GO TO 15
C   FIRST ASTERISK OF POSSIBLE ASTERISK PAIR
   35   KL=KL+1
      IF(ISHIFT(INPUT(KK+1)).NE.IASTRK)GO TO 36
      KK=KK+1
      INPUT(KL)=IEXPNT
       GO TO 15
   36 INPUT(KL)=ASTRSK
       GO TO 15
C   GIRST LETTER OF AN IDENTIFIER
   40 KL=KL+1
      INPUT(KL)=0
      LL=0
   41 INPUT(KL)=IPACK(INPUT(KL),      SPACE(6*LL,INPUT(KK)))
      KK=KK+1
      LL=LL+1
```

```
      IF(LL.GT.5) GO TO 43
     IF(DIGIT(INPUT(KK)).OR.LETTER(ISHIFT(INPUT(KK))))GO TO 41
      DO 42 LLL=LL,5
42    INPUT(KL)=IPACK(INPUT(KL),      SPACE(6*LLL,BLANK))
43    KK=KK-1
      GO TO 15
C     FIRST DIGIT OF NUMBER
45    KL=KL+1
      INPUT(KL)=NUMBER
      KL=KL+1
      TEMP=0.0
46     IF(INPUT(KK).NE.ZERO) GO TO 47
      ADDEND=0.0
      GO TO 56
47     IF(INPUT(KK).NE.ONE) GO TO 48
      ADDEND =1.0
      GO TO 56
48     IF(INPUT(KK)  .NE.TWO) GO TO 49
      ADDEND=2.0
      GO TO  56
49     IF(INPJT(KK).NE.THREE) GO TO 50
      ADDEND = 3.0
       GO TO 56
50     IF(INPUT(KK).NE. FOUR)  GO TO 51
      ADDEND=4.0
       GO TO 56
51     IF(INPUT(KK).NE.FIVE) GO TO 52
      ADDEND=5.0
       GO TO 56
52    IF(INPUT(KK).NE.SIX) GO TO 53
      ADDEND= 6.0
       GO TO 56
53     IF(INPUT(KK).NE.SEVEN) GO TO 54
      ADDEND= 7.0
       GO TO 56
54    IF(INPUT(KK).NE.EIGHT) GO TO 55
      ADDEND= 8.0
       GO TO 56
55    IF(INPUT(KK).NE.NINE)     GO TO 69
      ADDEND=9.0
56    TEMP=ADDEND+10.0*TEMP
      KK=KK+1
      GO TO 46
69    IF(INPUT(KK).EQ.PERIOD) GO TO 57
      GO TO 68
57    SCALE = 1.0
58     SCALE=0.1*SCALE
      KK=KK+1
      IF(INPUT(KK).NE.ZERO) GO TO 59
      GO TO 58
59     IF(INPUT(KK).NE.ONE) GO TO 60
      TEMP=SCALE+TEMP
         GO TO 58
60     IF(INPUT(KK) .NE. TWO) GO TO 61
      TEMP= 2.0*SCALE+TEMP
         GO TO 58
61    IF(INPUT(KK).NE.THREE)      GO TO 62
      TEMP=3.0*SCALE       +TEMP
         GO TO 58
62     IF(INPJT(KK).NE. FOUR)        GO TO 63
     TEMP=4.0      *SCALE + TEMP
```

```
            GO TO 58
   63      IF(INPUT(KK).NE.FIVE) GO    TO     64
         TEMP=5.0      *SCALE + TEMP
            GO TO 58
   64       IF(INPUT(KK).NE.SIX)    GO    TO    65
           TEMP=6.0    *SCALE + TEMP
            GO TO 58
   65     IF(INPUT(KK).NE.SEVEN)     GO TO    66
           TEMP=7.0    *SCALE + TEMP
            GO TO 58
   66      IF(INPUT(KK).NE. EIGHT) GO  TO      67
           TEMP  =8.0 *SCALE + TEMP
            GO TO 58
   67     IF(INPUT(KK).NE. NINE)  GO   TO  68
             TEMP=9.0 *SCALE + TEMP
            GO TO 58
   68     KK=KK-1
          CALL JUSTOT(TEMP,INPUT(KL),INPUT(KL+1))
          KL=KL+1
          GO TO 15
  200      INPUT(KL)=STRGHD
           LL=0
  201       KL=KL+1
           INPUT(KL)=0
  202       KK=KK+1
           IF(ISHIFT(INPUT(KK)).EQ.IASTRK) GO TO 204
           INPUT(KL)=IPACK(INPUT(KL),SPACE(6*LL,INPUT(KK)))
            IF(LL.GT.5) GO TO 203
            LL=LL+1
            GO TO 202
  203       KK=KK-1
            GO TO 15
  204       KK=KK+1
          GO TO 4
   80       KL=KL+1
            DO 81 KK=KL,3000
   81       INPUT(KK)=IBLANK
            RETURN
            END
$IBFTC DIGITX
       LOGICAL FUNCTION DIGIT(JIG)
           INTEGER ZERO,ONE,TWO,THREE,FOUR,FIVE,SIX,SEVEN,EIGHT
        DATA ZERO,ONE,TWO,THREE,FOUR,FIVE,SIX,SEVEN,EIGHT,NINE/
      1     1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
        IF(JIG.EQ.ZERO.OR.JIG.EQ.ONE.OR.JIG.EQ.TWO.OR.JIG.EQ.THREE.OR.
      1JIG.EQ.FOUR.OR.JIG.EQ.FIVE.OR.JIG.EQ.SIX.OR.JIG.EQ.SEVEN.OR.
      2JIG.EQ.EIGHT.OR.JIG.EQ.NINE) GO TO 8
           DIGIT = .FALSE.
           RETURN
     8      DIGIT = .TRUE.
           RETURN
           END
$IBFTC LETTRX
       LOGICAL FUNCTION LETTER(LET)
           INTEGER A,B,C,D,E,F,G,H,O,P,Q,R,S,T,U,V,W,X,Y,Z
          DATA A,B,C,D,E,F,G,H,I,J,K/
      12H0A,2H0B,2H0C,2H0D,2H0E,2H0F,2H0G,2H0H,2H0I,2H0J,2H0K/
           DATA L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z/
      12H0L,2H0M,2H0N,2H0O,2H0P,2H0Q,2H0R,2H0S,2H0T,2H0U,2H0V,2H0W,
      22H0X,2H0Y,2H0Z/
        IF(LET.EQ.A.OR.LET.EQ.B.OR.LET.EQ.C.OR.LET.EQ.D.OR.LET.EQ.E.OR.
```

```
     1LET.EQ.F.OR.LET.EQ.G.OR.LET.EQ.H.OR.LET.EQ.I.OR.LET.EQ.J.OR.LET
     2.EQ.K.OR.LET.EQ.L.OR.LET.EQ.M.OR.LET.EQ.N.OR.LET.EQ.O.OR.LET.EQ.
     3P.OR.LET.EQ.Q.OR.LET.EQ.R.OR.LET.EQ.S.OR.LET.EQ.T.OR.LET.EQ.U.OR.
     4LET.EQ.V.OR.LET.EQ.W.OR.LET.EQ.X.OR.LET.EQCY.OR.LET.EQ.Z)
     5    GO TO 8
          LETTER = .FALSE.
          RETURN
     8    LETTER=.TRUE.
          RETURN
          END
$IBMAP SPACEX  7
       ENTRY   SPACE
*   SPACE(BITSTORIGHT,WORDTOBESHIFTED)
SPACE  CLA*    3,4                FETCH SHIFTING NUMBER
       STA     *+3
       CAL*    4,4          STORE S,1-35 IN AC,BITS P,1-35
       ANA     MASK          AND WORD S,1-35 WITH AC P,1-35
       ARS     **           SHIFT RIGHT THE AC
       SLW     MM
       CLA     MM
       TRA     1,4
MM     BSS     1
MASK   OCT     770000000000            2-7'S,10-0'S
       END
$IBMAP IPK
       ENTRY   IPACK
*     TAKES THE LOGICAL OR OF TWO ALPHANUMERIC WORDS
IPACK  CAL*    3,4
       ORA*    4,4
       SLW     MM
       CLA     MM
       TRA     1,4
MM     BSS     1
       END
$IBMAP JUST
       ENTRY   JUSTOT
*              JUSTOT(FL,A,B)=THE ABSOLUTE VALUE OF FL
*                 IS TRANSFORMED TO 2 BCD WORDS AND
*                 STORED IN A AND B
JUSTOT SXA     BACK,1
       CLA*    3,4
       SSP
       XCA
       PXA     0,0
       AXT     6,1
       ALS     3
       LGL     3
       TIX     *-2,1,1
       STO*    4,4
       PXA     0,0
       AXT     6,1
       ALS     3
       ALS     3
       TIX     *-2,1,1
       STO*    5,4
BACK   AXT     **,1
       TRA     1,4
       END
$IBMAP ISHFT
*      SHIFTS THE ARGUMENT RIGHT ONE CHARACTER AND RETURNS VALUE
       ENTRY   ISHIFT
```

```
ISHIFT  CAL*    3,4
        ARS     6
        TRA     1,4
        END
$IBMAP  UNSAMEX
        ENTRY   UNSAME
UNSAM   CAL*    3,4
        ERA*    4,4
        TZE     1,4
        CLA     =1
        TRA     1,4
        END
$IBMAP  FSTSYX
        ENTRY   FSTSYM
FSTSYM  CAL*    3,4
        ANA     MASK1
        ORA     MASK2
        SLW     TEMP
        CLA     TEMP
        TRA     1,4
MASK1   OCT     770000000000
MASK2   OCT     006060606060
TEMP    BSS     1
        END
$ENTRY  TRANSL
$DATA
       .ENTRY .BGIN..NEW.FIBO,N.,.OUT..(.*     N=,N=10)..,
           FIBO= .$.FRML.K.,.IF.K.LEQ.      2 .THEN.1 .ELSE.
          FIBO.(K-1).+FIBO.(K-2).$.,.OUT..(.*FIBO= ,FIBO)..,
           .OUT..(.* FIBO(,N,.*) =    ,FIBO.(N).).
*      .END..EXIT.
```

Appendix 4. The EULER Polish Interpreter Listing

```
      INTEGER T,FORMAL,VARIBL,BLKNUM,STORAJ,ASSINE,
     1BEGIN,TRMNAT , SEMCLN, SYMBOL,COMMA,RSBSCP,CONCAT,TAIL,OUT,
     2TEST,SWITCH,THEN,FRSTOR,SCNDOR,FSTAND,SCNAND,ADD,
     3SUBTRC,FLTDIV,EXPNNT,PLUS, TOREAL, TOINTG, TOABSL,PRCHD,
     4PRCEND,TRUTH,FALSTY,GREATR,GRATEQ,UNDFND,PRCCHD
      DIMENSION LAVS(2000),LSTRTN(200),IDNTLS(1500),CPRCD(500),
     1    IOPRND(500),STORAJ(200),JUMPBK(200),PRMLS(200)
      COMMON/AVSLX/AVSL,CODE(500)
      INTEGER CODE
      DATA ICOMMA,LEPREN,IRPREN/1H,,6H     (,1H)/
      DATA LOGCAL, ISNMBR, ISLGCL, ISLABL, ISLIST, ISUNDF, ISPRN/
     16HO.LGCL,6HO.ISNU,6HO.ISLC,6HO.ISLA,6HO.ISLI,6HO.ISUN,6HO.ISPR/
      DATA TRMNAT,BEGIN,SEMCLN,NEW,LABEL,LABDEF,ASSINE,JUMP/
     16HO.END.,6HO.BGIN,3HO.,,6HO.NEW.,6HO.LABL,6HO.LBDF,2HO=,6HO.GOTO/
      DATA CUT,TEST,SWITCH,THEN,NEGATE,FRSTOR,SCNDOR/
     16HO.OUT.,5HO.IF.,6HO.SWCH,6HO.THEN,6HO.NOT.,6HO.FSOR,
     26HO.SCOR/
      DATA LESSEQ,ADD,SUBTRC,PLUS,NEG,MODULO,MLTPLY,INTDIV/
     16HO.LEQ.,2HO+,2HO-,6HO.PLUS,6HO.NEG.,6HO.MDLO,2HO*,4HO././
      DATA FLTDIV,EXPNNT,CONCAT,INSIDE,UNDFND,TAIL,LSCALL,LIST/
     12HO/,3HO**,6HO.CNCT,5HO.IN.,6HO.UNDF,6HO.TAIL,6HO.LSCL,6HO.LIST/
      DATA ISPRCD,ISYMBL,SYMBOL,RSBSCP,VARIBL/
     16HO.ISPR,6HO.ISSY,3HO.*,2HO),6HO.VRBL/
      DATA FSTAND,SCNAND,ISSAME,NOTSAM,GREATR,LESSTN,GRATEQ/
     16HO.FAND,6HO.SAND,5HO.EQ.,6HO.NEQ.,5HO.GT.,5HO.LT.,6HO.GEQ./
      DATA PRCCHD,PRCEND,FORMAL,LABEL,LISTHD,      COMMA,LSTEND/
     13HO.$,3HO$.,6HO.FRML,6HO.LABL,3HO.(,2HO,,3HO)./
      DATA NUMBER,TOREAL,LENGTH,TOINTG,TOABSL/
     16HO.NMBR,6HO.REAL,6HO.LNGT,6HO.INTG,6HO.ABST/
      DATA TRUTH,FALSTY/6HO.TRUE,6HO.FLSE/
      CALL INITAS(LAVS,2000)
        DO 1 IK=1,46
        T=11*IK
        I=T-10
        IF(T.GT.500)T=500
        READ(5,2)ITEMP,(CODE(INDEX),INDEX=I,T)
    2   FORMAT(A1,5X,11A6,8X)
        IF(ISHIFT(ITEMP).EQ.MLTPLY) GO TO 5
    1   CONTINUE
    5   WRITE(6,9006)(CODE(I),I=1,T)
        WRITE(6,9005)
      I=0
      IK=0
        IBASH=0
      BLKNUM=0
      JMPRTN=0
      T=0
   10 I=I+1
        CALL CUTOUT(7,CODE(I),IBASH)
      ICODE=ISHIFT(CODE(I))
        IF(ICODE .EQ. LSCALL) GO TO 300
        IF(ICODE .EQ. SYMBOL) GO TO 305
        IF(ICODE .EQ. TEST)   GO TO 430
        IF(ICODE .EQ. SWITCH) GO TO 440
        IF(ICODE .EQ. NEGATE) GO TO 445
```

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      IF(ICODE .EQ. THEN)   GO TO 10
      IF(ICODE .EQ. LIST)   GO TO 500
      IF(ICODE .EQ. CONCAT) GO TO 505
      IF(ICODE .EQ. TAIL)   GO TO 510
      IF(ICODE .EQ. LENGTH) GO TO 515
      IF(ICODE .EQ. LISTHD) GO TO 600
      IF(ICODE .EQ. COMMA)  GO TO 605
      IF(ICODE .EQ. LSTEND) GO TO 615
      IF(ICODE .EQ. RSBSCP) GO TO 650
      IF(ICODE .EQ. BEGIN)  GO TO 700
      IF(ICODE .EQ. TRMNAT) GO TO 705
      IF(ICODE .EQ. SEMCLN) GO TO 710
      IF(ICODE .EQ. VARIBL) GO TO 715
      IF(ICODE .EQ. NUMBER) GO TO 725
      IF(ICODE .EQ. UNDFND) GO TO 727
      IF(ICODE .EQ. NEW)    GO TO 730
      IF(ICODE .EQ. LABDEF) GO TO 731
      IF(ICODE .EQ. LABEL)  GO TO 735
      IF(ICODE .EQ. ASSINE) GO TO 740
      IF(ICODE .EQ. OUT)    GO TO 755
      IF(ICODE .EQ. FRSTOR) GO TO 775
      IF(ICODE .EQ. SCNDOR) GO TO 780
      IF(ICODE .EQ. SCNAND) GO TO 780
      IF(ICODE .EQ. FSTAND) GO TO 785
      IF(ICODE .EQ. PLUS)   GO TO 10
      IF(ICODE .EQ. NEG)    GO TO 781
      IF(ICODE .EQ. ISSAME) GO TO 790
      IF(ICODE .EQ. NOTSAM) GO TO 795
      IF(ICODE .EQ. GREATR) GO TO 796
      IF(ICODE .EQ. LESSTN) GO TO 797
      IF(ICODE .EQ. GRATEQ) GO TO 798
      IF(ICODE .EQ. LESSEQ) GO TO 799
      IF(ICODE .EQ. ADD)    GO TO 805
      IF(ICODE .EQ. SUBTRC) GO TO 807
      IF(ICODE .EQ. MLTPLY) GO TO 810
      IF(ICODE .EQ. FLTDIV) GO TO 811
      IF(ICODE .EQ. INTDIV) GO TO 812
      IF(ICODE .EQ. MODULO) GO TO 813
      IF(ICODE .EQ. EXPNNT) GO TO 816
      IF(ICODE .EQ. TRUTH)  GO TO 817
      IF(ICODE .EQ. FALSTY) GO TO 819
      IF(ICODE .EQ. LOGCAL) GO TO 820
      IF(ICODE .EQ. PROCHD) GO TO 840
      IF(ICODE .EQ. INSIDE) GO TO 845
      IF(ICODE .EQ. PRCEND) GO TO 865
      IF(ICODE .EQ. ISNMBR) GO TO 860
      IF(ICODE .EQ. ISLGCL) GO TO 861
      IF(ICODE .EQ. ISLABL) GO TO 862
      IF(ICODE .EQ. ISLIST) GO TO 863
      IF(ICODE .EQ. ISUNDF) GO TO 864
      IF(ICODE .EQ. ISPRCD) GO TO 866
      IF(ICODE .EQ. ISYMBL) GO TO 867
      IF(ICODE .EQ. ISRFRN) GO TO 868
      IF(ICODE .EQ. FORMAL) GO TO 870
      IF(ICODE .EQ. JUMP)   GO TO 930
      IF(ICODE .EQ. TOREAL) GO TO 937
```

```
      IF(ICCDE .EQ. TOINTG) GO TO 938
      IF(ICODE .EQ. TOABSL) GO TO 939
      WRITE(6,9931)
      STOP
C
C     ASSUMES VARIBL HAS PLACED A LINK TO THE DATUM IN CPRND(IK)
C
  300 LINK = LNKR(CPRND(IK))
      IF(ID(INHALT(LINK)).NE.6) GO TO 8860
      IOPRND(IK) = 6
      CALL STRDIR(CONT(LINK+1),OPRND(IK))
      GO TO 10
  305 I=I+1
      IK=IK+1
      IOPRND(IK)=7
      CALL STRDIR(CODE(I),OPRND(IK))
      GO TO 10
C
C     TEST OPERAND FOR TRUTH.  IF FALSE, SCAN AHEAD UNTIL A MATCHING
C     THEN IS FOUND.  IF TRUE, CONTINUE EVALUATION.
C
  430 IF(CPRND(IK).EQ.1.0) GO TO 10
      ITT=0
  431 I=I+1
      ICODE=ISHIFT(CODE(I))
      IF(ICODE.EQ.TEST)ITT=ITT+1
      IF(ICODE.EQ.THEN)GO TO 432
      GO TO 431
  432 IF(ITT.EQ.0) GO TO 10
      ITT=ITT-1
      GO TO 431
C
C     EXCHANGE TOPMOST OPERANDS DURING A CONDITIONAL STATEMENT.
C
  440 TEMP=OPRND(IK-1)
      ITT=IOPRND(IK-1)
      OPRND(IK-1)=CPRND(IK)
      IOPRND(IK-1)=IOPRND(IK)
      CPRND(IK)=TEMP
      IOPRND(IK)=ITT
      GO TO 10
C
C     NEGATE TOPMOST OPERAND FOR CONDITIONAL STATEMENT AND LOGICAL
C     NEGATION.
C
  445 IF(IOPRND(IK).NE.1) GO TO 8775
      OPRND(IK)=1.0-OPRND(IK)
      GO TO 10
C
C     CREATION OF A LIST OF LENGTH OPRND(IK).
C
  500 IF(IOPRND(IK).NE.0) GO TO 8806
      INDEX=OPRND(IK)
      ICPRND(IK)=3
      IF(INDEX.NE.0) GO TO 501
      CALL STRDIR(0,CPRND(IK))
```

```
            GO TO 10
  501       IVRBL=NUCELL(DUMMY)
            IF(INDEX.EQ.1) GO TO 503
            LLCELL=IVRBL
            DO 502 ITEMP=2,INDEX
            LRCELL=NUCELL(DUMMY)
            CALL SETIND(4,-1,LRCELL,LLCELL)
C     THE NUCELL ROUTINE ZEROES THE LNKR FIELDS.
  502       LLCELL=LRCELL
  503       CALL SETDIR(0,0,IVRBL,OPRND(IK))
            GO TO 10
C
C     CONCATENATION OF TWO LISTS. A LINK TO THE RESULTING LIST IS
C     RETURNED TO THE TOP OF THE OPRND STACK. THE TWO CONCATENATED LISTS
C     ARE COPIED BY THE COPY ROUTINE. THE COPY ROUTINE HAS PROVISIONS
C     FOR LISTS THAT HAVE ZERO REFERENCE COUNT (I.E.,NO NAME) AND FOR
C     EMPTY LISTS.
C
  505   IF(IOPRND(IK).NE.3.OR.IOPRND(IK-1).NE.3) GO TO 8510
        LINKO=LNKR(OPRND(IK-1))
        CALL COPY(LINKO,ITOP,IBOT)
        LINKO=LNKR(OPRND(IK))
        CALL COPY(LINKO,JTOP,JBOT)
        IK=IK-1
          CALL STRDIR(ITOP,OPRND(IK))
        CALL SETIND(-1,-1,JTOP,IBOT)
        GO TO 10
C
C     TAKES THE SUFFIX OF A LIST, IGNORES REFERENCE COUNT OF
C     FIRST CELL, AND PUTS LINK TO THAT CELL ON TOP OF OPERAND LIST
C
  510       ITEMP=LNKR(OPRND(IK))
            IF(IOPRND(IK).NE.3) GO TO 8510
            IF(ITEMP.EQ.0) GO TO 8511
            ITEMP=LNKR(INHALT(ITEMP))
            IF(ITEMP.EQ.0) GO TO 8650
            CALL SETDIR(ITEMP,OPRND(IK))
           CALL SETIND(-1,LNKL(INHALT(ITEMP))+1,-1,ITEMP)
            GO TO 10
C
C     FINDS THE LENGTH OF THE LIST WHOSE POINTER IS AN OPERAND.
C
  515       IF(IOPRND(IK).NE.3) GO TO 8510
            TEMP=0.0
            ITEMP=LNKR(OPRND(IK))
            IOPRND(IK)=0
  516     IF(ITEMP.LE.0) GO TO 517
          TEMP=TEMP+1.0
            ITEMP=LNKR(INHALT(ITEMP))
            GO TO 516
  517       OPRND(IK)=TEMP
            GO TO 10
C
C     A PLACE IS RESERVED ON THE OPERAND LIST FOR A LINK.
C
  600 IK=IK + 1
```

```
      IOPRND(IK) = 3
      CALL STRDIR(LISTHD,OPRND(IK))
      GO TO 10
C
C     TYPED INFORMATION ON TOP OF THE OPERAND LIST IS REPLACED BY
C     AN INTEGER LINK TO A LIST CELL THAT CONTAINS
C     THIS INFORMATION.  THE IK COUNT IS NOT DECREMENTED AND THE
C     SUBLIST REFERENCE COUNTERS ARE INCREMENTED.
C
  605     IKK=IOPRND(IK)
          IJJ=LNKR(OPRND(IK))
        IF(IKK.NE.3.OR.IJJ.LE.0) GO TO 610
          CALL SETIND(-1,LNKL(INHALT(IJJ))+1,-1,IJJ)
  610     ITEMP=NUCELL(DUMMY)
          CALL SETIND(IKK,0,0,ITEMP)
         CALL STRIND(OPRND(IK),ITEMP+1)
        CALL STRDIR(ITEMP,OPRND(IK))
        IOPRND(IK)=3
        GO TO 10
C
C     PERFORMS THE COMMA OPERATION ON TOPMOST DATUM IN OPERAND STACK.
C     THEN PROCEDES DOWN THE OPERAND STACK TO LINK TOGETHER OPERANDS
C     UNTIL LISTHEAD **.(** IS ENCOUNTERED AS AN OPERAND. FINALLY,CHECKS
C     TO SEE IF THE RESULTING LIST IS THE PARAMETERLIST OF A PROCEDURE
C     CALL.
C
  615   IF(INTRSC(OPRND(IK),LISTHD).NE.0) GO TO 620
        CALL STRDIR(0,OPRND(IK))
          GO TO 10
  620     ITEMP=NUCELL(DUMMY)
          IKK=IOPRND(IK)
          IJJ=LNKR(OPRND(IK))
          IF(IKK.NE.3.OR.IJJ.LE.0) GO TO 630
          CALL SETIND(-1,LNKL(INHALT(IJJ))+1,-1,IJJ)
  630     CALL SETIND(IKK,0,0,ITEMP)
        CALL STRIND(OPRND(IK),ITEMP+1)
          CALL STRDIR(ITEMP,OPRND(IK))
          IOPRND(IK)=3
  645     IF(INTRSC(OPRND(IK-1),LISTHD).EQ.0) GO TO 646
          CALL SETIND(-1,0,LNKR(OPRND(IK)),LNKR(OPRND(IK-1)))
          IK=IK-1
          GO TO 645
  646     IK=IK-1
          OPRND(IK)=OPRND(IK+1)
          IF(IOPRND(IK-1).NE.6) GO TO 10
C
C     THE FORMAL ROUTINE EXPECTS TO FIND A LINK TO THE FIRST
C     CELL OF AN ID-DATUM PAIR ON PRAMLS.  FORMAL CHECKS FOR
C     LISTEND AND PARAMETER MATCHING.  THE PARAMETER LIST IS LOCAL
C     TO THE CALLING BLOCK OF THE PROCEDURE AND IS DEMOLISHED BY END.
           JMPRTN=JMPRTN+1
           JUMPBK(JMPRTN)=I
        T=T+1
        ITT=3*T
        CALL STRDIR(OPRND(IK),PRAMLS(JMPRTN))
        CALL STRDIR(OPRND(IK),IDNTLS(ITT))
```

```
            CALL SETDIR(3,1,0,IDNTLS(ITT-1))
            I=OPRND(IK-1)
            IK=IK-2
            BLKNUM=BLKNUM+1
             STORAJ(BLKNUM)=T+1
             GO TO 10
C
C      THE RIGHT BRACKET ACTS AS AN OPERATOR SO THAT THE TOPMOST OPERAND
C      SPECIFIES THE CELL OF A LIST WHOSE LINK IS THE NEXT OPERAND
C      DOWN.  A REFERENCE (LINK) IS RETURNED TO THE NEXT OPERAND DOWN,
C      PRESERVES THE BLOCKNUMBER FOUND BY VARIBL.
C
   650      INDEX=OPRND(IK)
            IK=IK-1
            IF(INDEX.LE.0) GO TO 10
          LINK=LNKR(INHALT(1+LNKR(OPRND(IK))))
   651      IF(LINK.LT.2) GO TO 8650
            INDEX=INDEX-1
            IF(INDEX.EQ.0) GO TO 652
            LINK=LNKR(INHALT(LINK))
            GO TO 651
   652      CALL SETDIR(-1,-1,LINK,OPRND(IK))
            GO TO 10
C
   700      BLKNUM = BLKNUM + 1
            STORAJ(BLKNUM) = T+1
            GO TO 10
C      THIS IS THE BLOCK END ROUTINE. ITS MAIN FEATURE IS A SEARCH
C      FOR LISTS TO RETURN TO LAVS. THE BLOCKNUMBER IS DECREMENTED,
C      AND, IF EQUAL TO ZERO, THE PROGRAM TERMINATES.
C
   705      INDEX = STORAJ(BLKNUM)
            IF(T.LT.INDEX) GO TO 709
   706      LLNK=LNKR(IDNTLS(3*T))
            IF(ID(IDNTLS(3*T-1)).NE.3.OR.LLNK.LE.0)GO TO 708
             CALL ERASE(LLNK)
   708      ITT=3*T
            IDNTLS(ITT)=0
            IDNTLS(ITT-1)=0
            IDNTLS(ITT-2)=0
             T = T - 1
            IF(T.GE.INDEX) GO TO 706
   709      BLKNUM = BLKNUM - 1
            IF(BLKNUM .GT. 0) GO TO 10
            STOP
C
C      SEMICOLON REMOVES THE TOPMOST OPERAND OF THE OPERAND LIST.
C      IF THIS OPERAND IS A LINK TO SOME LIST WHOSE FIRST CELL HAS
C      ZERO REFERENCE COUNT ERASE IS CALLED.
C
   710 IF(IOPRND(IK) .NE. 3) GO TO 713
       LLNK = LNKR(OPRND(IK))
         IF(LLNK.LE.0) GO TO 713
         LCOUNT=LNKL(INHALT(LLNK))
       IF(LCOUNT .GT. 0) GO TO 713
       CALL ERASE (LLNK)
```

```
  713 IK = IK - 1
      GO TO 10
C
C     IT IS ASSUMED THAT LABELS AND REFERENCES ARE STORED IN THE LNKR
C     FIELDS OF WORDS AND THAT THEIR DYNAMIC BLOCKNUMBER IS STORED IN
C     THE LNKL FIELDS. THE NAME FOLLOWING THE VARIBL COMMAND IS LOOKED
C     UP ON THE IDENT STACK, AND A LINK TO IDENT(3*T'-1),FOR SOME T', IS
C     PLACED ON TOP OF THE OPRND STACK.
C
  715      I = I + 1
           ITEMP = T
           IVRBL = CODE(I)
  716     IF(INTRSC(IVRBL,IDNTLS(3*ITEMP-2)).EQ.0)GO TO 717
           ITEMP = ITEMP - 1
           IF (ITEMP .LE. 0) GO TO 8716
           GO TO 716
  717      IK = IK + 1
          LLNK=MADOV(IDNTLS(3*ITEMP-1))
           CALL SETDIR(0, LNKR(INHALT(LLNK)), LLNK, OPRND(IK))
           IOPRND(IK) = 5
           GO TO 10
C
  72?     T=I+2
          IK=IK+1
           CALL JUSTIN(OPRND(IK),CODE(I-1),CODE(I))
       IOPRND(IK) = 0
      GO TO 10
  727 IK=IK + 1
      OPRND(IK) = 0.0
      IOPRND(IK) = 4
      GO TO 10
C
  730      I = I + 1
           T = T + 1
           ITT=3*T
          IDNTLS(ITT-2)=CODE(I)
           CALL SETDIR(4,0,BLKNUM,IDNTLS(ITT-1))
          IDNTLS(ITT)=0
           GO TO 10
  731 I=I + 1
      GO TO 10
C
C     THIS ROUTINE SEARCHES FOR THE LOCATION OF THE
C     LABEL, THEN PLACES THE LINK TO THIS LABEL, EXPRESSED AS A
C     VALUE OF I, INTO IDNTLS(T, 3) ALONG WITH ITS BLOCKNUMBER.
C
  735      T=T + 1
          ITT=3*T
           I=I + 1
           KLBL = CODE(I)
          IDNTLS(ITT-2)=KLBL
          CALL SETDIR(2,0,BLKNUM,IDNTLS(ITT-1))
           INDEX = I
           ITEMP = 0
  736      INDEX = INDEX + 1
         ICODE=ISHIFT(CODE(INDEX))
```

```
      IF(ICODE.EQ.BEGIN) ITEMP=ITEMP+1
      ICODE=ISHIFT(CODE(INDEX))
      IF(ICODE.EQ.TRMNAT)  ITEMP=ITEMP-1
        IF(ITEMP .LT. 0) GO TO 8736
      IF(ICODE.NE.LABDEF)GO TO 736
        INDEX = INDEX + 1
       IF(CODE(INDEX).NE.KLBL .OR. ITEMP.NE.0) GO TO 736
        INDEX = INDEX + 1
  737 IF(ISHIFT(CODE(INDEX)).NE.LABDEF)GO TO 738
        INDEX = INDEX + 2
        GO TO 737
  738  CALL SETDIR(0,BLKNUM,INDEX,IDNTLS(ITT))
        GO TO 10
C
C     THE ASSIGNEE IS A REFERENCE (TYPE 5)  BECAUSE OF THE UNIFORM
C     CONVENTICNS OF TREATING THE SEQUENCE  **.VRBL.*NAME*** AND THE
C     RESULT OF USING RSBSCP ON A LIST FOR SUBSCRIPTING BOTH AS
C     REFERENCE POINTERS. THE LINKLEFT FIELD OF THE ASSIGNEE OPERAND
C     IS ITS DYNAMIC BLCCKNUMBER,AND THE LINKRIGHT FIELD POINTS TO THE
C     IDNTLS OR LIST CELL THAT PRECEDES ITS DATUM IN COMPUTER MEMORY.
C     IF THE ASSIGNED OPERAND IS A REFERENCE OR A LABEL, ITS LINKLEFT
C     FIELD ALSC CONTAINS THE DYNAMIC BLOCKNUMBER. IN THIS CASE, THE
C     ASSIGNMENT STATEMENT WILL NOT BE EXECUTED IF THE ASSIGNEE IS IN A
C     BLOCK GLOBAL TO THE BLOCK OF THE ASSIGNED.
C
  740   IF(IOPRND(IK-1) .NE. 5) GO TO 8740
        INDEX = IOPRND(IK)
        LRNK = LNKR(OPRND(IK))
        LINK = LNKR(OPRND(IK- 1))
        IF(INDEX .EQ. 5 .OR. INDEX .EQ. 2) GO TO 745
      IF(INDEX.NE.3.OR.LRNK.LE.0) GO TO 741
        CALL SETIND(-1, LNKL(INHALT(LRNK)) + 1, -1, LRNK)
C     LOCAL AND GLOBAL LISTS CAN BE ASSIGNED TO ONE ANOTHER
        CALL SETDIR(0,0,-1,OPRND(IK))
  741 IF(ID(INHALT(LINK)).NE.3.OR.LNKR(INHALT(LINK+1)).LE.0)GO TO 742
        CALL ERASE(INHALT(LINK + 1))
  742   CALL SETIND(INDEX, -1, -1, LINK)
        CALL STRIND(OPRND(IK), LINK + 1)
        OPRND(IK - 1) = OPRND(IK)
        IOPRND(IK - 1) = IOPRND(IK)
        IK = IK - 1
        GO TO 10
  745   IF(LNKL(OPRND(IK)) .GT. LNKL(OPRND(IK - 1))) GO TO 8745
        GO TO 741
C
C     THIS IS THE WRITECUT ROUTINE. THE TOP DATUM ON THE OPRND STACK IS
C     WRITTEN OUT, AND THIS DATUM IS LEFT UNTOUCHED ON THE OPRND STACK.
C
  755   WRITE(6,774)
        ITT=0
        ITEMP=IOPRND(IK)
        IF(ITEMP.NE.3) GO TO 761
C     761 IS THE LABEL CORRESPONDING TO A NON-LIST OUTPUT.
        IF(LNKR(OPRND(IK)).GT.0) GO TO 756
C     AN EMPTY LIST HAVING ZERO LINK IN O(IK) IS TREATED SEPARATELY.
        WRITE(6,770)
```

```
      WRITE(6,774)
       IBASH=0
       GO TO 10
  756  LSTCNT=0
       LLNK=LNKR(OPRND(IK))
C     LEFT PARENTHESIS OF OUTER LIST IS WRITTEN.
       CALL OUTOUT(7,LFPREN,ITT)
  757  INLNK=INHALT(LLNK)
       IF(ID(INLNK).NE.3)GO TO 758
C     LSTCNT GIVES DEPTH INTO LIST STRUCTURE WRITTEN OUT.
       LSTCNT=LSTCNT+1
C     DESCENT INTO A SUBLIST
       LSTRTN(LSTCNT)=LLNK
       LLNK=LNKR(INHALT(LLNK+1))
       CALL OUTOUT(7,LFPREN,ITT)
       GO TO 757
C     PRINTOUT OF A DATUM.  CHARACTERS NOT SEPARATED BY COMMAS HERE.
  758  CALL OUTOUT(ID(INLNK),INHALT(LLNK+1),ITT)
       IF(ID(INLNK).EQ.7) GO TO 759
       IF(LNKR(INLNK).GT.0) CALL OUTOUT(7,ICOMMA,ITT)
  759  IF(LNKR(INLNK).GT.0) GO TO 762
  760  CALL OUTOUT(7,IRPREN,ITT)
      IF(LSTCNT.LE.0) GO TO 763
C     RISE FROM SUBLIST TO MASTER LIST.
       LLNK=LNKR(INHALT(LSTRTN(LSTCNT)))
       LSTCNT=LSTCNT-1
       IF(LLNK.EQ.0) GO TO 760
       CALL OUTOUT(7,ICOMMA,ITT)
       GO TO 757
C     WRITEOUT OF NEXT ELEMENT OF A LIST.
  762    LLNK=LNKR(INLNK)
       GO TO 757
C     END OF LIST WRITEOUT.
  763  WRITE(6,774)
       IBASH=0
       GO TO 10
C     WRITEOUT OF NORMAL NONLIST ELEMENT.
  761  ICONTR=2
       CALL OUTOUT(ITEMP,OPRND(IK),ICONTR)
       WRITE(6,774)
       IBASH=0
       GO TO 10
  770  FORMAT(1H0,1X,3H( ))
  774   FORMAT(1H0/)
C
C     THIS ROUTINE CHECKS THE TOPMOST OPERAND FOR TRUTH OR FALSETY.
C     IF TRUE, SKIPS TO SCNDOR+1.  IF FALSE, DELETES OPERAND
C     AND PROCEDES TO EVALUATE SECOND OPERAND.  SECONDOR
C     FINDS AN OPERAND THAT IT LEAVES UNTOUCHED.
C
  775   IF(IOPRND(IK).NE.1) GO TO 8775
  776  IF(OPRND(IK).EQ.1.0) GO TO 777
       IK=IK-1
       GO TO 10
  777  ITT=0
  778  I=I+1
```

```
            ICODE=ISHIFT(CODE(I))
            IF(ICODE.EQ.              FRSTOR)ITT=ITT+1
            IF(ICODE.EQ.              SCNDOR)GO TO 779
              GO TO 778
      779     IF(ITT.EQ.0) GO TO 10
              ITT=ITT-1
              GO TO 778
      C
      780     IF(IOPRND(IK).NE.1) GO TO 8775
              GO TO 10
      C
      C       THIS ROUTINE CHECKS TOPMOST OPERAND FOR TRUTH OR FALSETY.
      C       IF FALSE, SKIPS TO SCNAND+1.  IF TRUE, DELETES OPERAND
      C       AND PROCEDES TO EVALUATE SECOND OPERAND.
      C
      785     IF(IOPRND(IK).NE.1) GO TO 8775
      786     IF(OPRND(IK).EQ.0.0) GO TO 787
              IK=IK-1
              GO TO 10
      787      ITT=0
      788      I=I+1
            ICODE=ISHIFT(CODE(I))
            IF(ICODE.EQ.              FSTAND)ITT=ITT+1
            IF(ICODE.EQ.              SCNAND)GO TO 789
               GO TO 788
      789      IF(ITT.EQ.0) GO TO 10
               ITT=ITT-1
               GO TO 788
      C
      C         A LINK IS PLACED TO PROCHD. SKIP TO PRCEND + 1.
      C
      840     IK = IK+1
              OPRND(IK) = I
              IOPRND(IK) = 6
              INDEX = 0
      841     I = I+1
            ICODE=ISHIFT(CODE(I))
            IF(ICODE.EQ.                   PROCHD)INDEX=INDEX+1
            IF(ICODE.EQ.                 PRCEND)GO TO 842
              GO TO 841
      842     IF(INDEX.LE.0) GO TO 10
              INDEX = INDEX-1
              GO TO 841
      C
      C         PROVIDES A RETURN JUMP AND DEMOLITION OF BLOCK STORAGE VIA
      C         THE ORDINARY END ROUTINE.
      C        ALSO DESTROYS PARAMETER LIST OF THE PROCEDURE IF IT HAS ONE.
      C
      865     I = JUMPBK(JMPRTN)
      6       JMPRTN = JMPRTN - 1
            GO TO 705
      5 C       705 IS WHERE THE END ROUTINE IS.
      C
      4 C     INITIATES PROCEDURE CALLS HAVING NO PARAMETERS AND FETCHES DATUM
      C       OF NON-PROCEDURE NAMES INTO OPRND(IK).
      3 C
      2
```

```
  845     LINK = LNKR(OPRND(IK))
          IDID = ID(INHALT(LINK))
          IOPRND(IK) = IDID
          IF(IDID .NE. 6) GO TO 850
          IK = IK - 1
          JMPRTN = 1 + JMPRTN
          JUMPBK(JMPRTN) = I
          PRAMLS(JMPRTN)=0.0
          BLKNUM = 1 + BLKNUM
          STORA.(BLKNUM) = 1 + T
          I = CONT(LINK + 1)
        IF(ISHIFT(CODE(I+1)).EQ.FORMAL)GO TO 8845
          GO TO 10
  850     CALL STRDIR(INHALT(LINK+1),OPRND(IK))
          GO TO 10
C
C     FORMAL CALLS FOR THE LINK OF A LIST OF PARAMATERS STORED ON TOP
C     OF PRAMLS.IF THIS LIST OF PARAMETERS IS TOO SHORT THE UNMATCHED
C     PROCEDURE PARAMETERS ARE UNDEFINED. THIS PARAMETER LIST HAS BEEN
C     MADE LOCAL TO THE CALLING BLOCK BY LSTEND.NO REFERENCE COUNTERS
C     NEED TO BE INCREMENTED FOR ANY POSSIBLE LIST PARAMETERS, SINCE THE
C     LIST CONSTRUCTION HAS ALREADY DONE THIS.
C
  870     LINK=LNKR(PRAMLS(JMPRTN))
          I=I+1
          T=T+1
          CALL STRDIR(CODE(I),IDNTLS(3*T-2))
          IF(LINK .EQ. C) GO TO 875
          CALL STRDIR(INHALT(LINK),INHLNK)
          CALL STRDIR(INHLNK,IDNTLS(3*T-1))
          IF(ID(INHLNK).NE.2.AND.ID(INHLNK).NE.5)GO TO     872
          CALL SETDIR(-1,-1,LNKL(INHALT(LINK+1)),IDNTLS(3*T-1))
C     THE BLOCK NUMBER OF THE REFERENCE OR LABEL IS BROUGHT TO
C     IDNTLS(T, 2)
  872     CALL STRDIR(INHALT(LINK+1),IDNTLS(3*T))
          CALL STRDIR(INHLNK,PRAMLS(JMPRTN))
          GO TO 10
  875     IDNTLS(3*T)=0
          CALL SETDIR(4,0,0,IDNTLS(3*T-1))
          GO TO 10
C
  805     OPRND(IK-1)=OPRND(IK-1)+OPRND(IK)
  806     IF(IOPRND(IK-1).NE.0.OR.IOPRND(IK).NE.0) GO TO 8806
          IK=IK-1
          GO TO 10
  807     OPRND(IK-1)=OPRND(IK-1)-OPRND(IK)
          GO TO 806
  810     OPRND(IK-1)=OPRND(IK-1)*OPRND(IK)
          GO TO 806
  811     IF(OPRND(IK).EQ.0.0) GO TO 8811
          OPRND(IK-1)=OPRND(IK-1)/OPRND(IK)
          GO TO 806
  812     IF(OPRND(IK).EQ.0.0) GO TO 8811
          ITEMP=OPRND(IK-1)/OPRND(IK)
          OPRND(IK-1)=ITEMP
          GO TO 806
```

```
      813   R2=OPRND(IK)
            IF(R2.EQ.0.0) GO TO 8811
            OPRND(IK-1)=AMOD(OPRND(IK-1),R2)
            GO TO 806
      C
      816   OPRND(IK-1)=OPRND(IK-1)**OPRND(IK)
            GO TO 806
      C
      790   IF(IOPRND(IK).EQ.7) GO TO 310
            IF(OPRND(IK-1)-OPRND(IK))791,793,791
      791   OPRND(IK-1) = 0.0
      792   IF(IOPRND(IK-1).NE.0.OR.IOPRND(IK).NE.0) GO TO 8792
            IK = IK-1
            IOPRND(IK) = 1
            GO TO 10
      310   IF(IOPRND(IK-1).NE.7)GO TO 8310
           IF(INTRSC(OPRND(IK-1),OPRND(IK)))791,793,791
      793   OPRND(IK-1) = 1.0
            GO TO 792
      C
      795   IF(OPRND(IK-1)-OPRND(IK)) 793,791,793
      796   IF(OPRND(IK-1)-OPRND(IK)) 791,791,793
      797   IF(OPRND(IK-1)-OPRND(IK)) 793,791,791
      798   IF(OPRND(IK-1)-OPRND(IK)) 791,793,793
      799   IF(OPRND(IK-1)-OPRND(IK)) 793,793,791
      C
      860   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.0) GO TO 871
            GO TO 873
      861   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.1) GO TO 871
            GO TO 873
      862   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.2) GO TO 871
            GO TO 873
      863   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.3) GO TO 871
            GO TO 873
      864   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.4) GO TO 871
            GO TO 873
      866   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.6) GO TO 871
            GO TO 873
      867   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.7) GO TO 871
            GO TO 873
      868   IF(ID(INHALT(LNKR(OPRND(IK)))).EQ.5) GO TO 871
            GO TO 873
      C
      871   OPRND(IK)=1.0
            ICPRND(IK)=1
            GO TO 10
      873   OPRND(IK)=0.0
            IOPRND(IK)=1
            GO TO 10
6     C
      817   OPRND(IK)=1.0
5     818   IOPRND(IK)=1
            IK=IK+1
4           GO TO 10
      819   OPRND(IK)=0.0
3           GO TO 818

2
```

```
      C
      820     IF(CPRND(IK).GT.0.0) GO TO 871
              GO TO 873
      C
      930     IF(IOPRND(IK).NE.2) GO TO 8930
              I=LNKR(OPRND(IK))-1
              JMPRTN= JMPRTN+LNKL(OPRND(IK))-BLKNUM
              IF(JMPRTN.LT.0) JMPRTN=0
              IK=0
              GO TO 10
      C
      937           IOPRND(IK)=0
                    GO TO 10
      938           ITEMP=OPRND(IK)
                    OPRND(IK)=ITEMP
                    GO TO 10
      939           IF(OPRND(IK).GE.+0.0) GO TO 10
      781     IF(IOPRND(IK).NE.0) GO TO 8806
              OPRND(IK)=-OPRND(IK)
                    GO TO 10
     8310     WRITE(6,9310)
              STOP
     8511     WRITE(6,9511)
              STOP
     8832     WRITE(6,9832)ITEMP
              STOP
     8930        WRITE(6,9930) I
                 STOP
     8716    WRITE(6,9716) IVRBL
                 STOP
     8845     WRITE(6,9845)CODE(I),CODE(I+1)
                 STOP
     8740    WRITE(6,9740)I
                 STOP
     8745    ITEMP = INHALT(LNKR(OPRND(IK - 1)) - 1)
              WRITE(6,9745) ITEMP
                 STOP
     8650     WRITE(6,9650)
              STOP
     8775    WRITE(6,9775)
              STOP
     8806     WRITE(6,9806)
              STOP
     8811     WRITE(6,9811)
              STOP
     8736     WRITE(6,9736)KLBL
             STOP
     8792     WRITE(6,9792)
              STOP
6    8860    WRITE(6,9860)
              STOP
5    8510    WRITE(6,9510)
              STOP
4    9005    FORMAT(1HO,/////////)
     9006    FORMAT(1HO,5X,12A6)
3    9310     FORMAT(1HO,52HATTEMPTED COMPARISON OF CHARACTER AND NONCHARACT

2
```

```
     1ER. )
9930 FORMAT(37HNO LABEL SUPPLIED TO JUMP INSTRUCTION,5X,A6)
9931      FORMAT(37HILLEGAL COMMAND OR OPERAND. TERMINATE)
9510   FORMAT(33HLIST OPERATION ON NONLIST OPERAND)
9511     FORMAT(20HSUFFIX OF EMPTY LIST)
9650    FORMAT(46HSUBSCRIPT CALLED FOR LIST CELLS NOT YET EXTANT)
9716    FORMAT(12HREFERENCE TO,2X,A6,2X,24HAN UNDECLARED IDENTIFIER)
9736      FORMAT(  A6,1X,35HIS NOT USED AS A LABEL IN ITS BLOCK)
9740     FORMAT(8HAT CODE(,I6,35H), ASSIGNMENT OF VALUE TO VALUE.      )
9745    FORMAT(45HASSIGNMENT OF LOCAL REFERENCE TO GLOBAL IDENT,2X,A6)
9775   FORMAT(47HATTEMPTED LOGICAL OPERATION, NONLOGICAL OPERAND)
9792   FORMAT(45HRELATION SOUGHT BETWEEN NONNUMERICAL OPERANDS)
9806    FORMAT(43HARITHMETIC ATTEMPT ON NONNUMERICAL OPERANDS)
9811    FORMAT (26HDIVISION BY ZERO ATTEMPTED)
9832 FORMAT(A6,36HLABEL NOT DECLARED AT HEAD OF BLOCK.)
9845   FORMAT(38HPARAMATERLESS PROCEDURE CALL EXPECTED.,2X,A6,A6)
9860    FORMAT(48HPROCEDURE CALL ON NONPROCEDURE VARIABLE AND LIST)
      END
```

SCHNEIDER,VI 001/68/799 DATE 01/
INITX - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE INITAS(M,N)
C
C     THIS SUBRCUTINE INITIALIZES THE STRUCTURE OF THE DIMENSIONED
C     ARRAY M INTO A LIST OF AVAILABLE SPACE WITH READER CELL AVSL.
            DIMENSION M(N)
      COMMCN/AVSLX/AVSL,CODE(500)
            DO 2 I = 1,N
    2       M(I) = 0
            K = N-2
      DO 3 I=1,K,2
    3 CALL SETDIR(-1,-1,MADOV(M(I+2)),M(I))
            CALL SETDIR(0,MADOV(M(N-1)),MADOV(M(1)),AVSL)
            RETURN
            END
C
```

SCHNEIDER,VI 001/68/799 DATE 01/03
ERASEX - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE ERASE(LINK)
C
C     RETURNS FIRST CELL OF LIST TO LAVS IF REFERENCE COUNT IS ZERO
C      OR ONE. OTHERWISE,DECREMENTS REFERENCE COUNT OF THE FIRST CELL.
C
         COMMON/AVSLX/AVSL,CODE(500)
      ILINK = INHALT(LINK)
       IF(LNKL(ILINK).GT.1) GO TO 2060
       CALL SETIND(-1,-1,LINK,LNKL(AVSL))
         CALL SETDIR(-1,IBTM(LINK,+1),-1,AVSL)
       RETURN
 2060    CALL SETIND(-1, LNKL(ILINK)-1, -1, LINK)
       RETURN
       END
```

SCHNEICER,VI 001/68/799 DATE 01/
IBTMX - EFN SOURCE STATEMENT - IFN(S) -

```
      FUNCTION IBTM(LLNK,IFLAG)
C
C     IF IFLAG=-1, FINDS THE LAST CELL OF A NONEMPTY LIST WHOSE FIRST
C     CELL HAS ADDRESS GIVEN BY LLNK. IF IFLAG=+1,RETURNS THE LAST LIST
C     CELL NOT REFERENCED BY ANOTHER LIST NAME.
C
      LLNR=LLNK
 2000 LLNN=LLNR
      LLNR=LNKR(INHALT(LLNN))
      IF(IFLAG)2002,3000,2001
 2001 IF(LNKL(INHALT(LLNR)))3000,2002,2005
 2002 IF(LLNR)3000,2005,2000
 2005 IBTM=LLNN
      RETURN
 3000 WRITE(6,3005)
 3005 FORMAT(1HO,14HERROR IN IBTM.  )
      STOP
      END
```

SCHNEIDER,VI 001/68/799 DATE 01/03
NUCELX - EFN SOURCE STATEMENT - IFN(S) -

```
      FUNCTION NUCELL(X)
C
C     GETS A NEW CELL FROM LAVS, IF THAT CELL HAS A SUBLIST,
C     RETURNS THE SUBLIST TO LAVS BY CALLING ERASE.
C
      COMMCN/AVSLX/AVSL,CODE(500)
      M=LNKR(AVSL)
      IF(M.GT.0) GO TC 1
    2 WRITE(6,901)
      STOP
    1 MM=INHALT(M)
      IF(ID(MM).NE.3.OR.LNKR(INHALT(M+1)).EQ.0) GO TC 3
    4 CALL ERASE(LNKR(INHALT(M+1)))
    3 CALL SETDIR(-1,-1,LNKR(MM),AVSL)
      CALL STRIND(0,M)
      CALL STRIND(0,M+1)
      NUCELL = M
      RETURN
  901 FORMAT(1H1,6X,33HLAVS EXHAUSTED-NUCELL TERMINATION)
      END
```

SCHNEIDER,VI 001/68/799 DATE 01.
COPYX - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE COPY(LLNK,MTOP,MBOT)
C
C     PUTS ZERO INTO LNKL OF ALL CELLS OF COPIED LIST. IF LLNK = 0,
C     AN EMPTY CELL IS RETURNED. IF LNKL (INHALT(LLNK))=0,RETURNS
C         LLNK.
          COMMON/AVSLX/AVSL,CODE(500)
      MTOP = LNKR(AVSL)
      KTOP = LLNK
      IF(KTOP.EQ.0) GO TO 2051
        IF(LNKL(INHALT(KTOP)).GT.0) GO TO 2050
      MTOP = KTOP
          MBOT=IBTM(MTOP,-1)
      RETURN
 2050   IKTOP = INHALT(KTOP)
        IKTOP1 = INHALT(KTOP+1)
          JTOP = NUCELL(DUMMY)
          CALL SETIND(IC(IKTOP),0,LNKR(AVSL),JTOP)
          CALL STRIND(IKTOP1,JTOP+1)
        IF(ID(IKTOP).NE.3.OR.LNKR(IKTOP1).LE.0) GO TO 2052
        CALL SETIND(-1,LNKL(IKTOP1)+1,-1,IKTOP1)
 2052   MBOT = LNKR(IKTOP)
        IF(MBOT.LE.0) GO TO 2054
        KTOP = MBOT
        GO TO 2050
 2054   MBOT = KTOP
        RETURN
 2051   MBOT = NUCELL(DUMMY)
        CALL SETIND(3,0,0,MBOT)
        RETURN
        END
C
```

SCHNEIDER,VI 001/68/799 DATE 01/03
OUTOUX - EFN SOURCE STATEMENT - IFN(S) -

```
      SUBROUTINE OUTOUT(ITYPE,CONTNT,LOCAT)
          DATA IFLSE,ITRUE,ILABEL,IUNDF,IREFRN,IPROCD/
     1    5HFALSE,4HTRUE,5HLABEL,6HUNDFND,6HREFRNC,6HPROCDR/
          LOCAT=LOCAT+1
 1000     IF(LOCAT.LE.12) GO TO 2000
          LOCAT=1
          WRITE(6,1050)
 1050     FORMAT(1H ,80X)
 2000     IF(ITYPE.NE.0) GO TO 2070
          GO TO 3000
 2070     IF(ITYPE.NE.1)GO TO 2071
          IF(CONTNT.EQ.0.0)ICNTNT=IFLSE
          IF(CONTNT.EQ.1.0)ICNTNT=ITRUE
          GO TO 2090
 2071     IF(ITYPE.NE.2) GO TO 2072
          ICNTNT=ILABEL
          GO TO 2090
 2072     IF(ITYPE.NE.4) GO TO  2073
          ICNTNT=IUNDF
          GO TO 2090
 2073     IF(ITYPE.NE.5) GO TO 2074
          ICNTNT=IREFRN
          GO TO 2090
 2074     IF(ITYPE.NE.6) GO TO 2075
          ICNTNT=IPROCD
          GO TO 2090
 2075     IF(ITYPE.NE.7) GO TO  2076
          CALL STRDIR(CONTNT,ICNTNT)
 2090     GO TO (401,402,403,404,405,406,407,408,409,410,411,412),LOCAT
 3000     GO TO (501,502,503,504,505,506,507,508,509,510,511,512),LOCAT
  401      WRITE(6,3401)ICNTNT
           RETURN
  402      WRITE(6,3402)ICNTNT
           RETURN
  403      WRITE(6,3403)ICNTNT
           RETURN
  404      WRITE(6,3404)ICNTNT
           RETURN
  405      WRITE(6,3405)ICNTNT
           RETURN
  406      WRITE(6,3406)ICNTNT
           RETURN
  407      WRITE(6,3407)ICNTNT
           RETURN
  408      WRITE(6,3408)ICNTNT
           RETURN
  409      WRITE(6,3409)ICNTNT
           RETURN
  410      WRITE(6,3410)ICNTNT
           RETURN
  411      WRITE(6,3411)ICNTNT
           RETURN
  412      WRITE(6,3412)ICNTNT
           RETURN
  501      WRITE(6,3501)CONTNT
```

```
            GO TO 2076
     502    WRITE(6,3502)CONTNT
            GO TO 2076
     503    WRITE(6,3503)CONTNT
            GO TO 2076
     504    WRITE(6,3504)CONTNT
            GO TO 2076
     505    WRITE(6,3505)CONTNT
            GO TO 2076
     506    WRITE(6,3506)CONTNT
            GO TO 2076
     507    WRITE(6,3507)CONTNT
            GO TO 2076
     508    WRITE(6,3508)CONTNT
            GO TO 2076
     509    WRITE(6,3509)CONTNT
            GO TO 2076
     510    WRITE(6,3510)CONTNT
            GO TO 2076
     511    WRITE(6,3511)CONTNT
            GO TO 2076
     512    WRITE(6,3512)CONTNT
    2076    LOCAT=LOCAT+1
            RETURN
    3401    FORMAT(1H+,A6)
    3402    FORMAT(1H+,6X,A6)
    3403    FORMAT(1H+,    12X,A6)
    3404    FORMAT(1H+,18X,A6)
    3405    FORMAT(1H+,24X,A6)
    3406    FORMAT(1H+,30X,A6)
    3407    FORMAT(1H+,36X,A6)
    3408    FORMAT(1H+,42X,A6)
    3409    FORMAT(1H+,48X,A6)
    3410    FORMAT(1H+,54X,A6)
    3411    FORMAT(1H+,60X,A6)
    3412    FORMAT(1H+,66X,A6)
    3501  FORMAT(1H+,F12.4)
    3502  FORMAT(1H+,6X,F12.4)
    3503  FORMAT(1H+,12X,F12.4)
    3504  FORMAT(1H+,18X,F12.4)
    3505  FORMAT(1H+,24X,F12.4)
    3506  FORMAT(1H+,30X,F12.4)
    3507  FORMAT(1H+,36X,F12.4)
    3508  FORMAT(1H+,42X,F12.4)
    3509  FORMAT(1H+,48X,F12.4)
    3510  FORMAT(1H+,54X,F12.4)
    3511  FORMAT(1H+,60X,F12.4)
    3512  FORMAT(1H+,66X,F12.4)
            END
```

SETI0001

```
      ENTRY   SETIND
*   THIS FUNCTION SETIND(ID,LNKL,LNKR,CELL) STORES ID IN ID          EULER
*   FIELD, LNKL IN LNKL FIELD, LNKR IN LNKR FIELD OF CELL WHOSE      EULER
*   ADDRESS IS IN WORD NAMED CELL. IF -1 APPEARS AS                  EULER
*   ANY PARAMETER BUT CELL, THAT FIELD IS LEFT UNCHANGED.            EULER

SETIND  STZ     MM                                                   EULER
        CLA*    6,4                                                  EULER
        STA     *+9                                                  EULER
        STA     *+15                                                 EULER
        STA     *+17                                                 EULER
        STA     *+18                                                 EULER
        CLA*    3,4                                                  EULER
        TMI     *+5                                                  EULER
        ALS     30                                                   EULER
        STO     MM                                                   EULER
        CAL     MASK1                                                EULER
        ANS     **                                                   EULER
        CLA*    4,4                                                  EULER
        TMI     *+6                                                  EULER
        ANA     MASK2                                                EULER
        ALS     15                                                   EULER
        ORS     MM                                                   EULER
        CAL     MASK3                                                EULER
        ANS     **                                                   EULER

        CLA*    5,4                                                  EULER
        TMI     *+2                                                  EULER
        STA     **                                                   EULER
        CLA     MM                                                   EULER
        ORS     **                                                   EULER
        TRA     1,4                                                  EULER
MM      BSS     1                                                    EULER
MASK1   OCT     007777777777                                         EULER
MASK2   OCT     000000077777                                         EULER
MASK3   OCT     770000077777                                         EULER
        END                                                          EULER
```

STRI0001

```
      ENTRY   STRIND
*   THIS FUNCTION STRIND(DATUM, IADRES) STORES THE VALUE
*   NAMED BY DATUM IN THE CELL WHOSE ADDRESS IS NAMED
*   BY IADRES.

STRIND CLA*    4,4              GET ADDRESS OF CELL.
       STA     *+2
       CLA*    3,4              GET DATUM'S VALUE.
       STO     **               STORE IT.
       TRA     1,4
       END
```

STRD0001

```
        ENTRY   STRDIR                                                  EULER
*   THIS FUNCTION STRDIR(DATUM,CELL) STORES THE VALUE                   EULER
*   NAMED BY DATUM IN THE WORD NAMED BY CALL, DATUM                     EULER
*   CAN BE EITHER FIXED OR FLOATING POINT AND THE FUNCTION CAN BE       EULER
*   NESTED.                                                             EULER

STRDIR CLA*     3,4             GET DATUM'S VALUE                       EULER
       STO*     4,4                                                     EULER
       TRA      1,4                                                     EULER
       END                                                              EULER
```

SETD0001

```
        ENTRY   SETDIR                                                  EULER
*   THIS FUNCTION SETDIR(ID,LNKL,LNKR,CELL) STORES ID IN ID FIELD,      EULER
*   LNKL IN LNKL FIELD LNKR IN LNKR FIELD OF WORD NAMED CELL.           EULER
*   IF -1 APPEARS AS ANY PARAMETER BUT CELL, THAT FIELD IS              EULER
*   LEFT UNCHANGED.                                                     EULER

SETDIR  STZ     MM              INITIALIZE MM                           EULER
        CLA*    3,4             GET THE ID                              EULER
        TMI     *+5             TEST FOR NEGATIVE                       EULER
        ALS     30                                                      EULER
        STO     MM              STORE SHIFTED ID FIELD                  EULER
        CAL     MASK1           MASK OUT THE ID PORTION                 EULER
        ANS*    6,4             OF CESS                                 EULER
        CLA*    4,4             GET THE LNKL                            EULER
        TMI     *+6             TEST FOR NEGATIVE                       EULER
        ANA     MASK2           BLOCK OUT OTHER FIELDS                  EULER
        ALS     15              SHIFT INTO POSITION                     EULER
        ORS     MM              AND SORE IN TEMPORARY                   EULER
        CAL     MASK3           MASK OUT LNKL                           EULER
        ANS*    6,4             PORTION OF CELL.                        EULER
        CLA*    5,4             GET THE LNKR.                           EULER
        TMI     *+2             TEST FOR NEGATIVE.                      EULER
        STA*    6,4             OVERLAY LNKR OF CELL.                   EULER
        CLA     MM              FETCH THE TEMPORARY.                    EULER
        ORS*    6,4             STORE THE TEMPORARY.                    EULER

        TRA     1,4                                                     EULER
MM      BSS     1                                                       EULER
MASK1   OCT     007777777777                                            EULER
MASK2   OCT     000000077777                                            EULER
MASK3   OCT     770000077777                                            EULER
        END                                                             EULER
```

CONT0001

```
        ENTRY   CONT                                                    EULER
        ENTRY   INHALT                                                  EULER
*   DELIVERS THE CONTENTS OF THE WORD WHOSE MACHINE ADDRESS             EULER
*   IS THE PARAMETER, AND IS STORED AS AN INTEGER. CONT IS USED         EULER
*   IN FLOATING POINT TO PREVENT TYPE CONVERSION AND INHALT IS          EULER
*   USED FOR INTEGER ARITHMETIC TO FOOL THE SYSTEM.                     EULER

CONT    TRA     *+1                                                     EULER
INHALT  CLA*    3,4             GETS ADDRESS STORED IN PARAMETER.       EULER
        STA     *+1                                                     EULER
        CLA     **              GET THE DATA.                           EULER
        TRA     1,4                                                     EULER
        END                                                             EULER
```

IDX 0001

```
        ENTRY   ID                                                      EULER
*   THIS PRIMITIVE FUNCTION RETURNS AS AN INTEGER THE ID FIELD          EULER
*   OF THE CELL NAMED AS PARAMETER.                                     EULER

ID      CLA*    3,4             GET THE CELL                            EULER
        ARS     30                                                      EULER
        TRA     1,4                                                     EULER
        END                                                             EULER
```

LNKL0001

```
        ENTRY   LNKL                                                    EULER
*   THIS PRIMITIVE FUNCTION RETURNS AS AN INTEGER THE LNKL              EULER
*   FIELD OF THE CELL NAMED AS A PARAMETER.                             EULER

LNKL    CLA*    3,4             GET CELL.                               EULER
        ANA     MASK            MASK OUT ID AND LNKR                    EULER
        ARS     15                                                      EULER
        TRA     1,4                                                     EULER
MASK    OCT     007777700000    5-7'S FOLLOWED BY 5-0'S                 EULER
        END                                                             EULER
```

LNKR0001

```
        ENTRY   LNKR                                                    EULER
*   THIS PRIMITIVE FUNCTION PRESENTS AS AN INTEGER THE MACHINE          EULER
*   ADDRESS CONTAINED IN THE RIGHT LINK FIELD OF THE CELL NAMED.        EULER

LNKR    CLA*    3,4             GET CELL.                               EULER
        ANA     MASK            MASK OUT ID AND LNKL                    EULER
        TRA     1,4                                                     EULER
MASK    OCT     000000077777    70'S AND 5-7'S.                         EULER
        END                                                             EULER
```

MAD00001

```
        ENTRY   MADOV                                                   EULER
*   FETCHES THE MACHINE ADDRESS OF THE CELL NAMED AS                    EULER
*   A PARAMETER                                                         EULER

MADOV   CLA     3,4             GET THE LOCATION OF THE CELL.           EULER
        TRA     1,4                                                     EULER
        END                                                             EULER
```

JUST0001

```
        ENTRY   JUSTIN
*               JUSTIN(FL,A,B)=THE BCD NUMBER STORED
*                  IN A AND B IS CONVERTED TO FL.
*
JUSTIN  SXA     BACK,1
        PXA     0,0
        LDQ*    4,4
        AXT     6,1
        RQL     3
        LGL     3
        TIX     *-2,1,1
        LDQ*    5,4
        AXT     6,1
        RQL     3
        LGL     3
        TIX     *-2,1,1
        SLW*    3,4
BACK    AXT     **,1
        TRA     1,4
        END
```

ISHF0001

```
*       SHIFTS THE ARGUMENT RIGHT ONE CHARACTER AND RETURNS VALUE
        ENTRY   ISHIFT

ISHIFT  CAL*    3,4
        ARS     6
        TRA     1,4
        END
```

INTR0001

```
        ENTRY   INTRSC
*       COMPARES TWO ALPHANUMERIC WORDS,RETURNING 0 IF THEY MATCH

INTRSC  CAL*    3,4                                                 EULER
        ERA*    4,4             COMPLEMENT OF LOGICAL WORD          EULER
        TRA     1,4                PUT IN AC                        EULER
        END                                                         EULDE
```

		.FBDBF	33621		EVEN	33633		.DDDFL	33654		.
		.MQD	33657		.PEX	3366C		.FEXP	33661		.
30.	FIOS 33715	.FIOS.	33715		.FSEL.	3407C		.FILR.	34074	*	.
		.FILL.	34113		.FCLS	34115	*	.FOPN	34121	*	R
		.REED	34276	*	.BIN	34277	*	.FCT	34300		.
		.TAP7.	34361								
31.	FIOH 34366	.FIOH.	34366		.FFIL.	35227		.FRTN.	35255		
32.	FWRD 35445	.FWRD.	35445								
33.	FRDD 35655	.FRDD.	35655								
34.	UNO5 35703	.UNO5.	35703								
35.	UNO6 35704	.UNO6.	35704		.BUFSZ	35705					
36.	FLOG 35710	ALOG10	35710	*	ALOG	35711					
37.	FXPF 36114	EXP	36114								
38.	FXP3 36235	.XP3.	36235								
39.	.IOCS 36362	.L(0)	36362		.MONSW	36402		.TEOR	36451		.
		.CLOS.	36614		.ATTC.	36627		.SH1	37041	*	.
		.OP4	37152	*	.OP7	37203	*	.OP9.2	37217	*	.
		.READ.	37272		.RER1.	37315		.WRIT.	37317		.
		.FEEIT	37640		.GTIOX	37661		.RW7	37777	*	.
		.SEL59	41065	*	.BSR.	41504		.EOTOF	41631		.
		.TCHEX	42173		.BASIO	42176	*				
40.	.IOCSM 42201										

I/O BUFFERS 42201 THRU 76705

UNUSED CORE 76706 THRU 77014

.BGIN..BGIN..(.* THIS I, .* S A DE, .* MONSTR,

.* ATION , .* PROGRA, .* M THAT, .* HAS ,

.* BEEN T, .* RANSLA, .* TED BY, .* THE E,

.* ULER , .* SYNTAC, .* TIC TR, .* ANSLAT,

.* CR AND, .* IS BE, .* ING , .* INTERP,

.* RETED , .* BY THE, .* EULER, .* MODIF,

.* IED PO, .* LISH , .* STRING, .* INTER,

.* PRETOR, .* .). .OUT. .END. ., .BGIN..NEW. X

. .NEW. S .VRBL.S .(.NMBR.202400000000, .$ .BGIN..VRBL.

X .VRBL.X .IN. .NMBR.201400000000+ = ., .VRBL.S

.VRBL.X .IN.) .IN. .END. $. , .$.(.* X=

, .VRBL.X .IN.). .OUT. $.). = ., .VRBL.X

.VRBL.S .NMBR.201400000000) .IN. = ., .(.* X=

, .VRBL.X .IN.). .OUT. ., .VRBL.S .NMBR.202400000000

) .IN. .END. ., .BGIN..NEW. A .NEW. R .VRBL.A .(

.NMBR.201400000000, .(.NMBR.202400000000, .NMBR.202600000000

```
). , .NMBR.203400000000). = ., .( .* A= ,
.VRBL.A .IN. ). .OUT. ., .VRBL.R .VRBL.A .NMBR.202400
000000) = ., .( .* R= , .VRBL.R .IN. ).
.OUT. ., .( .* R.(1)=, .VRBL.R .IN. .NMBR.201400000000
) .IN. ). .OUT. ., .( .* R.(2)=, .VRBL.R .IN.
.NMBR.202400000000) .IN. ). .OUT. ., .( .VRBL.A .*
R.(1)== , .VRBL.R .IN. .NMBR.201400000000) .IN. ).
.OUT. .END. ., .BGIN..NEW. N .NEW. FIBO .( .* N= ,
.VRBL.N .NMBR.204440000000= ). .OUT. ., .( .* FIBO=
, .VRBL.FIBO .$ .FRML.K .VRBL.K .IN. .NMBR.201400000000
.LEQ. .IF. .NMBR.201400000000.SWCH..THEN..NOT. .IF. .VRBL.FIBO .LSCL.
.( .VRBL.K .IN. .NMBR.201400000000- ). .VRBL.FIBO .LSCL.
.( .VRBL.K .IN. .NMBR.202400000000- ). + .SWCH..THEN.
., $. = ). .OUT. ., .( .* FIBO(, .VRBL.N
.IN. , .* ) = , .VRBL.FIBO .LSCL..( .VRBL.N .IN.
). ). .OUT. .END. ., .BGIN..NEW. P .NEW. A .NEW. I
.VRBL.P .$ .FRML.X .FRML.K .BGIN..VRBL.K .IN. .VRBL.
K .IN. .IN. .NMBR.201400000000+ = ., .( .* X=
, .VRBL.X .IN. ). .OUT. .END. $. = ., .( .*
I= , .VRBL.I .NMBR.201400000000= ). .OUT. ., .(
.* A= , .VRBL.A .( .NMBR.203400000000, .NMBR.204440
000000, .NMBR.205400000000). = ). .OUT. ., .VRBL.P
.LSCL..( .VRBL.A .VRBL.I .IN. ) .IN. , .VRBL.I
). .OUT. ., .VRBL.P .LSCL..( .$ .VRBL.A .VRBL.I
.IN. ) .IN. $. , .VRBL.I ). .OUT. ., .( .*
I= , .VRBL.I .IN. ). .OUT. .END.
```

```
.BGIN..BGIN..(     .*     ,      .*     ,      .*     ,      .*     ,      .*
,      .*     ,      .*     ,      .*     ,      .*     ,      .*     ,      .*
,      .*     ,      .*     ,      .*     ,      .*     ,      .*     ,      .*
,      .*     ,      .*     ,      .*     ,      .*     ,      .*     ,      .*
,      .*     ,      .*     ,      .*     ,      .*     ,      .*     ,      .*
).     .OUT.

      (THIS IS A DEMONSTRATION PROGRAM THAT HAS  BEEN TRANSLATED BY THE E
ULER  SYNTACTIC TRANSLATOR AND IS BEING   INTERPRETED BY THE EULER MODIF
IED POLISH  STRING INTERPRETOR.     )

.END. .,     .BGIN..NEW. .NEW. .VRBL..(     .NMBR.,      .$     ,      .$
).     =     .,     .VRBL..VRBL..NMBR.)     .IN.  =      .,     .(     .*
,      .VRBL..IN.   ).     .OUT.

      (  X=         2.0000)

.,     .VRBL..NMBR.)      .IN.   .BGIN..VRBL..VRBL..IN.   .NMBR.+      =
.,     .VRBL..VRBL..IN.   )      .IN.   .(     .*     ,      .VRBL..IN.   ).
.OUT.

      (   X=        3.0000)

$.     .END. $.     .END. .,     .BGIN..NEW. .NEW. .VRBL..(     .NMBR.,
.(     .NMBR.,      .NMBR.).     ,      .NMBR.).     =      .,     .(     .*
,      .VRBL..IN.   ).     .OUT.

      (   A=        (       1.0000,          (       2.0000,          3.0000
)      ,            4.0000)      )

.,     .VRBL..VRBL..NMBR.)      =      .,     .(     .*     ,      .VRBL..IN.
).     .OUT.

      (   R= REFRNC)

.,     .(     .*     ,      .VRBL..IN.   .NMBR.)      .IN.   ).     .OUT.

      (R.(1)=       2.0000)

.,     .(     .*     ,      .VRBL..IN.   .NMBR.)      .IN.   ).     .OUT.

      (R.(2)=       3.0000)

.,     .(     .VRBL..*     =      ,      .VRBL..IN.   .NMBR.)      .IN.   ).
.OUT.

      (R.(1)=       2.0000)

.END. .,     .BGIN..NEW. .NEW. .(     .*     ,      .VRBL..NMBR.=      ).
.OUT.

      (   N=        9.0000)

.,     .(     .*     ,      .VRBL..$     =      ).     .OUT.

      (FIBO= PROCDR)

.,     .(     .*     ,      .VRBL..IN.   ,      .*     ,      .VRBL..LSCL..(
.VRBL..IN.   ).     .FRML..VRBL..IN.   .NMBR..LEQ. .IF.   .NOT. .IF.   .VRBL.
```

```
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN.
.,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +
.SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH.
.THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.
.,    $.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH.
.THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.
.,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN.
.,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,
$.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH.
.THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,
$.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.    +
.SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH.
.THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.
.,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT.
.IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
```

```
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.
+     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT.
.IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN.
.,    $.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH.
.THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.
.,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT.
.IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.
+     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT.
.IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN.
.,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,
$.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT.
.IF.  .,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR.
.SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    +
.SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN.
.,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL.
```

```
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,
$.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH.
.THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,
$.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.    .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,
$.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT.
.IF.  .,    $.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,
$.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-
).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT.
.IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.
.NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL.
.(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.
.NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN.
.,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL.
.IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT.
.IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.
+     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.    +     .SWCH.
.THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML.
.VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL..IN.
.NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN.
.NOT. .IF.  .,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,
$.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.
-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR..SWCH..THEN..NOT.
.IF.  .,    $.    +     .SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR.
.SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    +
.SWCH..THEN..,    $.    .VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).
```

```
.FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.  .VRBL..LSCL..(    .VRBL.
.IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NOT. .IF.
.VRBL..LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR.
.LEQ. .IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    .VRBL..LSCL..(
.VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ. .IF.  .NMBR.
.SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,    $.    .VRBL.
.LSCL..(    .VRBL..IN.  .NMBR.-     ).    .FRML..VRBL..IN.  .NMBR..LEQ.
.IF.  .NMBR..SWCH..THEN..NOT. .IF.  .,    $.    +     .SWCH..THEN..,
$.    +     .SWCH..THEN..,    $.    +     .SWCH..THEN..,    $.    +
.SWCH..THEN..,    $.    ).    .OUT.

     ( FIBO(      9.0000,     ) =       55.0000)

.END. .,    .BGIN..NEW. .NEW. .NEW. .VRBL..$    =     .,    .(    .*
,     .VRBL..NMBR.=     ).    .OUT.

     (   I=       1.0000)

.,    .(    .*    ,     .VRBL..(    .NMBR.,     .NMBR.,     .NMBR.).
=     ).    .OUT.

     (   A=     (      4.0000,          9.0000,          16.0000)
)

.,    .VRBL..LSCL..(    .VRBL..VRBL..IN.  )     .IN.  ,     .VRBL.).
.FRML..FRML..BGIN..VRBL..IN.  .VRBL..IN.  .IN.  .NMBR.+     =     .,
.(    .*    ,     .VRBL..IN.  ).    .OUT.

     (  X=        4.0000)

.END. $.    .OUT.

     (  X=        4.0000)

.,    .VRBL..LSCL..(    .$    ,     .VRBL.).    .FRML..FRML..BGIN..VRBL.
.IN.  .VRBL..IN.  .IN.  .NMBR.+     =     .,    .(    .*    ,     .VRBL.
.IN.  .VRBL..VRBL..IN.  )     .IN.  $.    ).    .OUT.

     (  X=       16.0000)

.END. $.    .OUT.

     (  X=       16.0000)

.,    .(    .*    ,     .VRBL..IN.  ).    .OUT.

     (   I=       3.0000)

.END. Q00000

#LEGAL COMMAND CR OPERAND. TERMINATE
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