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*Now at University of NSW

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ABSTRACT

The syntax of the ACL language is described in terms of a directed-graph structure which is written in a machine independent language and automatically translated to NOVA assembly language. A syntax analyser based on this directed-graph structure is incorporated into a new version of the ACL-NOVA system to improve the response to terminal input and this, together with a number of other modifications, reduces the size of the system from 6¾K to under 6K words.

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COMPUTERS; PROGRAMMING; PROGRAMMING LANGUAGES

CONTENTS

1. INTRODUCTION

All input to the ACL-NOVA system (Sanger 1971; Bennett & Sanger 1973) is syntax checked for validity using a dynamic echo-checking mechanism. As each input character is received by the computer, it is examined and only sent back to a terminal to be printed (echoed) if it is syntactically correct. This application of the full-duplex mode of operation of a terminal provides interaction with the computer and protects the user from trivial typing errors. It also has the advantage that statements do not have to be checked for syntax at run time thus improving program execution times.

The syntax analyser also dynamically builds up an internal code representation of the input statement. The internal code representation of the statement as well as a number of indicators, such as the statement type, are set up by the syntax analyser to simplify run time processing and this produced more efficient program execution. The edit and error correction facilities provided in the ACL-NOVA system also influenced the design of the syntax analyser, since their use could dynamically alter the original statement.

In the original version of the ACL-NOVA system, the syntax analyser began its scan at the start of the input buffer each time a character was received. In this case, the time required to analyse a statement was essentially a quadratic function of the number of characters in the statement. The internal code representation was only updated for a valid character, but bracket counters and words used to describe the syntactical state of the statement were fully constructed each time a character was received. The first 135 words of each user area were used for saving user dependent information such as state indicators and counters, an input buffer, an internal code buffer and an output buffer.

In the latest version of ACL-NOVA, details of the current syntactical state of a statement are saved in each user area. Syntax analysis in this case begins with the current node pointer, and the time taken should then be a linear function of the number of characters in the statement.

2. DIRECTED-GRAPH SYNTAX ANALYSIS

2.1 General Discussion

The syntax of the ACL language used in the latest version of the ACL-NOVA system is represented by a directed-graph structure (Hayes & Hurst 1972; Hayes 1973) in which each element of the syntax is represented by a node in the graph. For the syntax of a statement to be correct, every element of the statement must match the corresponding node in the directed-graph. The

elements of the syntax are either single characters or groupings of other elements. Each element in the syntax has a corresponding node in the graph which represents that element and, in addition, each node in the graph may have a successor (or forward) node and an alternate node so that the ordering of the elements within the complete syntax may be represented. Optionally associated with each node in the graph is a semantic action routine (with an optional operand) which is executed on a match of a node and a character in the statement.

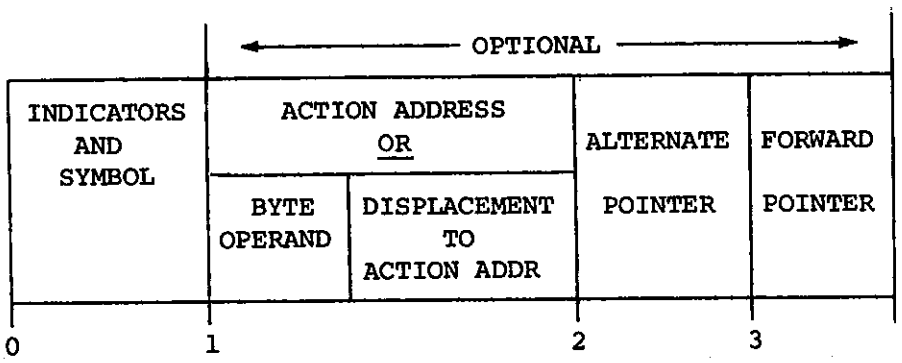
The syntax analysis of terminal input consists of taking each character as it is received and comparing it with the current node in the graph. If a match is obtained, an action routine may be optionally executed to check for extra constraints on the input character or to store the statement type in the internal code buffer. The character is translated to the appropriate internal code and stored in the internal code buffer, the address of the forward node is saved as the new current node address to indicate where syntax checking of the next input character is to begin, and the input character is echoed at the terminal. If a match is not obtained, the alternate node becomes the node to be matched and the process is repeated until either a match is obtained or all of the alternate nodes have been tested and an 'error' node has been encountered. In the latter case, the character is rejected (not echoed), the internal code buffer is not updated and the current node pointer in the user area remains unaltered. The appropriate combination of forward and alternate nodes thus describes the syntax of each statement while the action routines fill the vital role of checking for balanced brackets, storing appropriate internal codes in the internal code buffer, handling the error correction facilities, signalling the background when a statement is to be processed and many other functions essential to the ACL-NOVA system. Without the action routine capability, the directed-graph structure could not have been used for syntax analysing input to the ACL-NOVA system.

2.2 Directed-Graph Node

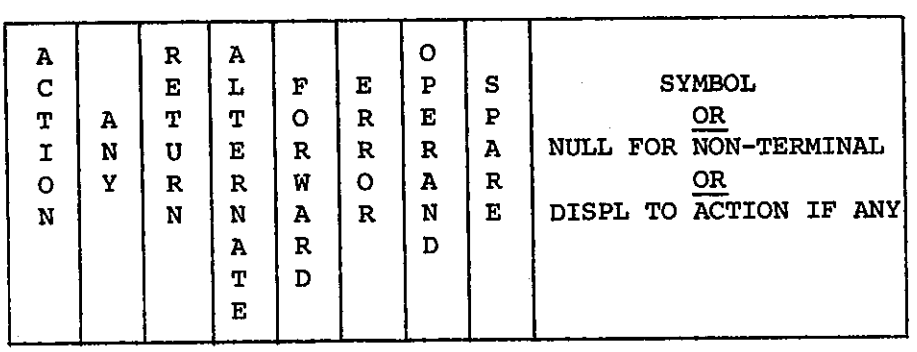
Every element of the syntax is represented by a directed-graph node which contains information about the type of node, the character to be matched, a forward pointer to be used if a match is obtained and an alternate pointer to be used in the case of mismatch. Special node types are used if an action routine is to be executed regardless of the input character code (an 'ANY' node), if control is to be passed to a sub-graph ('NON-TERMINAL' node), returned from a sub-graph ('RETURN' node), or if there is no match

possible for the input character being analysed ('ERROR' node). The ANY node is used to initialise pointers and buffers and, depending on the action routine given control, can be considered to provide either a genuine match (so that the forward pointer is stored as the new current node address) or a mismatch (so that alternate nodes are tested to obtain a match). The ACL language syntax requires only one sub-graph and this is used to analyse arithmetic statements and expressions. This means that only one word in the user area is required for a node address for return from a sub-graph.

The nodes used in the ACL-NOVA system are chosen to minimise the space required for the directed-graph structure. Each node consists of from one to four words as shown below:



The indicators and symbol word take the form:



where the first byte contains indicators showing if the node type is ANY, RETURN or ERROR or if the node contains an action routine pointer, an operand, an alternate pointer or a forward pointer; the second byte contains the character to be matched, a null character indicating a NON-TERMINAL node, or an 8-bit displacement into a table of action routine addresses for an ANY node. If a node does not contain a forward and/or alternate pointer, then the next node in the graph is used as the forward and/or alternate node respectively - this significantly reduces the space required for the directed-graph. It also turns out that one-byte operands are sufficient for the ACL-NOVA syntax analyser and the action word is compressed to a one-byte operand and

an 8-bit displacement into a table of action routine addresses if the OPERAND bit is set in the indicator byte. No action routine is allowed for a NON-TERMINAL node and, in this case, the action word contains the address of the first node in the sub-graph.

The complete syntax of the ACL language is defined by a six hundred and seventy word directed-graph and thirty five action routines amounting to four hundred and sixty words. The complete syntax checking of each input character is carried out by a seventy five word syntax monitor program (SNMON) that is used to analyse the directed-graph structure and that makes use of only two additional words (containing the current node address and the node address for return from a sub-graph) in each user work area. The NOVA assembly code version of the SNMON program is shown in Appendix A.

2.3 The Language for Describing Directed-Graph Nodes

To simplify the process for describing the syntax of the ACL language, a language for describing a node in the graph is used. Statements in this very simple (one statement) language are translated to NOVA assembly statements by a simple SNOBOL program (see Appendix B). The use of this language gives a number of distinct advantages:

(i) The syntax is specified more easily and compactly which reduces the initial coding times and also makes the task of debugging the syntax much more manageable.

(ii) Because of the relative compactness of the coding in the simple language, the number of trivial coding errors is greatly reduced and these are recognised quickly, either by the simple SNOBOL program or in the debugging phase.

(iii) The language description of the syntax for ACL affords a well documented, complete description of the syntax.

(iv) The syntax was specified in a machine indeperdent form so that implementation on a machine other than a NOVA computer would be greatly simplified as only the SNOBOL program would need to be rewritten.

The syntax of the simple language is:

[label] [symbol] [(action [(operand)])] [→forward] [; alternate] [: comment]

where [ ] indicates an optional field,

label - the name of the node (for referencing a node from another node),

symbol - . a single character in quotes,

. the name of an unprintable character, or a group of characters,

. null implies the node will match anything,

. '#' followed by the name of a sub-graph,

action - the name of the action routine associated with the node,

operand - an operand for the action routine,

forward - the name of the forward node,

alternate - . the name of the alternate node,

. '#' followed by an error number,

. RETURN indicates a successful return from a sub-graph.

The complete syntax description used by the ACL-NOVA system is given in Appendix C as an illustration of the use of the simple language which may, in fact, be used to describe the syntax of languages other than ACL (Hayes 1973). The NOVA assembly code expansion of the ACL syntax is shown in Appendix D.

2.4 Response to Terminal Input

The time taken to syntax check each character as it is received from a terminal is a measure of the system response to terminal input. To assess this response for the two syntax analysers used by the different versions of the ACL-NOVA system, a NOVA simulator (Sanger 1970) is used to syntax analyse the seventy one character statement 1+1*1+1*1+.....+1 under both systems. The simulation is set up so that each character in the statement is passed in turn to the syntax analyser for checking and a limited trace of the simulation program allows the elapsed CPU time to be printed out. The elapsed CPU time in milliseconds versus the number of input characters is shown in Figure 1 for both syntax analysers and these times apply to a NOVA computer with a 2.6 μsec cycle time.

In the original syntax checker the elapsed CPU time, T, required to analyse n input characters in the statement 1+1*1+1*1+.....+1 turns out to be a quadratic function of n, $T = 0.178\ n^2 + 1.203\ n - 0.355$. The CPU time required to analyse the (n+1)th character in the statement is the linear function

$$t = \frac{dT}{dn} = 0.356\ n + 1.203$$

where the longest time of 26.1 msec is required for the 71st character. This value is still well below the 100 msec required to print a character on a teletypewriter terminal and explains why the original ACL-NOVA system supporting five teletypewriter terminals was able to give a good response to terminal input. However, if the last character in the seventy character statement 1+1*1+1*1+.....+1*1+ is deleted using the '<1' option, then the total CPU time required to analyse sixty nine input characters must

elapse before output begins at the terminal. This elapsed time of 930 msec represents a worst case in the response to terminal input and it is quite noticeable by a terminal user.

The elapsed CPU time for the directed-graph syntax checker is a linear function of n, $T = 1.222\ n + 0.134$. In this case the CPU time required to analyse each input character is constant at 1.222 msec thus providing a very good response to terminal input. For the worst case described above, 84.5 msec is required by the new syntax analyser. This gives a user no noticeable delay on a 100 msec teletypewriter and is a considerable improvement over the 930 msec required by the previous version.

It is worth emphasising that the above times correspond to simulations of the original NOVA computer which is the slowest of the NOVA range of computers. The above trends would still apply on the newer computers, with the directed-graph syntax analyser providing a highly significant improvement in the response to terminal input.

2.5 Effects on Other Parts of the System

Implementation of the directed-graph syntax analyser reduced the size of the ACL-NOVA system. The size of the interrupt handler was significantly reduced as a number of special functions, previously processed before passing control to the syntax analyser, are now included in the directed-graph structure and processed by appropriate action routines. Character codes for syntax matching and various address constants used by the original syntax analyser previously occupied one third of the page zero area and are now freed for use by other routines.

This initial saving of system space provided the incentive to make a number of other system modifications. These included changes to the Background Control Program (BGCP) to carry out one scan (instead of two scans) of the user areas; changes to the floating point packages so that more use is made of common save areas and the routines are no longer general but are specific to the ACL-NOVA system; and changes to the process of saving stored statements so that statement numbers can be stored without requiring an extra word for the statement.

The new version of the ACL-NOVA system resulting from all these changes requires just under 6K words of memory compared to the original 6¾K words, provides more efficient processing of statements because of the simplified structure of the Background Control Program, and gives a significantly improved response to terminal input. The reduction in the time required to analyse terminal input lowers the overall system overhead and provides more

time for background statement processing.

3. CONCLUSIONS

The description of the syntax of the ACL language, in terms of a directed-graph structure written in a machine independent language, gives a number of distinct advantages. It provides a well documented, complete description of the ACL language and, because of the relative compactness of the coding in the simple language, it makes the task of debugging the syntax much more manageable. The simplicity of the machine independent language also allowed the SNOBOL program used to convert this language to NOVA assembly code to detect trivial coding errors.

Implementation of the directed-graph syntax analyser, together with a number of other system modifications, resulted in a version of the ACL-NOVA system that requires just under 6K words compared with the original 6¾K word system, and provided a significant improvement in the response to terminal input. The total CPU time required to analyse a statement using the directed-graph syntax checker is a linear function of the number of input characters compared with the original syntax checker where the function is quadratic. There is much better response to terminal input and less impact on other users, especially under worst case conditions.

4. REFERENCES

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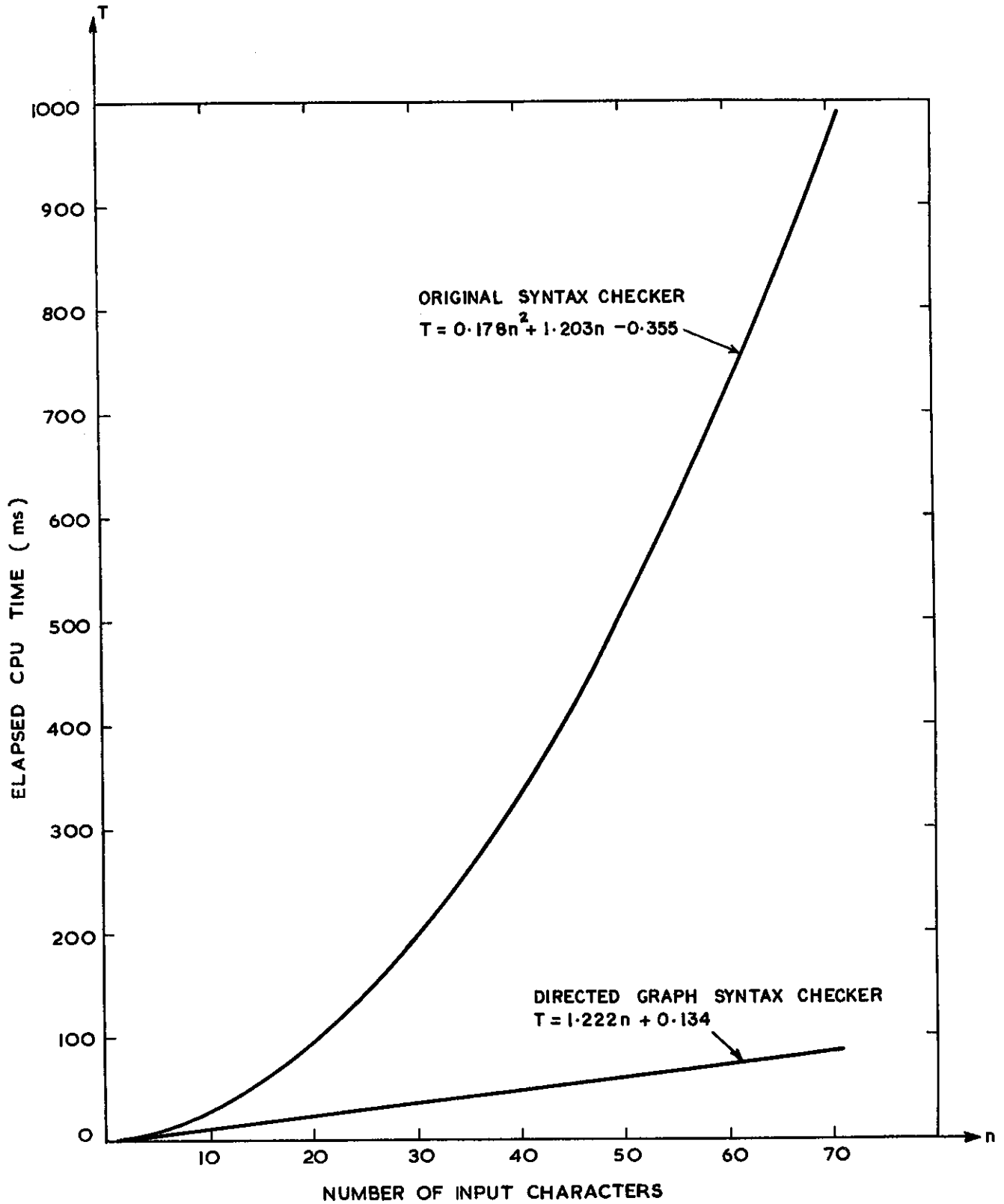

FIGURE 1. ELAPSED CPU TIMES RESULTING FROM THE SIMULATION OF THE SYNTAX ANALYSIS OF THE 71 CHARACTER STATEMENT 1+1*1+1*1+....+1 FOR A NOVA COMPUTER

APPENDIX A

NOVA ASSEMBLY CODE LISTING OF THE SNMON PROGRAM

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * 00489400
*                                                                                 * 00489500
*       SNMON - SYNTAX CHECKER MONITOR PROGRAM                                    * 00489600
*                                                                                 * 00489700
*        ON ENTRY: AC1 CONTAINS THE INPUT CHARACTER                               * 00489800
*                  SNM2S CONTAINS THE ADDRESS OF THE USER AREA                    * 00489900
*                                                                                 * 00490000
*        ON EXIT:  RETURN TO AC3 IF CHARACTER IS NOT VALID. OTHERWISE,            * 00490100
*                  RETURN TO AC3+1. AC1 CONTAINS THE CHARACTER                    * 00490200
*                  TO BE ECHOED AND ANY ADDITIONAL OUTPUT IS IN THE               * 00490300
*                  OUTPUT BUFFER, AND AC2 CONTAINS USER AREA ADDRESS.             * 00490400
*                                                                                 * 00490500
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * 00490600
SNMON   STA     3,SNM1S         SAVE RETURN ADDRESS                               00490700
        LDA     3,SNM2S         LOAD ADDR OF USER AREA                            00490800
        LDA     2,CNODE(3)      LOAD CURRENT NODE ADDRESS                         00490900
SNM1    LDA     0,0(2)          LOAD SYMB & IND WORD                              00491000
        LDA     3,SNM1M         LOAD MASK X(00FF)                                 00491100
        AND     0,3,SNR         ISOLATE SYMB & SKIP IF NONZERO                    00491200
        JMP     SNM7            OTHERWISE, PROCESS NONTERM                        00491300
        MOVL    0,0,SZC         SKIP IF NO ACTION ROUTINE                         00491400
        INC     2,2             OTHERWISE, ADD ONE TO PTR                         00491500
        STA     0,SNM3S         SAVE COPY OF SYMB & IND                           00491600
        STA     1,SNM4S         SAVE INPUT CHARACTER                              00491700
        STA     2,SNM5S         SAVE POSN UP TO IN CURRENT STMT                   00491800
        MOVL#   0,0,SZC         SKIP IF NOT ANY                                   00491900
        JMP     SNM2            OTHERWISE, FORM ACTION ADDRESS                    00492000
        SUBC    1,3,SZR         SKIP IF MATCH                                     00492100
        JMP     SNM10           OTHERWISE, PROCESS MISMATCH                       00492200
*  MATCH, CHECK FOR ACTION ROUTINE                                                00492300
        MOV     0,0,SNC         SKIP IF ACTION BIT IS ON                          00492400
        JMP     SNM4            OTHERWISE, UPDATE IC BUFFER                       00492500
*  ACTION ROUTINE, CHECK IF OPERAND PRESENT                                       00492600
        LDA     3,SNM2M         LOAD MASK X(0400)                                 00492700
        AND     0,3,SNR         SKIP IF OPERAND PRESENT                           00492800
        JMP     SNM3            OTHERWISE, EXECUTE ACTION ROUTINE                 00492900
        LDA     1,0(2)          LOAD ACTION WORD                                  00493000
        LDA     3,SNM1M         LOAD MASK X(00FF)                                 00493100
        AND     1,3             ISOLATE DISPL TO ACTION ROUTINE                   00493200
        SUBS    3,1             ISOLATE OPERAND                                   00493300
SNM2    LDA     2,SNM6C         LOAD PTR TO ACTION ADDR TABLE                     00493400
        ADD     3,2             POINT TO REQUIRED ENTRY                           00493500
SNM3    JSR     I  0(2)         EXECUTE ACTION ROUTINE                            00493600
        JMP     SNM9            BR, MISMATCH RETURN FROM ACTION                   00493700
*  NORMAL RETURN - GENERATE INTERNAL CODE                                         00493800
SNM4    JSR     I  SNM5C        FORM INTERNAL CODE                                00493900
*  RETURN WITH SPECIAL INTERNAL CODE                                              00494000
        JSR     I  SNM4C        STORE CODE IN IC BUFFER                           00494100
        LDA     0,SNM3S         LOAD SYMB & IND WORD                              00494200
        LDA     2,SNM5S         LOAD POSN UP TO AT CURRENT NODE                   00494300
        ADDL    0,0             SKIP OVER ANY & RETURN BITS                       00494400
        INC     2,2             POINT TO POSSIBLE ALT PTR                         00494500
*  MATCH, CHECK FOR FORWARD POINTER                                               00494600
        MOVL    0,0,SZC         SKIP IF NO ALT PTR                                00494700
        INC     2,2             OTHERWISE, ADD ONE TO PTR                         00494800
        MOVL    0,0,SZC         SKIP IF NO FORWARD PTR                            00494900
        LDA     2,0(2)          OTHERWISE, LOAD FORWARD PTR                       00495000
*  STORE NEW NODE POINTER                                                         00495100
SNM5    LDA     3,SNM2S         LOAD ADDR OF USER AREA                            00495200
        STA     2,CNODE(3)      STORE NEW NODE PTR                                00495300
        ISZ     SNM1S           ADD ONE TO RETURN ADDR - CHAR VALID               00495400
        LDA     1,SNM4S         LOAD CHAR TO BE ECHOED                            00495500
SNM6    LDA     2,SNM2S         LOAD ADDR OF USER AREA                            00495600
```

```
          JMP     I  SNM1S          RETURN                                    00495700
*  NON-TERMINAL                                                               00495800
SNM7      LDA        3,SNM2S        LOAD ADDR OF USER AREA                    00495900
          STA        2,ARETN(3)     STORE CURRENT NODE AS RETN ADDR           00496000
SNM8      LDA        2,1(2)         LOAD NEW NODE PTR                         00496100
          JMP        SNM1           PROCESS NEW NODE                          00496200
*  MISMATCH RETURN FROM ACTION                                                00496300
SNM17     LDA        1,SNM4S        LOAD INPUT CHARACTER                      00496400
SNM9      LDA        0,SNM3S        LOAD SYMB & IND WORD                      00496500
          LDA        2,SNM5S        LOAD POSN UP TO AT CURRENT NODE           00496600
*  MISMATCH - TAKE ALTERNATE OR RETURN                                        00496700
SNM10     ADDL       0,0,SZC        SKIP IF NOT RETURN                        00496800
          JMP        SNM15          OTHERWISE, RETURN WITH SUCCESS            00496900
          MOVL       0,0,SZC        SKIP IF NO ALT PTR                        00497000
          JMP        SNM8           OTHERWISE, CHECK ALTERNATE NODE           00497100
*  MISMATCH, NO ALTERNATE POINTER - IF NOT ERROR USE NEXT NODE                00497200
          ADDL#      0,0,SZC        SKIP IF NO ERROR                          00497300
          JMP        SNM6           RETURN CHARACTER NOT VALID                00497400
          INC        2,2            POINT TO POSSIBLE FORWARD PTR             00497500
          MOVL       0,0,SZC        SKIP IF NO FORWARD PTR                    00497600
          INC        2,2            OTHERWISE, ADD ONE TO PTR                 00497700
          JMP        SNM1           PROCESS NEXT NODE                         00497800
*  MISMATCH, RETURN WITH SUCCESS                                              00497900
SNM15     LDA        3,SNM2S        LOAD ADDR OF USER AREA                    00498000
          LDA        2,ARETN(3)     LOAD RETURN ADDRESS                       00498100
          LDA        0,0(2)         LOAD SYMB & IND WORD                      00498200
          INC        2,2            INCREMENT OVER NONTERM ADDR(ACT ONLY)     00498300
          ADDL       0,0            SKIP OVER ACT & ANY BITS                  00498400
          ADDL       0,0,SZC        SKIP IF NO ALT PTR                        00498500
          INC        2,2            OTHERWISE, ADD ONE TO PTR                 00498600
          INC        2,2            POINT TO FOR PTR (IF ANY)                 00498700
          MOVL       0,0,SZC        SKIP IF NO FOR PTR (USE NEXT NODE)        00498800
          LDA        2,0(2)         OTHERWISE, LOAD FOR PTR                   00498900
          JMP        SNM1           PROCESS NEW NODE                          00499000
SNM4C     DC         A(SNM13)                                                 00499100
SNM5C     DC         A(SNM11)                                                 00499200
SNM6C     DC         A(ACTBL-1)     PTR TO ACTION ADDR TABLE                  00499300
```

APPENDIX B

LISTING OF THE SNOBOL PROGRAM USED TO PROCESS THE MACHINE INDEPENDENT LANGUAGE

```
//
//SNOB    EXEC  SNOBOL,REGION=240K
        &DUMP     = 1
        &ANCHOR   = 1
        TABLE = TABLE(256,10)
        TABLE<'NONTERM'> = '00'
        TABLE<'A'      > = '41'
        TABLE<'B'      > = '42'
        TABLE<'C'      > = 'C3'
        TABLE<'D'      > = '44'
        TABLE<'E'      > = 'C5'
        TABLE<'F'      > = 'C6'
        TABLE<'G'      > = '47'
        TABLE<'H'      > = '48'
        TABLE<'I'      > = 'C9'
        TABLE<'J'      > = 'CA'
        TABLE<'K'      > = '4B'
        TABLE<'L'      > = 'CC'
        TABLE<'M'      > = '4D'
        TABLE<'N'      > = '4E'
        TABLE<'O'      > = 'CF'
        TABLE<'P'      > = '50'
        TABLE<'Q'      > = 'D1'
        TABLE<'R'      > = 'D2'
        TABLE<'S'      > = '53'
        TABLE<'T'      > = 'D4'
        TABLE<'U'      > = '55'
        TABLE<'V'      > = '56'
        TABLE<'W'      > = 'D7'
        TABLE<'X'      > = 'D8'
        TABLE<'Y'      > = '59'
        TABLE<'Z'      > = '5A'
        TABLE<'0'      > = '30'
        TABLE<'1'      > = 'B1'
        TABLE<'2'      > = 'B2'
        TABLE<'3'      > = '33'
        TABLE<'4'      > = 'B4'
        TABLE<'5'      > = '35'
        TABLE<'6'      > = '36'
        TABLE<'7'      > = 'B7'
        TABLE<'8'      > = 'B8'
        TABLE<'9'      > = '39'
        TABLE<'"'      > = '22'
        TABLE<"'"      > = '27'
        TABLE<'('      > = '28'
        TABLE<')'      > = 'A9'
        TABLE<'*'      > = 'AA'
        TABLE<'+'      > = '2B'
        TABLE<','      > = 'AC'
        TABLE<'-'      > = '2D'
        TABLE<'.'      > = '2E'
        TABLE<'/'      > = 'AF'
        TABLE<':'      > = '3A'
        TABLE<';'      > = 'BB'
        TABLE<'<'      > = '3C'
        TABLE<'>'      > = 'BE'
        TABLE<' '      > = 'A0'
        TABLE<'UPARROW'> = 'DE'
        TABLE<'ASSIGN' > = '5F'
        TABLE<'CR'     > = '8D'
```

```
          TABLE<'RUBOUT' > = 'FF'
          TABLE<'ESCAPE' > = '1B'
          TABLE<'?'      > = '3F'
          TABLE<'BELL'   > = '87'
          TABLE<'CNTRLX' > = '18'
          TABLE<'$'      > = '24'
          ACTBL     = TABLE(20,10)
          ACTBL<'SNT2A'> = '01'
          ACTBL<'SNT4A'> = '02'
          ACTBL<'SNT5A'> = '03'
          ACTBL<'SNT7A'> = '04'
          ACTBL<'SNT8A'> = '05'
          ACTBL<'SNT9A'> = '06'
          ACTBL<'SNT4B'> = '07'
          ACTBL<'SNT5B'> = '08'
          ACTBL<'SNT6B'> = '09'
          ACTBL<'SNT9B'> = '0A'
          ACTBL<'EDT3A'> = '0B'
          ACTBL<'EDT4A'> = '0C'
          ACTBL<'SNT2C'> = '0D'
          ACTBL<'AEX1A'> = '0E'
          ACTBL<'AEX3A'> = '0F'
          ACTBL<'AEX4A'> = '10'
          ACTBL<'AEX5A'> = '11'
          ACTBL<'AEX6A'> = '12'
          ACTBL<'AEX1B'> = '13'
          ACTBL<'AEX2B'> = '14'
          HEXTBL    = ARRAY('0:255')
          N         = 0
          WORK1     = '0123456789ABCDEF'
L1        WORK1 LEN(1) . D1 =                          :F(L3)
          WORK2     = '0123456789ABCDEF'
L2        WORK2 LEN(1) . D2 =                          :F(L1)
          HEXTBL<N> = D1 D2
          N = N + 1                                    :(L2)
L3        ACTION    = 128
          ANY       = 64
          RETURN    = 32
          ALTERN    = 16
          FORWARD   = 8
          ERR       = 4
          OPERAND   = 2
          BLNK      = SPAN(' ') \ NULL
          ALPHANUM  = 'ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789'
          LABELP    = BREAK(' ') . LABEL SPAN(' ')
          SYMP      = "'" LEN(1) . SYM "'"  NULL . NONT  \
+                   ('#' \ NULL) . NONT SPAN(ALPHANUM) . SYM \
+                   NULL . NONT NULL . SYM
          OPERP     = '(X(' LEN(2) . OPER '))' \ NULL . OPER
          ACTP      = '(' SPAN(ALPHANUM) . ACT OPERP ')' \ NULL . ACT
+                                                NULL . OPER
          FORP      = '->' BLNK SPAN(ALPHANUM) . FOR \ NULL . FOR
          ALTP      = 'RETURN' . ARET NULL . ALT NULL . ER \
+                   '#' SPAN(ALPHANUM) . ER NULL . ALT NULL . ARET \
+                   SPAN(ALPHANUM) . ALT NULL . ER NULL . ARET
          ALTP      = ';' BLNK ALTP \ NULL . ALT NULL . ER NULL . ARET
          COM       = ':' ARB \ NULL
          MACRO     = LABELP SYMP BLNK ACTP BLNK FORP BLNK ALTP BLNK COM
+                   POS(80)
READ      CARD      = INPUT                            :F(FEND)
```

```
          OUTPUT    = CARD
          CARD '*'                                        :S(COMMENT)
          ('*' CARD) LEN(72)  . PUNCH
          CARD      MACRO                                 :F(ERROR)
          (LABEL '          ') LEN(9) . LABEL
          IND       = Ø
          IND       = DIFFER(ARET) IND + RETURN
          IND       = DIFFER(ALT) IND + ALTERN
          IND       = DIFFER(FOR) IND + FORWARD
          IND       = DIFFER(ER) IND + ERR
          IND       = IDENT(SYM) IND + ANY                :S(PAT6)
          IDENT(NONT)                                     :S(PAT2)
          IDENT(ACT)                                      :S(PAT1)
          OUTPUT    = '***** WARNING ***** ACTION ON NON-TERMINAL NODE.'
          OPER      =
PAT1      ACT       = SYM
          SYM       = 'NONTERM'
PAT2      IND       = DIFFER(ACT) IND + ACTION
          IND       = DIFFER(OPER) IND + OPERAND
          PUNCH     = LABEL 'DC         X(' HEXTBL<IND> TABLE<SYM> ')'
          IDENT(OPER)                                     :S(PAT3)
          PUNCH     = '          DC         X(' OPER ACTBL<ACT> ')'
+                   :(PAT4)
PAT3      IDENT(ACT)                                      :S(PAT4)
          PUNCH = '          DC         A(' ACT ')'
PAT4      IDENT(ALT)                                      :S(PAT5)
          PUNCH     = '          DC         A(' ALT ')'
PAT5      IDENT(FOR)                                      :S(READ)
          PUNCH     = '          DC         A(' FOR ')'   :(READ)
PAT6      PUNCH     = LABEL 'DC         X(' HEXTBL<IND> ACTBL<ACT> ')'
+                   :(PAT4)
COMMENT   PUNCH     = CARD                                :(READ)
ERROR     OUTPUT    = '****************** INVALID MACRO ****************'
          NERR      = NERR + 1                            :(READ)
FEND      OUTPUT    = '*** END OF JOB ***'
          IDENT(NERR)                                     :S(END)
          OUTPUT    = '*************** NUMBER OF ERRORS WAS '
+                   NERR ' ****************'
END
/*
//
```

APPENDIX C

THE SYNTAX OF THE ACL LANGUAGE DESCRIBED USING THE MACHINE INDEPENDENT LANGUAGE

```
SYNT     CR (SNT1A)                          : CHECK FOR INITIAL CR
*   IF PAPER TAPE NOT READY FLAG IS SET, REJECT INPUT CHARACTER.
*   OTHERWISE, IF ACCEPT STMT INPUT, ONLY ALLOW ARITH STMT OR EXPRN.
         (SNT2A)                        : USE SYN18 AS ALT FOR ACCEPT INPUT
         ' ' (SNT3A) -> SYN7                 : INITIAL SPACE(GENERATE SEQ NO)
         (SNT4A) ; SN133                     : CHECK FOR 1ST DIGIT IN SEQ NO.
         (SNT5A) ; SYN20                     : CHECK FOR 2ND DIGIT IN SEQ NO.
         (SNT5A) ; SYN20                     : CHECK FOR 3RD DIGIT IN SEQ NO.
         ' ' (SNT6A) ; SYN20                 : SPACE AFTER SEQ NO.
SYN7     CR (SNT7A(X(44)))                   : STATEMENT TO BE DELETED
         (AEX1B) ; SYN21                     : CHECK FOR 1ST DIGIT IN STMT NO
         (SNT8A) ; SYN23                : CHECK FOR 2ND DIGIT IN STMT NO.
SYN10    ' ' (SNT3C) ; EDT                   : INDICATE STMT TO BE STORED
SYN11    CR (SNT7A(X(45)))                   : INSERT, DEL OR REPL STMT NO.
         'P' ; SYN28                         : CHECK FOR PAUSE STMT
         'A' ; SYN24
         'U' ; SYN25
         'S' ; SYN26
         'E' ; SYN27
         CR (SNT9A(X(59))) ; EDT             : INDICATE PAUSE STMT AND EXIT
SYN18    #AEXPS                              : CHECK FOR ARITH STMT OR EXPRN
SYN19    CR (SNT1B) ; EDT                    : INDICATE ARITH STMT OR EXPRN
SYN20    #AEX53 -> SYN19                     : DUMMY ENTRY TO AEXP FOR NUMBER
SYN21    ' ' (SNT2B) ; EDT                   : NO STMT NO. REQUIRED
*                                            : INDICATE STMT TO BE STORED
         ' ' -> SYN10 ; EDT
SYN23    ' ' (SNT3B) -> SYN10 ; EDT          : ONE DIGIT STMT NO.
*                                            : INDICATE STMT TO BE STORED
SYN24    #AEX54 -> SYN19                     : ENTRY TO AEXP AFTER 1 LETTER
SYN25    #AEX55 -> SYN19                     : ENTRY TO AEXP AFTER 2 LETTERS
SYN26    #AEX56 -> SYN19                     : ENTRY TO AEXP AFTER 3 LETTERS
SYN27    #AEX57 -> SYN19                     : ENTRY TO AEXP AFTER 4 LETTERS
SYN28    'E' ; SYN64                         : CHECK FOR END STMT
SYN29    'N' ; SYN32
         'D' ; SYN25
         CR (SNT9A(X(4A))) ; SYN26           : INDICATE END STMT
SYN32    #AEX58 -> SYN19                     : ENTRY TO AEXP AFTER LETTER E
SYN33    'I' ; SYN50                         : CHECK FOR IF STMT
         'F' ; SYN48
         '(' (SNT4B(X(5C))) ; SYN25          : STORE IF STMT TYPE
         #AEXPS                              : 1ST OPERAND IN IF STMT
         '.' (SNT5B(X(3C))) ; EDT            : LOAD SPECIAL CODE FOR . IN IF
         'G' ; SYN43                         : CHECK FOR RELATIONAL OPERATORS
SYN39    'T' ; SYN47
SYN40    '.' ; EDT
         #AEXPS                              : CHECK FOR 2ND OPERAND
         ')' (SNT5B(X(3D))) -> SYN49
SYN43    'L' -> SYN39
         'E' ; SYN46
         'Q' -> SYN40 ; EDT
SYN46    'N' ; EDT
SYN47    'E' -> SYN40 ; EDT
SYN48    #AEX59 -> SYN19                     : ENTRY TO AEXP AFTER LETTER I
SYN49    ' ' ; EDT
SYN50    'S' ; SYN56                         : CHECK FOR STOP STMT
SYN51    'T' ; SYN55
         'O' ; SYN25
         'P' ; SYN26
         CR (SNT9A(X(42))) ; SYN27           : INDICATE STOP STMT
SYN55    #AEX60 -> SYN19                     : ENTRY TO AEXP AFTER LETTER S
```

```
SYN56    'C' ; SYN76                        : CHECK FOR CALL STMT
SYN57    'A' ; SYN68
         'L' ; SYN25
         'L' ; SYN26
         ' ' (SNT6B(X(5D))) ; SYN27         : INDICATE CALL STMT
SYN61    #AEXPS                             : CHECK FOR OPERAND
SYN62    CR (SNT7B) ; EDT                   : PROCESS STMT
SYN63    #AEX61 -> SYN19                    : ENTRY TO AEXP AFTER LETTER C
SYN64    'C' ; SYN33                        : CHECK FOR STORED COMMENT
         ' ' ; SYN57
SYN66    CR (SNT9A(X(3F)))                  : INDICATE COMMENT STATEMENT
         (SNT5B) -> SYN66                   : ACCEPT ANY CHARACTER, IC=EC
SYN68    'O' ; SYN63                        : CHECK FOR CONTINUE STMT
         'N' ; SYN75
         'T' ; SYN26
         'I' ; SYN27
         'N' ; EDT
         'U' ; EDT
         'E' ; EDT
         CR (SNT9A(X(3E))) ; EDT            : INDICATE CONTINUE STMT
SYN75    #AEX62 -> SYN19                    : ENTRY TO AEXP AFTER LETTERS CO
SYN76    'R' ; SYN83                        : CHECK FOR RETURN STMT
         'E' ; SYN24
         'T' ; SYN25
         'U' ; SYN26
         'R' ; SYN27
         'N' ; EDT
         CR (SNT9A(X(5E))) ; EDT            : INDICATE RETURN STMT
SYN83    'A' ; SN104                        : CHECK FOR ACCEPT STMT
         'C' ; SN103
         'C' ; SYN25
         'E' ; SYN26
         'P' ; SYN27
         'T' ; EDT
         ' ' (SNT9B(X(55))) ; EDT
SYN90    (AEX4A) ; EDT                      : CHECK FOR  ALPHABETIC CHAR
         (AEX5A) ; SYN95                    : CHECK FOR ALPHANUMERIC CHAR
         (AEX5A) ; SYN95                    : CHECK FOR ALPHANUMERIC CHAR
         (AEX5A)                            : CHECK FOR ALPHANUMERIC CHAR
SYN94    ',' (SNT5B(X(34))) -> SYN90 ; SYN62 : LOOK FOR DELIMETER COMMA
SYN95    '(' (SNT5B(X(31))) ; SYN94         : SUBSCRIPTED VARIABLE BRACKET
         '*' (SNT1C) -> SN101
         #AEXPS                             : CHECK FOR SUBSCRIPT
         ',' (SNT5B(X(35))) ; SN100         : SUBS VBLE COMMA IN ACCEPT
         #AEXPS                             : CHECK FOR 2ND SUBSCRIPT
SN100    ')' -> SYN94 ; EDT                 : SUBS VBLE CLOSING BRACKET
SN101    ',' (SNT5B(X(35))) ; SN100         : SUBS VBLE COMMA IN CLEAR STMT
         '*' -> SN100 ; EDT
SN103    #AEX63 -> SYN19                    : ENTRY TO AEXP AFTER LETTER A
SN104    'T' ; SN132                        : CHECK FOR TYPE STMT
SN105    'Y' ; SYN24
         'P' ; SYN25
         'E' ; SYN26
         ' ' -> SN110 ; SN206
SN109    CR (SNT9A(X(49)))
SN110    ';' -> SN109
         ':' -> SN109
SN111    '<' ; SN119                        : CHECK FOR POSITIONAL PARAM
         '<' -> EDIT2
         (EDT3A) ; SN122                    : NONZERO DIGIT.LT.INPUT CHARS
```

```
        (EDT4A)                              : DIGIT WITH SUM.LT.INPUT CHARS
        CR (EDT5A)                           : DELETE CHARACTERS AND RETYPE
        #AEX53
SN117   '>' ; EDT
        ',' (SNT5B(X(34))) ; EDT
SN119   ''' ; SN130
        '"' ; SN123
        '*' -> SN124 ; EDT
SN122   #AEXPS -> SN117
SN123   (SNT5B)                              : ACCEPT ANY CHARACTER
SN124   ''' ; SN123
        '"' -> SN124
SN126   ',' (SNT5B(X(34))) -> SN111          : LOOK FOR DELIMETER
        ';' -> SN109
        ':' -> SN109
        CR (SNT9A(X(49))) ; EDT              : INDICATE TYPE STMT
SN130   '='
        #AEXPS -> SN126                      : CHECK FOR ARITH STMT OR EXPRN
SN132   'G' ; SYN18                          : CHECK FOR GO TO STMT
        'O' ; SYN24
        ' ' ; SYN25
        'T' ; EDT
        'O' ; EDT
        ' ' (SNT6B(X(48))) -> SYN61 ; EDT    : INDICATE GO TO STMT
SN133   'R' ; SN137                          : CHECK FOR RUN STMT
        'U' ; SYN24
        'N' ; SYN25
        CR (SNT9A(X(4B))) ; SYN26            : INDICATE RUN STMT
SN137   'L' ; SN147                          : CHECK FOR LIST STMT
        'I' ; SN146
        'S' ; SYN25
        'T' ; SYN26
        CR (SNT9A(X(4D)))
        ':' (SNT6B(X(4D))) -> SN145
        ' ' (SNT6B(X(4D))) ; SYN27
SN143   #AEXPS                               : CHECK 1ST OPERAND
*   IF NO COMMA LOOK FOR CR, OTHERWISE CHECK 2ND OPERAND
        ',' (SNT5B(X(34))) -> SYN61 ; SYN62
SN145   ' ' -> SN143 ; SYN62
SN146   #AEX64 -> SYN19                      : ENTRY TO AEXP AFTER LETTER L
SN147   'E' ; SN152                          : CHECK FOR EDIT STMT
        'D' ; SYN29                          : CHECK FOR END IF NOT D
        'I' ; SYN25
        'T' ; SYN26
        ' ' (SNT6B(X(4C))) -> SYN61 ; SYN27     : INDICATE EDIT STMT
SN152   'P' ; SN158                          : CHECK FOR PA OR PB
        'A' ; SN155
        ' ' (SNT6B(X(5A))) -> SYN61 ; SYN25     : INDICATE PA STMT
SN155   'B' ; SYN24
        ' ' (SNT6B(X(5B))) -> SYN61 ; SYN25     : INDICATE PB STMT
SN158   'C' ; SN207                              : CHECK FOR CLEAR STMT
        ' ' -> SYN66                             : CHECK FOR COMMENT
        'L' ; SYN63
        'E' ; SYN25
        'A' ; SYN26
        'R' (SNT2C(X(4E))) ; SYN27
        ' ' -> SYN90 ; SYN62
SN165   'S' ; SN187
        'Y' ; SN174
        'M' ; SYN25
```

```
          'B' ; SYN26
          'O' ; SYN27
          'L' ; EDT
          'S' ; EDT
          ':'
          CR (SNT9A(X(4F))) ; EDT          : INDICATE SYMBOLS STMT
SN174     'P' ; SN179                      : CHECK FOR SPACE STMT
          'A' ; SYN25
          'C' ; SYN26
          'E' ; SYN27
          CR (SNT9A(X(41))) ; EDT          : INDICATE SPACE STMT
SN179     'U' ; SYN51                      : CHECK FOR SUSPEND STMT
          'S' ; SYN25
          'P' ; SYN26
          'E' ; SYN27
          'N' ; EDT
          'D' ; EDT
          ':'
          CR (SNT9A(X(50))) ; EDT          : INDICATE SUSPEND STMT
SN187     'F' ; SN196                      : CHECK FOR FTRON
          'T' ; SYN24
          'R' ; SYN25
          'O' ; SYN26
          'N' ; SN193
          CR (SNT9A(X(53))) ; EDT          : INDICATE FTRON STMT
SN193     'F' ; SYN27
          'F' ; EDT
          CR (SNT9A(X(54))) ; EDT          : INDICATE FTROFF STMT
SN196     'T' ; SN132                      : CHECK FOR TRON AND TROFF
          'R' ; SN105
          'O' ; SYN25
          'N' ; SN202
          ' ' (SNT6B(X(51))) -> SYN61              : INDICATE TRON STMT
          CR (SNT9A(X(51))) ; SYN27
SN202     'F' ; SYN26
          'F' ; SYN27
          ' ' (SNT6B(X(52))) -> SYN61              : INDICATE TROFF STMT
          CR (SNT9A(X(52))) ; EDT
SN206     CR (SNT9A(X(49))) ; SYN27                : INDICATE TYPE STMT
SN207     '$' ; SN165
          ' ' ; #5
SN209     CR (SNT9A(X(56)))                        : SPECIAL $ STMT
          (SNT5B) -> SN209
AEXPS     (AEX1A)                          : INITIALISE POINTERS
AEXP      '+' (AEX2A) -> AEX2              : UNARY PLUS OR MINUS
          '-' (AEX2A)
AEX2      'A' ; AEX8                       : ABS
AEX3      'B' ; AEX6
AEX4      'S' ; AEX30
AEX5      '(' (AEX3A(X(32))) -> AEXP ; AEX31       : FUNCTION BRACKET
AEX6      'T' ; AEX29                      : ATN
AEX7      'N' -> AEX5 ; AEX30
AEX8      'C' ; AEX10                      : COS
AEX9      'O' -> AEX4 ; AEX29
AEX10     'D' ; AEX15                      : DPT
          'P' ; AEX29
          'T' ; AEX30
          '(' (AEX3A(X(32))) ; AEX31       : FUNCTION BRACKET
          '"' -> AEXP ; AEXP
AEX15     'E' ; AEX18                      : EXP
```

```
AEX16    'X' ; AEX29
         'P' -> AEX5 ; AEX30
AEX18    'I' ; AEX21                    : INT
AEX19    'N' ; AEX29
         'T' -> AEX5 ; AEX30
AEX21    'L' ; AEX24                    : LOG
AEX22    'O' ; AEX29
         'G' -> AEX5 ; AEX30
AEX24    'S' ; AEX28                    : SIN
AEX25    'I' -> AEX7
         'Q' ; AEX29                    : SQR
         'R' -> AEX5 ; AEX30
AEX28    (AEX4A) ; AEX41                : ALPHABETIC CHARACTER
AEX29    (AEX5A) ; AEX40                : ALPHANUMERIC CHARACTER
AEX30    (AEX5A) ; AEX40                : ALPHANUMERIC CHARACTER
AEX31    (AEX5A)                        : ALPHANUMERIC CHARACTER
AEX32    ASSIGN (AEX7A) -> AEXP         : ASSIGNMENT ARROW
AEX33    ')' (AEX8A) -> AEX33            : AEX32 IS FORPTR FOR SUBS VBLE
         ',' (AEX9A) -> AEXP            : COMMA IN SUBSCRIPTED VARIABLE
         '+' (AEX2A) -> AEX2
         '-' (AEX2A) -> AEX2
         '*' (AEX2A) -> AEX2
         '/' (AEX2A) -> AEX2
         UPARROW (AEX2A) -> AEX2
         '<' -> EDIT1                   : CHECK FOR EDIT CHARACTER
         (AEX2B) ; RETURN               : RETURN IF ZERO BRACKET LEVEL
AEX40    '(' (AEX6A(X(31))) -> AEXP ; AEX32  : SUBS VBLE BRACKET
AEX41    '(' (AEX3A(X(30))) -> AEXP     : NORMAL OPENING BRACKET
         (AEX1B) ; AEX51                : DECIMAL NUMBER
AEX43    (AEX1B) -> AEX43               : DECIMAL NUMBER
         '.' ; AEX46
AEX45    (AEX1B) -> AEX45               : DECIMAL NUMBER
AEX46    'E' ; AEX33                    : EXPONENT SYMBOL
         '+' (SNT5B(X(39))) -> AEX49    : EXPONENT PLUS
         '-' (SNT5B(X(3A)))             : EXPONENT MINUS
AEX49    (AEX1B) ; EDT                  : DECIMAL NUMBER IN EXPONENT
         (AEX1B) -> AEX33 ; AEX33       : 2ND DIGIT IN EXPONENT
AEX51    '.' ; EDT
         (AEX1B) -> AEX45               : DECIMAL NUMBER
EDT      '<' ; #1
EDIT1    '<' ; EDIT4
EDIT2    '<' (EDT1A)
         CR (EDT2A) ; #2
EDIT4    (EDT3A) ; #3                   : NONZERO DIGIT.LT.INPUT CHARS
         (EDT4A)                        : DIGIT WITH SUM.LT.INPUT CHARS
         CR (EDT5A) ; #4                : DELETE CHARACTERS AND RETYPE
AEX53    (AEX1A) ; AEX43
AEX54    (AEX1A) ; AEX29
AEX55    (AEX1A) ; AEX30
AEX56    (AEX1A) ; AEX31
AEX57    (AEX1A) ; AEX32
AEX58    (AEX1A) ; AEX16
AEX59    (AEX1A) ; AEX19
AEX60    (AEX1A) ; AEX25
AEX61    (AEX1A) ; AEX9
AEX62    (AEX1A) ; AEX4
AEX63    (AEX1A) ; AEX3
AEX64    (AEX1A) ; AEX22
```

APPENDIX D

THE NOVA ASSEMBLY CODE EXPANSION OF THE ACL SYNTAX

```
*SYNT     CR (SNT1A)                      : CHECK FOR INITIAL CR          00562200
SYNT      DC        X(808D)                                               00562300
          DC        A(SNT1A)                                              00562400
*    IF PAPER TAPE NOT READY FLAG IS SET, REJECT INPUT CHARACTER.         00562500
*    OTHERWISE, IF ACCEPT STMT INPUT, ONLY ALLOW ARITH STMT OR EXPRN.     00562600
*         (SNT2A)                    : USE SYN18 AS ALT FOR ACCEPT INPUT  00562700
          DC        X(4001)                                               00562800
*         ' ' (SNT3A) -> SYN7         : INITIAL SPACE(GENERATE SEQ NO)00562900
          DC        X(88A0)                                               00563000
          DC        A(SNT3A)                                              00563100
          DC        A(SYN7)                                               00563200
*         (SNT4A) ; SN133             : CHECK FOR 1ST DIGIT IN SEQ NO.00563300
          DC        X(5002)                                               00563400
          DC        A(SN133)                                              00563500
*         (SNT5A) ; SYN20             : CHECK FOR 2ND DIGIT IN SEQ NO.00563600
          DC        X(5003)                                               00563700
          DC        A(SYN20)                                              00563800
*         (SNT5A) ; SYN20             : CHECK FOR 3RD DIGIT IN SEQ NO.00563900
          DC        X(5003)                                               00564000
          DC        A(SYN20)                                              00564100
*         ' ' (SNT6A) ; SYN20         : SPACE AFTER SEQ NO.           00564200
          DC        X(90A0)                                               00564300
          DC        A(SNT6A)                                              00564400
          DC        A(SYN20)                                              00564500
*SYN7      CR (SNT7A(X(44)))          : STATEMENT TO BE DELETED       00564600
SYN7      DC        X(828D)                                               00564700
          DC        X(4404)                                               00564800
*         (AEX1B) ; SYN21             : CHECK FOR 1ST DIGIT IN STMT NO00564900
          DC        X(5013)                                               00565000
          DC        A(SYN21)                                              00565100
*         (SNT8A) ; SYN23           : CHECK FOR 2ND DIGIT IN STMT NO.     00565200
          DC        X(5005)                                               00565300
          DC        A(SYN23)                                              00565400
*SYN10     ' ' (SNT3C) ; EDT          : INDICATE STMT TO BE STORED    00565500
SYN10     DC        X(90A0)                                               00565600
          DC        A(SNT3C)                                              00565700
          DC        A(EDT)                                                00565800
*SYN11     CR (SNT7A(X(45)))          : INSERT, DEL OR REPL STMT NO.  00565900
SYN11     DC        X(828D)                                               00566000
          DC        X(4504)                                               00566100
*         'P' ; SYN28                 : CHECK FOR PAUSE STMT          00566200
          DC        X(1050)                                               00566300
          DC        A(SYN28)                                              00566400
*         'A' ; SYN24                                                     00566500
          DC        X(1041)                                               00566600
          DC        A(SYN24)                                              00566700
*         'U' ; SYN25                                                     00566800
          DC        X(1055)                                               00566900
          DC        A(SYN25)                                              00567000
*         'S' ; SYN26                                                     00567100
          DC        X(1053)                                               00567200
          DC        A(SYN26)                                              00567300
*         'E' ; SYN27                                                     00567400
          DC        X(10C5)                                               00567500
          DC        A(SYN27)                                              00567600
*         CR (SNT9A(X(59))) ; EDT     : INDICATE PAUSE STMT AND EXIT  00567700
          DC        X(928D)                                               00567800
          DC        X(5906)                                               00567900
          DC        A(EDT)                                                00568000
*SYN18     #AEXPS                     : CHECK FOR ARITH STMT OR EXPRN 00568100
SYN18     DC        X(8000)                                               00568200
          DC        A(AEXPS)                                              00568300
*SYN19     CR (SNT1B) ; EDT            : INDICATE ARITH STMT OR EXPRN  00568400
```

```
SYN19    DC         X(908D)                                                00568500
         DC         A(SNT1B)                                               00568600
         DC         A(EDT)                                                 00568700
*SYN20    #AEX53 -> SYN19              : DUMMY ENTRY TO AEXP FOR NUMBER00568800
SYN20    DC         X(8800)                                                00568900
         DC         A(AEX53)                                               00569000
         DC         A(SYN19)                                               00569100
*SYN21    ' ' (SNT2B) ; EDT            : NO STMT NO. REQUIRED             00569200
SYN21    DC         X(90A0)                                                00569300
         DC         A(SNT2B)                                               00569400
         DC         A(EDT)                                                 00569500
*                                     : INDICATE STMT TO BE STORED       00569600
*         ' ' -> SYN10 ; EDT                                              00569700
         DC         X(18A0)                                                00569800
         DC         A(EDT)                                                 00569900
         DC         A(SYN10)                                               00570000
*SYN23    ' ' (SNT3B) -> SYN10 ; EDT   : ONE DIGIT STMT NO.               00570100
SYN23    DC         X(98A0)                                                00570200
         DC         A(SNT3B)                                               00570300
         DC         A(EDT)                                                 00570400
         DC         A(SYN10)                                               00570500
*                                     : INDICATE STMT TO BE STORED       00570600
*SYN24    #AEX54 -> SYN19              : ENTRY TO AEXP AFTER 1 LETTER     00570700
SYN24    DC         X(8800)                                                00570800
         DC         A(AEX54)                                               00570900
         DC         A(SYN19)                                               00571000
*SYN25    #AEX55 -> SYN19              : ENTRY TO AEXP AFTER 2 LETTERS    00571100
SYN25    DC         X(8800)                                                00571200
         DC         A(AEX55)                                               00571300
         DC         A(SYN19)                                               00571400
*SYN26    #AEX56 -> SYN19              : ENTRY TO AEXP AFTER 3 LETTERS    00571500
SYN26    DC         X(8800)                                                00571600
         DC         A(AEX56)                                               00571700
         DC         A(SYN19)                                               00571800
*SYN27    #AEX57 -> SYN19              : ENTRY TO AEXP AFTER 4 LETTERS    00571900
SYN27    DC         X(8800)                                                00572000
         DC         A(AEX57)                                               00572100
         DC         A(SYN19)                                               00572200
*SYN28    'E' ; SYN64                  : CHECK FOR END STMT               00572300
SYN28    DC         X(10C5)                                                00572400
         DC         A(SYN64)                                               00572500
*SYN29    'N' ; SYN32                                                     00572600
SYN29    DC         X(104E)                                                00572700
         DC         A(SYN32)                                               00572800
*         'D' ; SYN25                                                     00572900
         DC         X(1044)                                                00573000
         DC         A(SYN25)                                               00573100
*         CR (SNT9A(X(4A))) ; SYN26    : INDICATE END STMT                00573200
         DC         X(928D)                                                00573300
         DC         X(4A06)                                                00573400
         DC         A(SYN26)                                               00573500
*SYN32    #AEX58 -> SYN19              : ENTRY TO AEXP AFTER LETTER E     00573600
SYN32    DC         X(8800)                                                00573700
         DC         A(AEX58)                                               00573800
         DC         A(SYN19)                                               00573900
*SYN33    'I' ; SYN50                  : CHECK FOR IF STMT                00574000
SYN33    DC         X(10C9)                                                00574100
         DC         A(SYN50)                                               00574200
*         'F' ; SYN48                                                     00574300
         DC         X(10C6)                                                00574400
         DC         A(SYN48)                                               00574500
*         '(' (SNT4B(X(5C))) ; SYN25   : STORE IF STMT TYPE               00574600
         DC         X(9228)                                                00574700
         DC         X(5C07)                                                00574800
         DC         A(SYN25)                                               00574900
*         #AEXPS                       : 1ST OPERAND IN IF STMT           00575000
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          DC        X(8000)                                                00575100
          DC        A(AEXPS)                                               00575200
*          '.' (SNT5B(X(3C))) ; EDT      : LOAD SPECIAL CODE FOR . IN IF  00575300
          DC        X(922E)                                                00575400
          DC        X(3C08)                                                00575500
          DC        A(EDT)                                                 00575600
*          'G' ; SYN43                   : CHECK FOR RELATIONAL OPERATORS 00575700
          DC        X(1047)                                                00575800
          DC        A(SYN43)                                               00575900
*SYN39     'T' ; SYN47                                                     00576000
SYN39     DC        X(10D4)                                                00576100
          DC        A(SYN47)                                               00576200
*SYN40     '.' ; EDT                                                       00576300
SYN40     DC        X(102E)                                                00576400
          DC        A(EDT)                                                 00576500
*          #AEXPS                        : CHECK FOR 2ND OPERAND          00576600
          DC        X(8000)                                                00576700
          DC        A(AEXPS)                                               00576800
*          ')' (SNT5B(X(3D))) -> SYN49                                     00576900
          DC        X(8AA9)                                                00577000
          DC        X(3D08)                                                00577100
          DC        A(SYN49)                                               00577200
*SYN43     'L' -> SYN39                                                    00577300
SYN43     DC        X(08CC)                                                00577400
          DC        A(SYN39)                                               00577500
*          'E' ; SYN46                                                     00577600
          DC        X(10C5)                                                00577700
          DC        A(SYN46)                                               00577800
*          'Q' -> SYN40 ; EDT                                              00577900
          DC        X(18D1)                                                00578000
          DC        A(EDT)                                                 00578100
          DC        A(SYN40)                                               00578200
*SYN46     'N' ; EDT                                                       00578300
SYN46     DC        X(104E)                                                00578400
          DC        A(EDT)                                                 00578500
*SYN47     'E' -> SYN40 ; EDT                                              00578600
SYN47     DC        X(18C5)                                                00578700
          DC        A(EDT)                                                 00578800
          DC        A(SYN40)                                               00578900
*SYN48     #AEX59 -> SYN19               : ENTRY TO AEXP AFTER LETTER I   00579000
SYN48     DC        X(8800)                                                00579100
          DC        A(AEX59)                                               00579200
          DC        A(SYN19)                                               00579300
*SYN49     ' ' ; EDT                                                       00579400
SYN49     DC        X(10A0)                                                00579500
          DC        A(EDT)                                                 00579600
*SYN50     'S' ; SYN56                   : CHECK FOR STOP STMT            00579700
SYN50     DC        X(1053)                                                00579800
          DC        A(SYN56)                                               00579900
*SYN51     'T' ; SYN55                                                     00580000
SYN51     DC        X(10D4)                                                00580100
          DC        A(SYN55)                                               00580200
*          'O' ; SYN25                                                     00580300
          DC        X(10CF)                                                00580400
          DC        A(SYN25)                                               00580500
*          'P' ; SYN26                                                     00580600
          DC        X(1050)                                                00580700
          DC        A(SYN26)                                               00580800
*          CR (SNT9A(X(42))) ; SYN27     : INDICATE STOP STMT             00580900
          DC        X(928D)                                                00581000
          DC        X(4206)                                                00581100
          DC        A(SYN27)                                               00581200
*SYN55     #AEX60 -> SYN19               : ENTRY TO AEXP AFTER LETTER S   00581300
SYN55     DC        X(8800)                                                00581400
          DC        A(AEX60)                                               00581500
          DC        A(SYN19)                                               00581600
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*SYN56    'C' ; SYN76                    : CHECK FOR CALL STMT          00581700
SYN56     DC        X(10C3)                                             00581800
          DC        A(SYN76)                                            00581900
*SYN57    'A' ; SYN68                                                   00582000
SYN57     DC        X(1041)                                             00582100
          DC        A(SYN68)                                            00582200
*         'L' ; SYN25                                                   00582300
          DC        X(10CC)                                             00582400
          DC        A(SYN25)                                            00582500
*         'L' ; SYN26                                                   00582600
          DC        X(10CC)                                             00582700
          DC        A(SYN26)                                            00582800
*         ' ' (SNT6B(X(5D))) ; SYN27     : INDICATE CALL STMT           00582900
          DC        X(92A0)                                             00583000
          DC        X(5D09)                                             00583100
          DC        A(SYN27)                                            00583200
*SYN61    #AEXPS                         : CHECK FOR OPERAND            00583300
SYN61     DC        X(8000)                                             00583400
          DC        A(AEXPS)                                            00583500
*SYN62    CR (SNT7B) ; EDT               : PROCESS STMT                 00583600
SYN62     DC        X(908D)                                             00583700
          DC        A(SNT7B)                                            00583800
          DC        A(EDT)                                              00583900
*SYN63    #AEX61 -> SYN19                : ENTRY TO AEXP AFTER LETTER C 00584000
SYN63     DC        X(8800)                                             00584100
          DC        A(AEX61)                                            00584200
          DC        A(SYN19)                                            00584300
*SYN64    'C' ; SYN33                    : CHECK FOR STORED COMMENT     00584400
SYN64     DC        X(10C3)                                             00584500
          DC        A(SYN33)                                            00584600
*         ' ' ; SYN57                                                   00584700
          DC        X(10A0)                                             00584800
          DC        A(SYN57)                                            00584900
*SYN66    CR (SNT9A(X(3F)))              : INDICATE COMMENT STATEMENT   00585000
SYN66     DC        X(828D)                                             00585100
          DC        X(3F06)                                             00585200
*         (SNT5B) -> SYN66               : ACCEPT ANY CHARACTER, IC=EC  00585300
          DC        X(4808)                                             00585400
          DC        A(SYN66)                                            00585500
*SYN68    'O' ; SYN63                    : CHECK FOR CONTINUE STMT      00585600
SYN68     DC        X(10CF)                                             00585700
          DC        A(SYN63)                                            00585800
*         'N' ; SYN75                                                   00585900
          DC        X(104E)                                             00586000
          DC        A(SYN75)                                            00586100
*         'T' ; SYN26                                                   00586200
          DC        X(10D4)                                             00586300
          DC        A(SYN26)                                            00586400
*         'I' ; SYN27                                                   00586500
          DC        X(10C9)                                             00586600
          DC        A(SYN27)                                            00586700
*         'N' ; EDT                                                     00586800
          DC        X(104E)                                             00586900
          DC        A(EDT)                                              00587000
*         'U' ; EDT                                                     00587100
          DC        X(1055)                                             00587200
          DC        A(EDT)                                              00587300
*         'E' ; EDT                                                     00587400
          DC        X(10C5)                                             00587500
          DC        A(EDT)                                              00587600
*         CR (SNT9A(X(3E))) ; EDT        : INDICATE CONTINUE STMT       00587700
          DC        X(928D)                                             00587800
          DC        X(3E06)                                             00587900
          DC        A(EDT)                                              00588000
*SYN75    #AEX62 -> SYN19                : ENTRY TO AEXP AFTER LETTERS C00588100
SYN75     DC        X(8800)                                             00588200
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         DC        A(AEX62)                                                  00588300
         DC        A(SYN19)                                                  00588400
*SYN76    'R' ; SYN83                    : CHECK FOR RETURN STMT            00588500
SYN76    DC        X(10D2)                                                   00588600
         DC        A(SYN83)                                                  00588700
*         'E' ; SYN24                                                       00588800
         DC        X(10C5)                                                   00588900
         DC        A(SYN24)                                                  00589000
*         'T' ; SYN25                                                       00589100
         DC        X(10D4)                                                   00589200
         DC        A(SYN25)                                                  00589300
*         'U' ; SYN26                                                       00589400
         DC        X(1055)                                                   00589500
         DC        A(SYN26)                                                  00589600
*         'R' ; SYN27                                                       00589700
         DC        X(10D2)                                                   00589800
         DC        A(SYN27)                                                  00589900
*         'N' ; EDT                                                         00590000
         DC        X(104E)                                                   00590100
         DC        A(EDT)                                                    00590200
*         CR (SNT9A(X(5E))) ; EDT        : INDICATE RETURN STMT             00590300
         DC        X(928D)                                                   00590400
         DC        X(5E06)                                                   00590500
         DC        A(EDT)                                                    00590600
*SYN83    'A' ; SN104                    : CHECK FOR ACCEPT STMT            00590700
SYN83    DC        X(1041)                                                   00590800
         DC        A(SN104)                                                  00590900
*         'C' ; SN103                                                       00591000
         DC        X(10C3)                                                   00591100
         DC        A(SN103)                                                  00591200
*         'C' ; SYN25                                                       00591300
         DC        X(10C3)                                                   00591400
         DC        A(SYN25)                                                  00591500
*         'E' ; SYN26                                                       00591600
         DC        X(10C5)                                                   00591700
         DC        A(SYN26)                                                  00591800
*         'P' ; SYN27                                                       00591900
         DC        X(1050)                                                   00592000
         DC        A(SYN27)                                                  00592100
*         'T' ; EDT                                                         00592200
         DC        X(10D4)                                                   00592300
         DC        A(EDT)                                                    00592400
*         ' ' (SNT9B(X(55))) ; EDT                                          00592500
         DC        X(92A0)                                                   00592600
         DC        X(550A)                                                   00592700
         DC        A(EDT)                                                    00592800
*SYN90     (AEX4A) ; EDT                 : CHECK FOR  ALPHABETIC CHAR       00592900
SYN90    DC        X(5010)                                                   00593000
         DC        A(EDT)                                                    00593100
*         (AEX5A) ; SYN95               : CHECK FOR ALPHANUMERIC CHAR      00593200
         DC        X(5011)                                                   00593300
         DC        A(SYN95)                                                  00593400
*         (AEX5A) ; SYN95               : CHECK FOR ALPHANUMERIC CHAR      00593500
         DC        X(5011)                                                   00593600
         DC        A(SYN95)                                                  00593700
*         (AEX5A)                       : CHECK FOR ALPHANUMERIC CHAR      00593800
         DC        X(4011)                                                   00593900
*SYN94    ',' (SNT5B(X(34))) -> SYN90 ; SYN62 : LOOK FOR DELIMETER COMMA    00594000
SYN94    DC        X(9AAC)                                                   00594100
         DC        X(3408)                                                   00594200
         DC        A(SYN62)                                                  00594300
         DC        A(SYN90)                                                  00594400
*SYN95    '(' (SNT5B(X(31))) ; SYN94    : SUBSCRIPTED VARIABLE BRACKET     00594500
SYN95    DC        X(9228)                                                   00594600
         DC        X(3108)                                                   00594700
         DC        A(SYN94)                                                  00594800
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*          '*' (SNT1C) -> SN101                                                  00594900
           DC         X(88AA)                                                    00595000
           DC         A(SNT1C)                                                   00595100
           DC         A(SN101)                                                   00595200
*          #AEXPS                        : CHECK FOR SUBSCRIPT                 00595300
           DC         X(8000)                                                    00595400
           DC         A(AEXPS)                                                   00595500
*          ',' (SNT5B(X(35))) ; SN100    : SUBS VBLE COMMA IN ACCEPT           00595600
           DC         X(92AC)                                                    00595700
           DC         X(3508)                                                    00595800
           DC         A(SN100)                                                   00595900
*          #AEXPS                        : CHECK FOR 2ND SUBSCRIPT             00596000
           DC         X(8000)                                                    00596100
           DC         A(AEXPS)                                                   00596200
*SN100     ')' -> SYN94 ; EDT            : SUBS VBLE CLOSING BRACKET           00596300
SN100      DC         X(18A9)                                                    00596400
           DC         A(EDT)                                                     00596500
           DC         A(SYN94)                                                   00596600
*SN101     ',' (SNT5B(X(35))) ; SN100    : SUBS VBLE COMMA IN CLEAR STMT       00596700
SN101      DC         X(92AC)                                                    00596800
           DC         X(3508)                                                    00596900
           DC         A(SN100)                                                   00597000
*          '*' -> SN100 ; EDT                                                    00597100
           DC         X(18AA)                                                    00597200
           DC         A(EDT)                                                     00597300
           DC         A(SN100)                                                   00597400
*SN103     #AEX63 -> SYN19               : ENTRY TO AEXP AFTER LETTER A        00597500
SN103      DC         X(8800)                                                    00597600
           DC         A(AEX63)                                                   00597700
           DC         A(SYN19)                                                   00597800
*SN104     'T' ; SN132                   : CHECK FOR TYPE STMT                 00597900
SN104      DC         X(10D4)                                                    00598000
           DC         A(SN132)                                                   00598100
*SN105     'Y' ; SYN24                                                           00598200
SN105      DC         X(1059)                                                    00598300
           DC         A(SYN24)                                                   00598400
*          'P' ; SYN25                                                           00598500
           DC         X(1050)                                                    00598600
           DC         A(SYN25)                                                   00598700
*          'E' ; SYN26                                                           00598800
           DC         X(10C5)                                                    00598900
           DC         A(SYN26)                                                   00599000
*          ' ' -> SN110 ; SN206                                                  00599100
           DC         X(18A0)                                                    00599200
           DC         A(SN206)                                                   00599300
           DC         A(SN110)                                                   00599400
*SN109     CR (SNT9A(X(49)))                                                     00599500
SN109      DC         X(828D)                                                    00599600
           DC         X(4906)                                                    00599700
*SN110     ';' -> SN109                                                          00599800
SN110      DC         X(088B)                                                    00599900
           DC         A(SN109)                                                   00600000
*          ':' -> SN109                                                          00600100
           DC         X(083A)                                                    00600200
           DC         A(SN109)                                                   00600300
*SN111     '<' ; SN119                   : CHECK FOR POSITIONAL PARAM          00600400
SN111      DC         X(103C)                                                    00600500
           DC         A(SN119)                                                   00600600
*          '<' -> EDIT2                                                          00600700
           DC         X(083C)                                                    00600800
           DC         A(EDIT2)                                                   00600900
*          (EDT3A) ; SN122               : NONZERO DIGIT.LT.INPUT CHARS        00601000
           DC         X(500B)                                                    00601100
           DC         A(SN122)                                                   00601200
*          (EDT4A)                       : DIGIT WITH SUM.LT.INPUT CHARS       00601300
           DC         X(400C)                                                    00601400
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*          CR (EDT5A)                    : DELETE CHARACTERS AND RETYPE  00601500
          DC         X(808D)                                            00601600
          DC         A(EDT5A)                                           00601700
*          #AEX53                                                       00601800
          DC         X(8000)                                            00601900
          DC         A(AEX53)                                           00602000
*SN117     '>' ; EDT                                                   00602100
SN117     DC         X(10BE)                                            00602200
          DC         A(EDT)                                             00602300
*          ',' (SNT5B(X(34))) ; EDT                                     00602400
          DC         X(92AC)                                            00602500
          DC         X(3408)                                            00602600
          DC         A(EDT)                                             00602700
*SN119     ''' ; SN130                                                 00602800
SN119     DC         X(1027)                                            00602900
          DC         A(SN130)                                           00603000
*          ''' ; SN123                                                  00603100
          DC         X(1027)                                            00603200
          DC         A(SN123)                                           00603300
*          ''' -> SN124 ; EDT                                           00603400
          DC         X(1827)                                            00603500
          DC         A(EDT)                                             00603600
          DC         A(SN124)                                           00603700
*SN122     #AEXPS -> SN117                                             00603800
SN122     DC         X(8800)                                            00603900
          DC         A(AEXPS)                                           00604000
          DC         A(SN117)                                           00604100
*SN123     (SNT5B)                       : ACCEPT ANY CHARACTER        00604200
SN123     DC         X(4008)                                            00604300
*SN124     ''' ; SN123                                                 00604400
SN124     DC         X(1027)                                            00604500
          DC         A(SN123)                                           00604600
*          ''' -> SN124                                                 00604700
          DC         X(0827)                                            00604800
          DC         A(SN124)                                           00604900
*SN126     ',' (SNT5B(X(34))) -> SN111   : LOOK FOR DELIMETER          00605000
SN126     DC         X(8AAC)                                            00605100
          DC         X(3408)                                            00605200
          DC         A(SN111)                                           00605300
*          ';' -> SN109                                                 00605400
          DC         X(08BB)                                            00605500
          DC         A(SN109)                                           00605600
*          ':' -> SN109                                                 00605700
          DC         X(083A)                                            00605800
          DC         A(SN109)                                           00605900
*          CR (SNT9A(X(49))) ; EDT       : INDICATE TYPE STMT          00606000
          DC         X(928D)                                            00606100
          DC         X(4906)                                            00606200
          DC         A(EDT)                                             00606300
*SN130     '"'                                                         00606400
SN130     DC         X(0022)                                            00606500
*          #AEXPS -> SN126               : CHECK FOR ARITH STMT OR EXPRN 00606600
          DC         X(8800)                                            00606700
          DC         A(AEXPS)                                           00606800
          DC         A(SN126)                                           00606900
*SN132     'G' ; SYN18                   : CHECK FOR GO TO STMT        00607000
SN132     DC         X(1047)                                            00607100
          DC         A(SYN18)                                           00607200
*          'O' ; SYN24                                                  00607300
          DC         X(10CF)                                            00607400
          DC         A(SYN24)                                           00607500
*          ' ' ; SYN25                                                  00607600
          DC         X(10A0)                                            00607700
          DC         A(SYN25)                                           00607800
*          'T' ; EDT                                                    00607900
          DC         X(10D4)                                            00608000
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          DC        A(EDT)                                                  00608100
*          'O' ; EDT                                                        00608200
          DC        X(10CF)                                                 00608300
          DC        A(EDT)                                                  00608400
*          ' ' (SNT6B(X(48))) -> SYN61 ; EDT   : INDICATE GO TO STMT       00608500
          DC        X(9AA0)                                                 00608600
          DC        X(4809)                                                 00608700
          DC        A(EDT)                                                  00608800
          DC        A(SYN61)                                                00608900
*SN133     'R' ; SN137                    : CHECK FOR RUN STMT             00609000
SN133     DC        X(10D2)                                                 00609100
          DC        A(SN137)                                                00609200
*          'U' ; SYN24                                                      00609300
          DC        X(1055)                                                 00609400
          DC        A(SYN24)                                                00609500
*          'N' ; SYN25                                                      00609600
          DC        X(104E)                                                 00609700
          DC        A(SYN25)                                                00609800
*          CR (SNT9A(X(4B))) ; SYN26      : INDICATE RUN STMT              00609900
          DC        X(928D)                                                 00610000
          DC        X(4B06)                                                 00610100
          DC        A(SYN26)                                                00610200
*SN137     'L' ; SN147                    : CHECK FOR LIST STMT            00610300
SN137     DC        X(10CC)                                                 00610400
          DC        A(SN147)                                                00610500
*          'I' ; SN146                                                      00610600
          DC        X(10C9)                                                 00610700
          DC        A(SN146)                                                00610800
*          'S' ; SYN25                                                      00610900
          DC        X(1053)                                                 00611000
          DC        A(SYN25)                                                00611100
*          'T' ; SYN26                                                      00611200
          DC        X(10D4)                                                 00611300
          DC        A(SYN26)                                                00611400
*          CR (SNT9A(X(4D)))                                                00611500
          DC        X(828D)                                                 00611600
          DC        X(4D06)                                                 00611700
*          ':' (SNT6B(X(4D))) -> SN145                                      00611800
          DC        X(8A3A)                                                 00611900
          DC        X(4D09)                                                 00612000
          DC        A(SN145)                                                00612100
*          ' ' (SNT6B(X(4D))) ; SYN27                                       00612200
          DC        X(92A0)                                                 00612300
          DC        X(4D09)                                                 00612400
          DC        A(SYN27)                                                00612500
*SN143     #AEXPS                         : CHECK 1ST OPERAND              00612600
SN143     DC        X(8000)                                                 00612700
          DC        A(AEXPS)                                                00612800
*    IF NO COMMA LOOK FOR CR, OTHERWISE CHECK 2ND OPERAND                   00612900
*          ',' (SNT5B(X(34))) -> SYN61 ; SYN62                              00613000
          DC        X(9AAC)                                                 00613100
          DC        X(3408)                                                 00613200
          DC        A(SYN62)                                                00613300
          DC        A(SYN61)                                                00613400
*SN145     ' ' -> SN143 ; SYN62                                             00613500
SN145     DC        X(18A0)                                                 00613600
          DC        A(SYN62)                                                00613700
          DC        A(SN143)                                                00613800
*SN146     #AEX64 -> SYN19                : ENTRY TO AEXP AFTER LETTER L   00613900
SN146     DC        X(8800)                                                 00614000
          DC        A(AEX64)                                                00614100
          DC        A(SYN19)                                                00614200
*SN147     'E' ; SN152                    : CHECK FOR EDIT STMT            00614300
SN147     DC        X(10C5)                                                 00614400
          DC        A(SN152)                                                00614500
*          'D' ; SYN29                    : CHECK FOR END IF NOT D         00614600
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         DC        X(1044)                                                  00614700
         DC        A(SYN29)                                                 00614800
*         'I' ; SYN25                                                       00614900
         DC        X(10C9)                                                  00615000
         DC        A(SYN25)                                                 00615100
*         'T' ; SYN26                                                       00615200
         DC        X(10D4)                                                  00615300
         DC        A(SYN26)                                                 00615400
*         ' ' (SNT6B(X(4C))) -> SYN61 ; SYN27     : INDICATE EDIT STMT     00615500
         DC        X(9AA0)                                                  00615600
         DC        X(4C09)                                                  00615700
         DC        A(SYN27)                                                 00615800
         DC        A(SYN61)                                                 00615900
*SN152    'P' ; SN158                    : CHECK FOR PA OR PB               00616000
SN152    DC        X(1050)                                                  00616100
         DC        A(SN158)                                                 00616200
*         'A' ; SN155                                                       00616300
         DC        X(1041)                                                  00616400
         DC        A(SN155)                                                 00616500
*         ' ' (SNT6B(X(5A))) -> SYN61 ; SYN25     : INDICATE PA STMT       00616600
         DC        X(9AA0)                                                  00616700
         DC        X(5A09)                                                  00616800
         DC        A(SYN25)                                                 00616900
         DC        A(SYN61)                                                 00617000
*SN155    'B' ; SYN24                                                       00617100
SN155    DC        X(1042)                                                  00617200
         DC        A(SYN24)                                                 00617300
*         ' ' (SNT6B(X(5B))) -> SYN61 ; SYN25     : INDICATE PB STMT       00617400
         DC        X(9AA0)                                                  00617500
         DC        X(5B09)                                                  00617600
         DC        A(SYN25)                                                 00617700
         DC        A(SYN61)                                                 00617800
*SN158    'C' ; SN207                    : CHECK FOR CLEAR STMT             00617900
SN158    DC        X(10C3)                                                  00618000
         DC        A(SN207)                                                 00618100
*         ' ' -> SYN66                   : CHECK FOR COMMENT                00618200
         DC        X(08A0)                                                  00618300
         DC        A(SYN66)                                                 00618400
*         'L' ; SYN63                                                       00618500
         DC        X(10CC)                                                  00618600
         DC        A(SYN63)                                                 00618700
*         'E' ; SYN25                                                       00618800
         DC        X(10C5)                                                  00618900
         DC        A(SYN25)                                                 00619000
*         'A' ; SYN26                                                       00619100
         DC        X(1041)                                                  00619200
         DC        A(SYN26)                                                 00619300
*         'R' (SNT2C(X(4E))) ; SYN27                                        00619400
         DC        X(92D2)                                                  00619500
         DC        X(4E0D)                                                  00619600
         DC        A(SYN27)                                                 00619700
*         ' ' -> SYN90 ; SYN62                                              00619800
         DC        X(18A0)                                                  00619900
         DC        A(SYN62)                                                 00620000
         DC        A(SYN90)                                                 00620100
*SN165    'S' ; SN187                                                       00620200
SN165    DC        X(1053)                                                  00620300
         DC        A(SN187)                                                 00620400
*         'Y' ; SN174                                                       00620500
         DC        X(1059)                                                  00620600
         DC        A(SN174)                                                 00620700
*         'M' ; SYN25                                                       00620800
         DC        X(104D)                                                  00620900
         DC        A(SYN25)                                                 00621000
*         'B' ; SYN26                                                       00621100
         DC        X(1042)                                                  00621200
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          DC        A(SYN26)                                                00621300
*          'O' ; SYN27                                                      00621400
          DC        X(10CF)                                                 00621500
          DC        A(SYN27)                                                00621600
*          'L' ; EDT                                                       00621700
          DC        X(10CC)                                                 00621800
          DC        A(EDT)                                                  00621900
*          'S' ; EDT                                                       00622000
          DC        X(1053)                                                 00622100
          DC        A(EDT)                                                  00622200
*          ':'                                                             00622300
          DC        X(003A)                                                 00622400
*          CR (SNT9A(X(4F))) ; EDT        : INDICATE SYMBOLS STMT          00622500
          DC        X(928D)                                                 00622600
          DC        X(4F06)                                                 00622700
          DC        A(EDT)                                                  00622800
*SN174     'P' ; SN179                    : CHECK FOR SPACE STMT           00622900
SN174     DC        X(1050)                                                 00623000
          DC        A(SN179)                                                00623100
*          'A' ; SYN25                                                     00623200
          DC        X(1041)                                                 00623300
          DC        A(SYN25)                                                00623400
*          'C' ; SYN26                                                     00623500
          DC        X(10C3)                                                 00623600
          DC        A(SYN26)                                                00623700
*          'E' ; SYN27                                                     00623800
          DC        X(10C5)                                                 00623900
          DC        A(SYN27)                                                00624000
*          CR (SNT9A(X(41))) ; EDT        : INDICATE SPACE STMT            00624100
          DC        X(928D)                                                 00624200
          DC        X(4106)                                                 00624300
          DC        A(EDT)                                                  00624400
*SN179     'U' ; SYN51                    : CHECK FOR SUSPEND STMT         00624500
SN179     DC        X(1055)                                                 00624600
          DC        A(SYN51)                                                00624700
*          'S' ; SYN25                                                     00624800
          DC        X(1053)                                                 00624900
          DC        A(SYN25)                                                00625000
*          'P' ; SYN26                                                     00625100
          DC        X(1050)                                                 00625200
          DC        A(SYN26)                                                00625300
*          'E' ; SYN27                                                     00625400
          DC        X(10C5)                                                 00625500
          DC        A(SYN27)                                                00625600
*          'N' ; EDT                                                       00625700
          DC        X(104E)                                                 00625800
          DC        A(EDT)                                                  00625900
*          'D' ; EDT                                                       00626000
          DC        X(1044)                                                 00626100
          DC        A(EDT)                                                  00626200
*          ':'                                                             00626300
          DC        X(003A)                                                 00626400
*          CR (SNT9A(X(50))) ; EDT        : INDICATE SUSPEND STMT          00626500
          DC        X(928D)                                                 00626600
          DC        X(5006)                                                 00626700
          DC        A(EDT)                                                  00626800
*SN187     'F' ; SN196                    : CHECK FOR FTRON                00626900
SN187     DC        X(10C6)                                                 00627000
          DC        A(SN196)                                                00627100
*          'T' ; SYN24                                                     00627200
          DC        X(10D4)                                                 00627300
          DC        A(SYN24)                                                00627400
*          'R' ; SYN25                                                     00627500
          DC        X(10D2)                                                 00627600
          DC        A(SYN25)                                                00627700
*          'O' ; SYN26                                                     00627800
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          DC         X(10CF)                                                  00627900
          DC         A(SYN26)                                                 00628000
*          'N' ; SN193                                                       00628100
          DC         X(104E)                                                  00628200
          DC         A(SN193)                                                 00628300
*          CR (SNT9A(X(53))) ; EDT       : INDICATE FTRON STMT              00628400
          DC         X(928D)                                                  00628500
          DC         X(5306)                                                  00628600
          DC         A(EDT)                                                   00628700
*SN193     'F' ; SYN27                                                       00628800
SN193     DC         X(10C6)                                                  00628900
          DC         A(SYN27)                                                 00629000
*          'F' ; EDT                                                         00629100
          DC         X(10C6)                                                  00629200
          DC         A(EDT)                                                   00629300
*          CR (SNT9A(X(54))) ; EDT       : INDICATE FTROFF STMT             00629400
          DC         X(928D)                                                  00629500
          DC         X(5406)                                                  00629600
          DC         A(EDT)                                                   00629700
*SN196     'T' ; SN132                   : CHECK FOR TRON AND TROFF         00629800
SN196     DC         X(10D4)                                                  00629900
          DC         A(SN132)                                                 00630000
*          'R' ; SN105                                                       00630100
          DC         X(10D2)                                                  00630200
          DC         A(SN105)                                                 00630300
*          'O' ; SYN25                                                       00630400
          DC         X(10CF)                                                  00630500
          DC         A(SYN25)                                                 00630600
*          'N' ; SN202                                                       00630700
          DC         X(104E)                                                  00630800
          DC         A(SN202)                                                 00630900
*          ' ' (SNT6B(X(51))) -> SYN61          : INDICATE TRON STMT        00631000
          DC         X(8AA0)                                                  00631100
          DC         X(5109)                                                  00631200
          DC         A(SYN61)                                                 00631300
*          CR (SNT9A(X(51))) ; SYN27                                         00631400
          DC         X(928D)                                                  00631500
          DC         X(5106)                                                  00631600
          DC         A(SYN27)                                                 00631700
*SN202     'F' ; SYN26                                                       00631800
SN202     DC         X(10C6)                                                  00631900
          DC         A(SYN26)                                                 00632000
*          'F' ; SYN27                                                       00632100
          DC         X(10C6)                                                  00632200
          DC         A(SYN27)                                                 00632300
*          ' ' (SNT6B(X(52))) -> SYN61          : INDICATE TROFF STMT       00632400
          DC         X(8AA0)                                                  00632500
          DC         X(5209)                                                  00632600
          DC         A(SYN61)                                                 00632700
*          CR (SNT9A(X(52))) ; EDT                                           00632800
          DC         X(928D)                                                  00632900
          DC         X(5206)                                                  00633000
          DC         A(EDT)                                                   00633100
*SN206     CR (SNT9A(X(49))) ; SYN27          : INDICATE TYPE STMT          00633200
SN206     DC         X(928D)                                                  00633300
          DC         X(4906)                                                  00633400
          DC         A(SYN27)                                                 00633500
*SN207     '$' ; SN165                                                       00633600
SN207     DC         X(1024)                                                  00633700
          DC         A(SN165)                                                 00633800
*          ' ' ; #5                                                          00633900
          DC         X(04A0)                                                  00634000
*SN209     CR (SNT9A(X(56)))                  : SPECIAL $ STMT              00634100
SN209     DC         X(828D)                                                  00634200
          DC         X(5606)                                                  00634300
*          (SNT5B) -> SN209                                                  00634400
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          DC        X(4808)                                                  00634500
          DC        A(SN209)                                                 00634600
*AEXPS     (AEX1A)                          : INITIALISE POINTERS           00634700
AEXPS     DC        X(400E)                                                  00634800
*AEXP      '+' (AEX2A) -> AEX2              : UNARY PLUS OR MINUS           00634900
AEXP      DC        X(882B)                                                  00635000
          DC        A(AEX2A)                                                 00635100
          DC        A(AEX2)                                                  00635200
*          '-' (AEX2A)                                                      00635300
          DC        X(802D)                                                  00635400
          DC        A(AEX2A)                                                 00635500
*AEX2      'A' ; AEX8                       : ABS                           00635600
AEX2      DC        X(1041)                                                  00635700
          DC        A(AEX8)                                                  00635800
*AEX3      'B' ; AEX6                                                       00635900
AEX3      DC        X(1042)                                                  00636000
          DC        A(AEX6)                                                  00636100
*AEX4      'S' ; AEX30                                                      00636200
AEX4      DC        X(1053)                                                  00636300
          DC        A(AEX30)                                                 00636400
*AEX5      '(' (AEX3A(X(32))) -> AEXP ; AEX31      : FUNCTION BRACKET        00636500
AEX5      DC        X(9A28)                                                  00636600
          DC        X(320F)                                                  00636700
          DC        A(AEX31)                                                 00636800
          DC        A(AEXP)                                                  00636900
*AEX6      'T' ; AEX29                      : ATN                           00637000
AEX6      DC        X(10D4)                                                  00637100
          DC        A(AEX29)                                                 00637200
*AEX7      'N' -> AEX5 ; AEX30                                              00637300
AEX7      DC        X(184E)                                                  00637400
          DC        A(AEX30)                                                 00637500
          DC        A(AEX5)                                                  00637600
*AEX8      'C' ; AEX10                      : COS                           00637700
AEX8      DC        X(10C3)                                                  00637800
          DC        A(AEX10)                                                 00637900
*AEX9      'O' -> AEX4 ; AEX29                                              00638000
AEX9      DC        X(18CF)                                                  00638100
          DC        A(AEX29)                                                 00638200
          DC        A(AEX4)                                                  00638300
*AEX10     'D' ; AEX15                      : DPT                           00638400
AEX10     DC        X(1044)                                                  00638500
          DC        A(AEX15)                                                 00638600
*          'P' ; AEX29                                                      00638700
          DC        X(1050)                                                  00638800
          DC        A(AEX29)                                                 00638900
*          'T' ; AEX30                                                      00639000
          DC        X(10D4)                                                  00639100
          DC        A(AEX30)                                                 00639200
*          '(' (AEX3A(X(32))) ; AEX31      : FUNCTION BRACKET               00639300
          DC        X(9228)                                                  00639400
          DC        X(320F)                                                  00639500
          DC        A(AEX31)                                                 00639600
*          '"' -> AEXP ; AEXP                                               00639700
          DC        X(1822)                                                  00639800
          DC        A(AEXP)                                                  00639900
          DC        A(AEXP)                                                  00640000
*AEX15     'E' ; AEX18                      : EXP                           00640100
AEX15     DC        X(10C5)                                                  00640200
          DC        A(AEX18)                                                 00640300
*AEX16     'X' ; AEX29                                                      00640400
AEX16     DC        X(10D8)                                                  00640500
          DC        A(AEX29)                                                 00640600
*          'P' -> AEX5 ; AEX30                                              00640700
          DC        X(1850)                                                  00640800
          DC        A(AEX30)                                                 00640900
          DC        A(AEX5)                                                  00641000
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*AEX18    'I' ; AEX21                    : INT                          00641100
AEX18     DC        X(10C9)                                             00641200
          DC        A(AEX21)                                            00641300
*AEX19    'N' ; AEX29                                                   00641400
AEX19     DC        X(104E)                                             00641500
          DC        A(AEX29)                                            00641600
*         'T' -> AEX5 ; AEX30                                           00641700
          DC        X(18D4)                                             00641800
          DC        A(AEX30)                                            00641900
          DC        A(AEX5)                                             00642000
*AEX21    'L' ; AEX24                    : LOG                          00642100
AEX21     DC        X(10CC)                                             00642200
          DC        A(AEX24)                                            00642300
*AEX22    'O' ; AEX29                                                   00642400
AEX22     DC        X(10CF)                                             00642500
          DC        A(AEX29)                                            00642600
*         'G' -> AEX5 ; AEX30                                           00642700
          DC        X(1847)                                             00642800
          DC        A(AEX30)                                            00642900
          DC        A(AEX5)                                             00643000
*AEX24    'S' ; AEX28                    : SIN                          00643100
AEX24     DC        X(1053)                                             00643200
          DC        A(AEX28)                                            00643300
*AEX25    'I' -> AEX7                                                   00643400
AEX25     DC        X(08C9)                                             00643500
          DC        A(AEX7)                                             00643600
*         'Q' ; AEX29                    : SQR                          00643700
          DC        X(10D1)                                             00643800
          DC        A(AEX29)                                            00643900
*         'R' -> AEX5 ; AEX30                                           00644000
          DC        X(18D2)                                             00644100
          DC        A(AEX30)                                            00644200
          DC        A(AEX5)                                             00644300
*AEX28    (AEX4A) ; AEX41                : ALPHABETIC CHARACTER         00644400
AEX28     DC        X(5010)                                             00644500
          DC        A(AEX41)                                            00644600
*AEX29    (AEX5A) ; AEX40                : ALPHANUMERIC CHARACTER       00644700
AEX29     DC        X(5011)                                             00644800
          DC        A(AEX40)                                            00644900
*AEX30    (AEX5A) ; AEX40                : ALPHANUMERIC CHARACTER       00645000
AEX30     DC        X(5011)                                             00645100
          DC        A(AEX40)                                            00645200
*AEX31    (AEX5A)                        : ALPHANUMERIC CHARACTER       00645300
AEX31     DC        X(4011)                                             00645400
*AEX32    ASSIGN (AEX7A) -> AEXP         : ASSIGNMENT ARROW             00645500
AEX32     DC        X(885F)                                             00645600
          DC        A(AEX7A)                                            00645700
          DC        A(AEXP)                                             00645800
*AEX33    ')' (AEX8A) -> AEX33           : AEX32 IS FORPTR FOR SUBS VBLE00645900
AEX33     DC        X(88A9)                                             00646000
          DC        A(AEX8A)                                            00646100
          DC        A(AEX33)                                            00646200
*         ',' (AEX9A) -> AEXP            : COMMA IN SUBSCRIPTED VARIABLE 00646300
          DC        X(88AC)                                             00646400
          DC        A(AEX9A)                                            00646500
          DC        A(AEXP)                                             00646600
*         '+' (AEX2A) -> AEX2                                           00646700
          DC        X(882B)                                             00646800
          DC        A(AEX2A)                                            00646900
          DC        A(AEX2)                                             00647000
*         '-' (AEX2A) -> AEX2                                           00647100
          DC        X(882D)                                             00647200
          DC        A(AEX2A)                                            00647300
          DC        A(AEX2)                                             00647400
*         '*' (AEX2A) -> AEX2                                           00647500
          DC        X(88AA)                                             00647600
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          DC        A(AEX2A)                                                    00647700
          DC        A(AEX2)                                                     00647800
*          '/' (AEX2A) -> AEX2                                                  00647900
          DC        X(88AF)                                                     00648000
          DC        A(AEX2A)                                                    00648100
          DC        A(AEX2)                                                     00648200
*          UPARROW (AEX2A) -> AEX2                                             00648300
          DC        X(88DE)                                                     00648400
          DC        A(AEX2A)                                                    00648500
          DC        A(AEX2)                                                     00648600
*          '<' -> EDIT1                  : CHECK FOR EDIT CHARACTER            00648700
          DC        X(083C)                                                     00648800
          DC        A(EDIT1)                                                    00648900
*          (AEX2B) ; RETURN              : RETURN IF ZERO BRACKET LEVEL        00649000
          DC        X(6014)                                                     00649100
*AEX40     '(' (AEX6A(X(31))) -> AEXP ; AEX32  : SUBS VBLE BRACKET             00649200
AEX40     DC        X(9A28)                                                     00649300
          DC        X(3112)                                                     00649400
          DC        A(AEX32)                                                    00649500
          DC        A(AEXP)                                                     00649600
*AEX41     '(' (AEX3A(X(30))) -> AEXP    : NORMAL OPENING BRACKET              00649700
AEX41     DC        X(8A28)                                                     00649800
          DC        X(300F)                                                     00649900
          DC        A(AEXP)                                                     00650000
*          (AEX1B) ; AEX51               : DECIMAL NUMBER                      00650100
          DC        X(5013)                                                     00650200
          DC        A(AEX51)                                                    00650300
*AEX43     (AEX1B) -> AEX43              : DECIMAL NUMBER                      00650400
AEX43     DC        X(4813)                                                     00650500
          DC        A(AEX43)                                                    00650600
*          '.' ; AEX46                                                         00650700
          DC        X(102E)                                                     00650800
          DC        A(AEX46)                                                    00650900
*AEX45     (AEX1B) -> AEX45              : DECIMAL NUMBER                      00651000
AEX45     DC        X(4813)                                                     00651100
          DC        A(AEX45)                                                    00651200
*AEX46     'E' ; AEX33                   : EXPONENT SYMBOL                     00651300
AEX46     DC        X(10C5)                                                     00651400
          DC        A(AEX33)                                                    00651500
*          '+' (SNT5B(X(39))) -> AEX49   : EXPONENT PLUS                       00651600
          DC        X(8A2B)                                                     00651700
          DC        X(3908)                                                     00651800
          DC        A(AEX49)                                                    00651900
*          '-' (SNT5B(X(3A)))            : EXPONENT MINUS                      00652000
          DC        X(822D)                                                     00652100
          DC        X(3A08)                                                     00652200
*AEX49     (AEX1B) ; EDT                 : DECIMAL NUMBER IN EXPONENT          00652300
AEX49     DC        X(5013)                                                     00652400
          DC        A(EDT)                                                      00652500
*          (AEX1B) -> AEX33 ; AEX33      : 2ND DIGIT IN EXPONENT               00652600
          DC        X(5813)                                                     00652700
          DC        A(AEX33)                                                    00652800
          DC        A(AEX33)                                                    00652900
*AEX51     '.' ; EDT                                                           00653000
AEX51     DC        X(102E)                                                     00653100
          DC        A(EDT)                                                      00653200
*          (AEX1B) -> AEX45              : DECIMAL NUMBER                      00653300
          DC        X(4813)                                                     00653400
          DC        A(AEX45)                                                    00653500
*EDT       '<' ; #1                                                            00653600
EDT       DC        X(043C)                                                     00653700
*EDIT1     '<' ; EDIT4                                                         00653800
EDIT1     DC        X(103C)                                                     00653900
          DC        A(EDIT4)                                                    00654000
*EDIT2     '<' (EDT1A)                                                         00654100
EDIT2     DC        X(803C)                                                     00654200
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          DC        A(EDT1A)                                                00654300
*          CR (EDT2A) ; #2                                                 00654400
          DC        X(848D)                                                 00654500
          DC        A(EDT2A)                                                00654600
*EDIT4     (EDT3A) ; #3                 : NONZERO DIGIT.LT.INPUT CHARS     00654700
EDIT4     DC        X(440B)                                                 00654800
*          (EDT4A)                      : DIGIT WITH SUM.LT.INPUT CHARS    00654900
          DC        X(400C)                                                 00655000
*          CR (EDT5A) ; #4              : DELETE CHARACTERS AND RETYPE     00655100
          DC        X(848D)                                                 00655200
          DC        A(EDT5A)                                                00655300
*AEX53     (AEX1A) ; AEX43                                                 00655400
AEX53     DC        X(500E)                                                 00655500
          DC        A(AEX43)                                                00655600
*AEX54     (AEX1A) ; AEX29                                                 00655700
AEX54     DC        X(500E)                                                 00655800
          DC        A(AEX29)                                                00655900
*AEX55     (AEX1A) ; AEX30                                                 00656000
AEX55     DC        X(500E)                                                 00656100
          DC        A(AEX30)                                                00656200
*AEX56     (AEX1A) ; AEX31                                                 00656300
AEX56     DC        X(500E)                                                 00656400
          DC        A(AEX31)                                                00656500
*AEX57     (AEX1A) ; AEX32                                                 00656600
AEX57     DC        X(500E)                                                 00656700
          DC        A(AEX32)                                                00656800
*AEX58     (AEX1A) ; AEX16                                                 00656900
AEX58     DC        X(500E)                                                 00657000
          DC        A(AEX16)                                                00657100
*AEX59     (AEX1A) ; AEX19                                                 00657200
AEX59     DC        X(500E)                                                 00657300
          DC        A(AEX19)                                                00657400
*AEX60     (AEX1A) ; AEX25                                                 00657500
AEX60     DC        X(500E)                                                 00657600
          DC        A(AEX25)                                                00657700
*AEX61     (AEX1A) ; AEX9                                                  00657800
AEX61     DC        X(500E)                                                 00657900
          DC        A(AEX9)                                                 00658000
*AEX62     (AEX1A) ; AEX4                                                  00658100
AEX62     DC        X(500E)                                                 00658200
          DC        A(AEX4)                                                 00658300
*AEX63     (AEX1A) ; AEX3                                                  00658400
AEX63     DC        X(500E)                                                 00658500
          DC        A(AEX3)                                                 00658600
*AEX64     (AEX1A) ; AEX22                                                 00658700
AEX64     DC        X(500E)                                                 00658800
          DC        A(AEX22)                                                00658900
ACTBL     DC        A(SNT2A)                                                00659000
          DC        A(SNT4A)                                                00659100
          DC        A(SNT5A)                                                00659200
          DC        A(SNT7A)                                                00659300
          DC        A(SNT8A)                                                00659400
          DC        A(SNT9A)                                                00659500
          DC        A(SNT4B)                                                00659600
          DC        A(SNT5B)                                                00659700
          DC        A(SNT6B)                                                00659800
          DC        A(SNT9B)                                                00659900
          DC        A(EDT3A)                                                00660000
          DC        A(EDT4A)                                                00660100
          DC        A(SNT2C)                                                00660200
          DC        A(AEX1A)                                                00660300
          DC        A(AEX3A)                                                00660400
          DC        A(AEX4A)                                                00660500
          DC        A(AEX5A)                                                00660600
          DC        A(AEX6A)                                                00660700
          DC        A(AEX1B)                                                00660800
          DC        A(AEX2B)                                                00660900
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