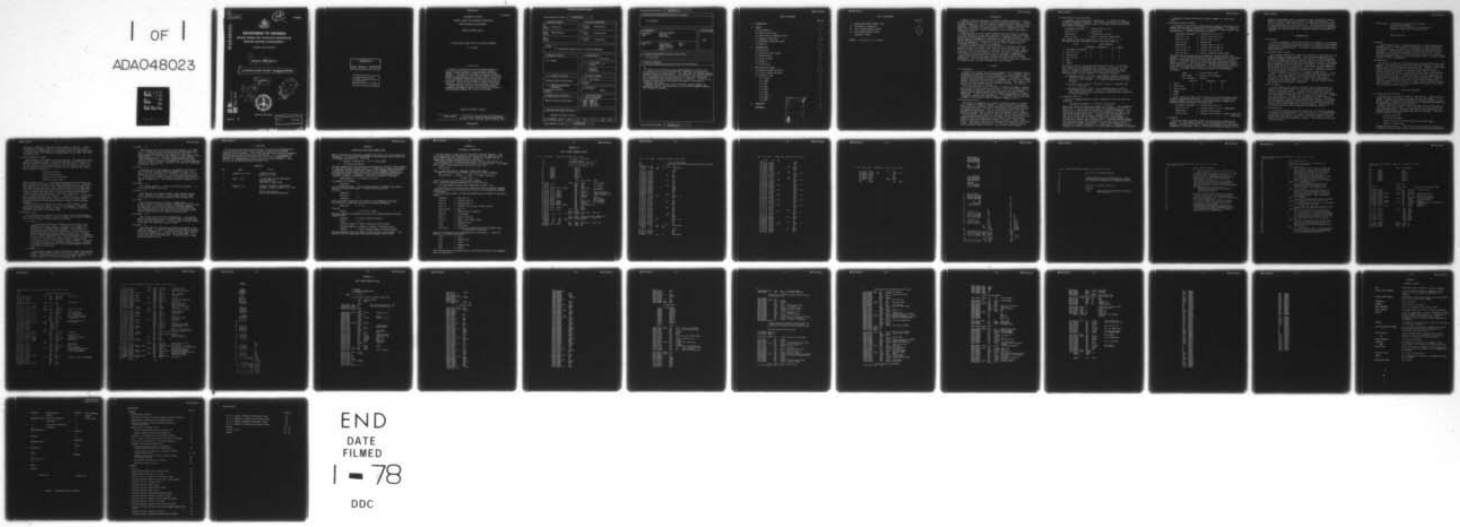
AD-A048 023 WEAPONS RESEARCH ESTABLISHMENT SALISBURY (AUSTRALIA) F/G 9/2
A FINITE-STATE PARSER FOR PDP-11 AND NOVA COMPUTERS.(U)
JUL 77 G S BRIMBLE

UNCLASSIFIED WRE-TR-1842(A) NL

1 OF 1
ADA048023



END
DATE FILMED
1 - 78
DDC

WRE-TR-1842 (A)

AR-000-600

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

WEAPONS RESEARCH ESTABLISHMENT

SALISBURY, SOUTH AUSTRALIA

TECHNICAL REPORT 1842 (A)

A FINITE-STATE PARSER FOR PDP-11 AND NOVA COMPUTERS

G.S. BRIMBLE

Jul 77

13p.

Approved for Public Release

JULY 1977

AR-000-600

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

WEAPONS RESEARCH ESTABLISHMENT

TECHNICAL REPORT 1842(A)

A FINITE-STATE PARSER FOR PDP-11 AND NOVA COMPUTERS

G.S. Brimble

S U M M A R Y

A method is described for creating computer programs to analyse text for compliance with a specified structure; examples of such programs are command decoders and format checkers. The paper shows how analysis programs are easily produced by constructing a table directly from a specification of the intended data format and presenting this as input to a non-specific parser subroutine which has been written and is described. Facilities are included to execute user-written subroutines when key structures are recognised in the input.

Programs have been written in PDP-11 and NOVA assembly language to implement the parser, and instructions for use of these programs, examples and listings are included.

POSTAL ADDRESS: The Director, Weapons Research Establishment, Box 2151, G.P.O., Adelaide, South Australia, 5001

DOCUMENT CONTROL DATA SHEET

Security classification of this page: UNCLASSIFIED

1 DOCUMENT NUMBERS

AR Number: AR-000-600

Report Number: WRE-TR-1842(A)

Other Numbers:

2 SECURITY CLASSIFICATION

a. Complete Document: Unclassified

b. Title in Isolation: Unclassified

c. Summary in Isolation: Unclassified

3 TITLE

A FINITE-STATE PARSER FOR PDP-11 AND NOVA COMPUTERS

4 PERSONAL AUTHOR(S):

G.S. Brimble

5 DOCUMENT DATE:

July 1977

6 6.1 TOTAL NUMBER OF PAGES: 38

6.2 NUMBER OF REFERENCES: 4

7 7.1 CORPORATE AUTHOR(S):

Weapons Research Establishment

7.2 DOCUMENT (WING) SERIES AND NUMBER

Applied Physics Wing
TR-1842

8 REFERENCE NUMBERS

a. Task: DST 76/190

b. Sponsoring Agency:

9 COST CODE: 185256

10 IMPRINT (Publishing establishment):

Weapons Research Establishment

11 COMPUTER PROGRAM(S) (Title(s) and language(s))

TESTP - MACRO 11
PARSE - MACRO 11
TESTP - NOVA ASS.L.
PARSE - NOVA ASS.L.

12 RELEASE LIMITATIONS (of the document):

Approved for public release

12.0	OVERSEAS	NO		P.R.	1	A		B		C		D		E	

Security classification of this page: UNCLASSIFIED

Security classification of this page: UNCLASSIFIED

13 ANNOUNCEMENT LIMITATIONS (of the information on these pages):

No limitation

14 DESCRIPTORS:

a. EJC Thesaurus Terms: computer programs; analyzing; subroutines

b. Non-Thesaurus Terms: text analysis; command decoders; format checkers; parsers; PDP-11; NOVA

15 COSATI CODES:

0902

16 LIBRARY LOCATION CODES (for libraries listed in the distribution):

SW SD SR AACA

17 SUMMARY OR ABSTRACT:
(if this is security classified, the announcement of this report will be similarly classified)

A method is described for creating computer programs to analyse text for compliance with a specified structure; examples of such programs are command decoders and format checkers. The paper shows how analysis programs are easily produced by constructing a table directly from a specification of the intended data format and presenting this as input to a non-specific parser subroutine which has been written and is described. Facilities are included to execute user-written subroutines when key structures are recognized in the input.

Programs have been written in PDP-11 and NOVA assembly language to implement the parser, and instructions for use of these programs, examples and listings are included.

Security classification of this page: UNCLASSIFIED

TABLE OF CONTENTS

LIST OF APPENDICES

FIGURE 1. Evolution of list structure

1. INTRODUCTION

A commonly occurring requirement in assembly language programming is analysis of input text strings to implement activities described by that input. Examples are typed commands to a real-time program or mnemonic-encoded instructions to an assembler. Programmers tend to solve this problem by writing a decoder routine specifically tailored to the expected format; if it is permissible in the application, the format is usually compressed to be as cryptic as possible to simplify this task.

Another solution is to use a general-purpose decoder routine which operates on a coded description of the format expected in the data to detect the presence of salient structures and direct implementation of appropriate actions. This method allows the programmer to concentrate on the description of the data format and the execution of the actions invoked by the input, and results in easier writing and debugging. In addition, a rich and natural command format is encouraged and expansion is easy to accommodate.

The code produced by using a table-driven parser is often very similar in execution to an ad hoc decoder, while being far easier to understand. The features included in the parser can be tailored to suit the size and complexity of the job; whilst some overhead is inevitable, for large or complex formats the efficiency of the code produced by the two techniques is comparable.

The routines described here were originally developed to decode keyboard commands on a real-time data logger and have since been used for text format verification. They are principally designed to recognize structures encountered in command strings, but other structures are easily included.

2. THEORY

2.1 Preliminaries

A good way to describe an artificial language of the kind commonly used in computing is by a phrase-structure grammar(ref.1). This technique consists of grouping together basic structural elements to form more complex items, which in turn are grouped to build up the language. An example is a natural language like English, where letters are grouped to form words, words to make phrases, clauses etc. and these parts to make sentences. The grammar is the set of rules which defines how such combinations are made, i.e. the rules describe the syntax of the language.

It is also necessary to use a language to describe the grammar; some way must be found to set out the rules of syntax. This can be done in English, but problems of inexactness of meaning arise with such a rich language. A simpler and more formal language (a meta-language) is preferable for such description. Backus-Naur Form (BNF) is a meta-language which was developed to describe syntactic rules unambiguously. A form of BNF will be used here; a summary of the elements of BNF is included in Appendix I(ref.2).

2.2 Table-driven parsers

The process of examining a data sample to determine whether it conforms with a particular grammar is parsing. A simple strategy for designing a parser program is to develop a table which directs a set of general routines to carry out the parse; the table is constructed from the syntax rules of the grammar being analysed. This is a table-driven parser; the table specifies the transitions or changes which occur between states or elements within the grammar. The table is a transition table or state table(ref.3).

The parsing procedure consists of starting at the top or head state of the transition table and comparing the first element of the input with the syntactic types which identify the columns in the table. Where a match occurs, a transition is specified by a pointer in the table to the next state or row. This process continues until a transition is found to a special state indicating success or failure. This is best seen by example.

2.3 Constructing a transition table

A language is described below in BNF(ref.3). It consists of simple arithmetic assignment statements. The elements which make up the language are the meta-components <letter>, <null>, =, and <operator> as defined from basic objects in Appendix I.

<assignment statement> :: = <letter> <rest of a.s.>

<rest of a.s.> :: = <expression>

<expression> :: = <letter> <rest of exp.>

<rest of exp.> :: = <null> | <operator> <expression>

This grammar allows such constructs as A = B + C and D = A * G - D. The transition table constructed directly from this grammar is:

State	Meta component			
	<letter>	<operator>	=	<null>
1. <assignment statement>	2	5	5	5
2. <rest of a.s.>	5	5	3	5
3. <expression>	4	5	5	5
4. <rest of exp.>	5	3	5	6

5. ERROR

6. SUCCESS

The table is built by considering each definition in turn. If the first meta-component on the right-hand side is found, the second must be found next so it becomes the target for the next stage of the parse; thus a pointer is entered in the table, specifying a transition to that state. The parse process for the statement A = B proceeds as follows:

(a) Entering at state 1, the first input element A matches <letter> and a transition occurs to state 2. Anything which did not start with a letter, e.g. the statement - B = C, would be another object and fail the parse.

(b) In state 2, the = causes a transition to state 3; statements like A + B = C would fail.

(c) B matches <letter> in state 3 and a transition occurs to state 4 where <null> causes success. Here A = BC would fail, but A = B + C would proceed because the + would match an <operator> and a transition to state 3 would occur.

2.4 Language restriction

The above language definition could be simplified if the first state was changed to:

<assignment statement> ::= <letter> = <expression>

However the transition table cannot handle this structure. The intermediate state <rest of a.s.> was necessary so that in the right-hand side of the definition, a single object is followed by a single meta-component. This ensures that at any stage in the parse no backtracking is necessary if the route being followed fails(ref.3). Parsing is then fast and efficient at the cost of restricting the range of grammars which can be handled. Application of this rule will produce a right linear regular grammar, i.e. a finite state (Chomsky type 3) grammar(ref.1). Simple precedence languages are produced by finite state grammars(ref.3) and these ensure a unique parse tree through the grammar for any input. Every finite language can be generated by a regular grammar(ref.1), and the majority of languages used in computing are finite (i.e. consist of a finite number of combination of elements).

A program to analyse according to a regular grammar is a finite-state parser.

2.5 Subsidiary transition tables

A situation can occur where a particular meta-component constructed in the grammar could be used as a pseudo-object within the grammar. An example of this occurs if the example of Section 2.3 is modified to require three letter variable names. Then the BNF definition becomes:

```
<assignment statement> ::= <letter> <rest of a.s.1>
<rest of a.s.1>        ::= <letter> <rest of a.s.2>
<rest of a.s.2>        ::= <letter> <rest of a.s>
<rest of a.s.>         ::= <expression>
<expression>           ::= <letter> <rest of exp. 1>
<rest of exp. 1>       ::= <letter> <rest of exp. 2>
<rest of exp. 2>       ::= <letter> <rest of exp.>
<rest of exp.>         ::= <null> | <operator> <expression>
```

The same kind of structure has been invoked each time the variable name appears. It would be more efficient to define a pseudo-object in a subsidiary transition table which can then be used in the main table as if it were an object. A successful parse in the subsidiary table would be equivalent to matching the object. The effect of the subexpression structure is similar to the subroutine concept in programming. The BNF definition and transition tables for the example would consist of a main table and definition as in Section 2.3, but with <letter> replaced by <name>, and the subsidiary structures:

```
<name>         ::= <letter> <more name>
<more name>    ::= <letter> <rest of name>
<rest of name> ::= <letter>
```

	<letter>	=	<operator>	<null>
1. <name>	2	5	5	5
2. <more name>	3	5	5	5
3. <rest of name>	4	5	5	5
4. RETURN				
5. ERROR				

In this particular example another solution could have been found without using the subexpression structure. If the definition of a variable name could be changed to be one or more letters unrestricted in length, then powerful recursive definitions can be used thus:

```
<assignment statement> ::= <letter> <rest of a.s.>
<rest of a.s.>         ::= <letter> <rest of a.s> | = <expression>
<expression>           ::= <letter> <rest of exp.>
<rest of exp.>         ::= <letter> <rest of exp.> | <null> | <operator>
                                                     <expression>
```

2.6 Semantics

The parser merely determines whether or not the input is syntactically correct. Its only output is logical - the sentence parsed or it did not. Normally, the input is intended to trigger some operation within the program depending on its content; that is, the input has meaning or semantics in the

context of the program, and it is examined in order to decode the semantics. Semantic structure is much more difficult to formalise and describe. However, in a practical table-driven parser, it is possible to allow execution of subroutines each time a transition occurs. This permits the programmer to execute code in his program at key points during the parse when particular structures are recognized, and this is generally adequate for implementing semantics.

3. IMPLEMENTATION

3.1 Discussion

In order to implement a finite-state parser on a computer, it is necessary to have a set of routines each of which recognizes one object of the language, a formalism for storing the transition table and an executive to direct the matching and transition process. In practice, some extensions permit greater efficiency(ref.4).

3.2 Transition table storage

The transition table will be stored in a computer as a list because of the sequential nature of computer memory. This is easily accomplished and a number of redundant transitions removed, by altering the table construction. A list can be made consisting of a series of cells, one for each transition. The first entry of each cell names the meta-component or object to be matched and is equivalent to the column heading in the table; the next entry points to the target state for the transition. Furthermore, all meta-components which are not allowed in a particular state, i.e. will produce an error, can be designated by the pseudo-object <anything else>. Then the transition table for the example of Section 2.3 is as shown in figure 1(a).

Normally symbolic labels are used in assembly language, and thus as state pointers. The object <anything else> always points to the ERROR exit so this cell can be contracted to a single "end of state" code which is recognized by the parser executive. The final list for the example is smaller than the original table (figure 1(b)). When many objects exist in the language the improvement is substantial.

3.3 Pseudo-objects

In most computing applications, structures like words and numbers are needed as basic elements along with individual ASCII characters like key letters or punctuation marks. Conceptually these applications can be satisfied by defining the entire character set as objects and constructing words and numbers in subsidiary tables as explained in Section 2.5. However, it is more efficient to include words and numbers as pseudo-objects by providing routines in the parser to recognize them directly. The objects which this parser recognizes include the individual characters of the ASCII set, any arbitrary character, specific words of any length, any arbitrary letter string, integer numbers, and end-of-line marks. Other objects can be added by users who write the appropriate recognition routines.

3.4 Action routines

A facility to execute user-written subroutines is provided by expanding the cell in the transition table to include a pointer to a subroutine which is executed if the transition is taken. The parser includes a null subroutine which does nothing; then in those transitions where no action is needed a pointer to this subroutine is placed. Then the cell of the transition table list is:

```
                    :
(state label:)  code indicating type of object to match
                (any trailing arguments)
                pointer to action subroutine if match succeeds
                pointer to target state if match succeeds
                    :
                end of state code
                    :
```

3.5 Defaults

A useful feature arises if another pseudo-object is defined which always succeeds so that its action routine and transition are always implemented. Its usefulness lies in its ability to allow defaults in the input string. For example, a command structure might be decoded to determine user-entered parameters; if a particular parameter is missing, the test for it would fail but by following this with the matching object the parse can proceed to the next parameter, leaving an initialised default value. A specific example of this is set out in Appendix II.

3.6 Construction

The parser is written as a subroutine which is called from the user's main program. The objects or syntactic types which are recognized are defined as numeric codes for constructing the transition table. Pointers to this table and the text string to be analysed are passed in the subroutine call. Analysis proceeds in the parser by using the object codes to vector to a routine to match that object; if the match occurs a success return executes the action subroutine for the transition, then selects the target state to find the next object code. If the match fails, a failure return skips the action routine and target pointers to select the object from the following transition. If the end-of-state code is found, control returns to the calling program with an error code; if a success state is entered, a success code is returned. If the parse failed a pointer to the place in the input where failure occurred is available.

4. HOW TO USE THE PARSER

4.1 Calling sequence for PDP-11

The subroutine call 'JSR PC, PARSE' initiates parsing. Register RØ will contain the result of the parse on return - RØ = Ø if successful, = -2 if failed. Registers R3 to R6 are unaffected by the parse, although one word of stack space is temporarily used for each level of subexpression evaluation. The parser returns to the caller by 'RTS PC'.

When the call occurs, R1 must point to the first byte in a byte array of 7-bit ASCII text to be analysed. If the parse fails, R1 will point to the first unrecognized byte. Register R2 must point to the head state of the transition table defining the grammar which the text must obey. The cells of this table have the format

```
syntactic type code
any trailing arguments
address of action subroutine (pointer for indirect jump)
address of target state
```

The end-of state code is -1. The address of the "do nothing" subroutine is available by using the symbol "NULL." The parser executes action subroutines

by 'JSR PC, @ POINTER' so they must resume the parse by 'RTS PC'. Action subroutines must preserve registers R1 and R2 and tidy the stack if used.

The parser is assembled into its own program section to avoid symbol clash. The symbols 'NULL.' and 'PARSE' are declared global, as are 'NUM.' and 'CHAR.' (see Section 4.3).

4.2 Calling sequence for NOVA

The instruction 'JSR PARSE' will initiate parsing. This passes the return address to the parser in AC3. Accumulator AC1 must hold a word pointer to the text string to be analysed, stored as 7 bit ASCII bytes in .TXTM 1, i.e. the first character in the top byte (MSB's) then the second in the low byte. AC2 must contain a pointer to the head state of the transition table which has the format for each cell

syntactic type code

any trailing arguments

address of action subroutine

address of target state

The end-of-state code is -1. The user must define page zero locations for CHAR. and NUM. and the mask variable IDMSK containing 377 octal. The parser uses locations 20, 21 and 30. Auto increment register 20 is assigned the label STPT by the parser and is used to hold the pointer to the state table; 21 is TXPT and points to the text string word by word, and 30 is STACK and indexes a 10-word stack which allows 5 levels of nesting of subexpressions.

After parsing, AC0 carries back a result code to the caller. If a successful parse occurred, AC0 = 0; if it failed, AC0 = -1. If the parse fails, the page zero register 21 (TXPT) is pointing to the word containing the byte which caused the failure, except that if the first byte in the string fails TXPT will point one word before it because of auto increment management.

Action routines are called as subroutines via 'JSR @ POINTER' so they must resume the parse by 'JMP 0, 3' or similar arrangement. No other accumulators need preservation by routines. The 'do-nothing' subroutine provided by the parser is at address 'NULL.'.

4.3 Syntactic types

The following entries indicate the octal number code for each syntactic type with the symbols assigned to them by the parser in definition statements, plus a brief description of the objects they represent.

4.3.1 ALPH. = 1

This matches all following alphabetic characters until a non-alphabetic character is found. It amounts to an "ignore text" specification, allowing optional extensions on key symbols, etc. The entry has a trailing one-word argument. The low byte is a maximum byte count to limit the amount of text to be ignored, with 0 corresponding to the largest limit (256 characters). The high byte is a flag indicating whether spaces and tabs count as alphabetic or non-alphabetic characters; flag = 0 if the former, 1 if the latter. If flag = 1, the match will cease if a space or tab is found. This type only fails if the character count is exceeded. Note that it succeeds if there are no alphabetic characters, since its effect is to push the text pointer on to the next non-alphabetic character, which can be the next byte.

4.3.2 NUMB. = 2

This matches a decimal integer whose value is stored in the parser-defined location 'NUM.' (global) in a PDP-11 or 'NUM.' (page zero) in a NOVA. Conversion stops at the first non-numeric character. It always succeeds - if no numerals are present, NUM. = 0.

4.3.3 KEY. = 3

Key words are one or more specific ASCII characters, e.g. "NAME" or "*". These follow the type specification in the transition table as trailing arguments, and terminate with a null byte. The NOVA assembler will correctly store them if in .TXTM 1 mode the .TXT pseudo-operator is used. The PDP-11 MACRO assembler provides a .ASCIZ pseudo-operator; the .EVEN pseudo-operator must be used after the string to return to word boundaries. For single character keywords, a literal argument is possible - for PDP-11 use '.BYTE 'X,Ø' and for NOVA '256.*"X'.

4.3.4 EOF. = 4

Equivalent to the null operator in the examples of Section 2.3, this matches ESC, ALT MODE, FORM FEED, RUBOUT, CR codes. On a PDP-11, if a CR is found and it is trailed by a LF, the LF is also matched and the text pointer will indicate the character after the LF. The particular terminator found is available to the action subroutine in register R3. In a NOVA the particular character is in ACØ.

4.3.5 MTCH. = 5

This always succeeds. It does not move the text pointer. It forces action and/or a new state.

4.3.6 ANY. = 6

This puts the next character into the parser-defined location 'CHAR.' (global) on a PDP-11 or 'CHAR.' (page zero) on a NOVA. It succeeds for all characters except EOF (14) or rubout (377).

4.3.7 SUBX. = 7

This code asks the parser to match a subexpression, i.e. to attempt to match a structure defined by a subsidiary transition table. The type entry is followed by a single word trailing argument containing the address of the head state of the subsidiary table. This subexpression state table must contain a state with the type 'ENDX.' as the success exit to return to the main table.

4.3.8 ENDX. = 1Ø

This is the success exit from a subexpression. It causes the parser to carry out the success action and target in the transition which called the subexpression. It has no action or target entries of its own in the subsidiary transition table.

4.3.9 END. = Ø

This type indicates successful parse and must be present in the transition table. It cannot be included in a subsidiary transition table for a subexpression. It causes the parser to return control to the user's program with the success code in RØ or ACØ. It is the only exit for a successful parse. It has no action or target entries associated with it.

5. CONCLUSION

It has been found in practice that programs can be written and debugged more easily and faster using the structure described, compared with individual algorithms for text decoding. The routines described and listed in the appendices have been used and found to match their descriptions. It is recommended that consideration should be given to using them in any text or command handling routines, or to implementing a similar structure for special purposes. Their use can save considerable program development time.

REFERENCES

No.	Author	Title
1	Cardenas, A.F. et al	"Computer Science". Wiley (N.Y.), 1972.
2	Naur, P. (ed.)	"Revised Report on the Algorithmic Language ALGOL 68" Comm. ACM 6, January 1963
3	Maginnis, J.B.	"Elements of Compiler Construction" Appleton - Century - Crofts (N.Y.), 1972
4	-	"TPARS Users Manual". RSX-11D V6A System Release Notes.

APPENDIX I

BACKUS-NAUR FORM (BACKUS NORMAL FORM)

BNF is a formalism for describing languages which consists of a set of definition statements. It contains two metalinguistic connectives which cannot be part of the language being described. These are

::= meaning "is defined by"; it is a single symbol

| the logical OR operator

The other components of the formalism are metalinguistic variables, being sequences of characters enclosed in angle brackets < > having symbolic meaning, and objects or marks which are basic undefinable elements of the language being described. Juxtaposition of marks and/or variables in a formula signifies juxtaposition of the sequences denoted. Statements in BNF consist of concatenation of meta-linguistic variables, metalinguistic connectives and objects in the form

<metacomponent> ::= <variable> <variable> .....

For example, the statement

<operator> ::= +

is a valid BNF definition. The variable <operator> is defined as the symbol + which is an object ("plus sign" - it cannot itself be defined).
Similarly

<operator> ::= -

<operator> ::= *

<operator> ::= /

define alternative meanings of the variable or meta-component <operator>.
This definition is made more convenient by using the OR operator

<operator> ::= +| -| *| /

Similarly

<digit> ::= 1| 2| 3| 4| 5| 6| 7| 8| 9| Ø

Then more powerful meta-components are built up by combining objects and meta-components thus:

<integer> ::= <digit> | <digit> <integer>

<sign> ::= +| -

<fractional part> ::= <digit> | <fractional part> <digit>

<unsigned number> ::= <integer> | <integer> .<fractional part>

<number> ::= <sign> <unsigned number> | <unsigned number>

The meta-components <null> and <empty> signify the null set of symbols. In a practical line-structured input they would correspond to end of line.

APPENDIX II

AN EXAMPLE OF PARSER USE

The same example is coded below for both PDP-11 and NOVA computers. The PDP-11 program uses RSX-11D operating system directives for input and output, and the NOVA program uses RTOS directives; however both should still be comprehensible without understanding these directives.

The example decodes a command string typical of an RSX system command (it requests creation of a User File Directory entry on a storage unit). The command has a mandatory format specifying a device and a user code

UFD_XX:[N,N]

where _ represents space, X represents letters and N digits.

A number of options can be included, and these are shown in brackets

UFD_XX(N):(XX.....)[N(NN.....), N(NN.....)](/PRO = [R,R,R,R])
(/ALLOC = NN.....)

where R represents any combination of <null> | R| W| E| D
Thus a legitimate command incorporating all options would be

UFD_DK1:SCRATCH [200,200] /PRO = [RWED, RW,,R] /ALLOC = 300

Action routines are not shown in the examples but would be assembly language subprograms to cause the system executive to carry out the operations specified by the command.

The finite-state grammar, in BNF using pseudo-objects available in the parser, follows:

<command> ::= UFD_<next 1>
<next 1> ::= <letter> <next 2>
<next 2> ::= <letter> <next 3>
<next 3> ::= <number> <device term.> | <device term.>
<device term.> ::= :<next 4>
<next 4> ::= <word> <next 5> | <next 5>
<next 5> ::= <uic> <opts>
<opts> ::= <null> | /<next 6>
<next 6> ::= ALLOC = <a|c> | PRO = <pro>
<a|c> ::= <number> <opts>
<pro> ::= [<rest pro>
<rest pro> ::=]<opts> | ,<rest pro> | R <rest pro> | W <rest pro> |
E <rest pro> | D <rest pro>

Here <uic> has been used as a pseudo-object for illustration. It must be defined in a subsidiary definition.

<uic> ::= [<u1>
<u1> ::= <number> <u2>
<u2> ::= ,<u3>
<u3> ::= <number> <u4>
<u4> ::=]<null>

These definitions are translated directly into transition tables in the examples whose listings follow

APPENDIX III

PDP-11 PARSER PROGRAM LISTING

```
TESTP - TEST PARSER     MACRO 01013  24-AUG-77 12:30  PAGE 1

                                        .TITLE TESTP - TEST PARSER
                                        ;
                                        ;G. CRIMBLE 30/9/76
                                        ;MODIFIED TO NEW TYPE SYMBOLS 26/1/77
                                        ;
                                        ; WILL LINK TO PARSER.OBJ AT TKB
                                        ;
 000000                                         END.=0
 000001                                         ALPH.=1
 000002                                         NUMB.=2
 000003                                         KEY.=3
 000004                                         EOF.=4
 000005                                         MTCH.=5
 000006                                         ANY.=6
 000007                                         SUBX.=7
 000010                                         ENDX.=10
                                        ;
                                                .MCALL  EXIT$S  DIR$    QIOW$
                                        ;
000000                                  TESTP:  DIR$    #PRMPT          ;INDICATE READY
000006  103774                                 BCS     TESTP
000010                                          DIR$    #CML            ;GET COMMAND
000016  103770                                  BCS     TESTP
000020  026727  000240  000000G                 CMP     IOST,#IE.EOF    ;IS IT CTRL-Z?
000026  001441                                  BEQ     EXIT            ;THEN FINISH
000030  016701  000232                          MOV     IOST+2,R1
000034  062701  000270'                         ADD     #CMB,R1         ;POINT TO LAST BYTE
000040  116711  000221                          MOVB    IOST+1,(R1)     ;STORE TERMINATING CHAR
000044  012701  000270'                         MOV     #CMB,R1         ;PREPARE TO PARSE
000050  012702  000412'                         MOV     #START,R2
000054  004767  000000G                         JSR     PC,PARSE        ;PARSE
000060  005700                                  TST     R0              ;GOOD PARSE?
000062  001416                                  BEQ     SUX             ;YES - INDICATE
000064  010167  000166                          MOV     R1,ERP+Q.IOPL   ;NO - PRINT WHY
000070  162701  000270'                         SUB     #CMB,R1         ;SET BYTE COUNT
000074  160167  000166                          SUB     R1,IOST+2
000100  016767  000162  000152                  MOV     IOST+2,ERP+Q.IOPL+2
000106                                          DIR$    #ERP
000114  000167  177660                          JMP     TESTP
000120                                  SUX:    DIR$    #SUXMES
000126  000167  177646                          JMP     TESTP
000132                                  EXIT:   EXIT$S
000140                                  PRMPT:  QIOW$   IO.WVB,5,24,,,,<PRPT,4,44>
000162     124     123     124          PRPT:   .ASCII'TST>'
000165     076
000166                                  CML:    QIOW$   IO.RLB,5,24,,IOST,,<CMB,82.,40>
000210                                  SUXMES: QIOW$   IO.WVB,5,24,,,,<SMS,8.,40>
000232     123     125     103          SMS:    .ASCII'SUCCESS!'
000235     103     105     123
000240     123     041
000242                                  ERP:    QIOW$   IO.WVB,5,24,,,,<CMB,40.,40>
000264  000000  000000                  IOST:   .WORD   0,0
000270                                  CMB:    .BLKB   82.
```

```
TESTP - TEST PARSEP     MACRO D1013  24-AUG-77 12:50  PAGE 2


                                        ; STATE TABLE FOR COMMAND
                                        ; UFD DK0:SIXNAM[100,100]/PRO=(RWED,RWED,RWED,RWED)/ALLOC=300
                                        ;
000412  000003                 START:  KEY.
000414     125      106      104        .ASCIZ'UFD '
000417     040      000
                                        .EVEN
000422  000000G                        NULL.
000424  000430'                        N1
000426  177777                        -1
000430  000006                 N1:     ANY.
000432  000000G                        NULL.
000434  000440'                        N2
000436  177777                        -1
000440  000006                 N2:     ANY.
000442  000000G                        NULL.
000444  000450'                        N3
000446  177777                        -1
000450  000002                 N3:     NUMB.
000452  000000G                        NULL.
000454  000466'                        DEV1
000456  000005                         MTCH.
000460  000000G                        NULL.
000462  000466'                        DEV1
000464  177777                        -1
000466  000003                 DEV1:   KEY.
000470     072      000                .BYTE   ':,0
000472  000000G                        NULL.
000474  000500'                        N4
000476  177777                        -1
000500  000001                 N4:     ALPH.
000502  000406                         406
000504  000000G                        NULL.
000506  000512'                        N5
000510  177777                        -1
000512  000007                 N5:     SUBX.
000514  000704'                        UIC
000516  000000G                        NULL.
000520  000524'                        OPTS
000522  177777                        -1
000524  000004                 OPTS:   EOF.
000526  000000G                        NULL.
000530  000764'                        ENDIT
000532  000003                         KEY.
000534     057      000                .BYTE   '/,0
000536  000000G                        NULL.
000540  000544'                        N6
000542  177777                        -1
000544  000003                 N6:     KEY.
000546     101      114      114        .ASCIZ'ALLOC='
000551     117      103      075
000554     000

                                        .EVEN
000556  000000G                        NULL.
000560  000600'                        ALC
000562  000003                         KEY.
000564     120      122      117        .ASCIZ'PRO='
```

```
TESTP - TEST PARSER     MACRO D1013  24-AUG-77 12:50  PAGE 2-1


     000567     075     000
106                                             .EVEN
107 000572  000000G                             NULL.
108 000574  000610'                             PRO
109 000576  177777                              -1
110 000600  000002                      ALC:    NUMB.
111 000602  000000G                             NULL.
112 000604  000524'                             OPTS
113 000606  177777                              -1
114 000610  000003                      PRO:    KEY.
115 000612      133     000                     .BYTE   '[,0
116 000614  000000G                             NULL.
117 000616  000622'                             SPRO
118 000620  177777                              -1
119 000622  000003                      SPRO:   KEY.
120 000624      135     000                     .BYTE   '],0
121 000626  000000G                             NULL.
122 000630  000524'                             OPTS
123 000632  000003                              KEY.
124 000634      054     000                     .BYTE   ',,0
125 000636  000000G                             NULL.
126 000640  000622'                             SPRO
127 000642  000003                              KEY.
128 000644      122     000                     .BYTE   'R,0
129 000646  000000G                             NULL.
130 000650  000622'                             SPRO
131 000652  000003                              KEY.
132 000654      127     000                     .BYTE   'W,0
133 000656  000000G                             NULL.
134 000660  000622'                             SPRO
135 000662  000003                              KEY.
136 000664      105     000                     .BYTE   'E,0
137 000666  000000G                             NULL.
138 000670  000622'                             SPRO
139 000672  000003                              KEY.
140 000674      104     000                     .BYTE   'D,0
141 000676  000000G                             NULL.
142 000700  000622'                             SPRO
143 000702  177777                              -1
144 000704  000003                      UIC:    KEY.
145 000706      133     000                     .BYTE   '[,0
146 000710  000000G                             NULL.
147 000712  000716'                             U1
148 000714  177777                              -1
149 000716  000002                      U1:     NUMB.
150 000720  000000G                             NULL.
151 000722  000726'                             U2
152 000724  177777                              -1
153 000726  000003                      U2:     KEY.
154 000730      054     000                     .BYTE   ',,0
155 000732  000000G                             NULL.
156 000734  000740'                             U3
157 000736  177777                              -1
158 000740  000002                      U3:     NUMB.
159 000742  000000G                             NULL.
160 000744  000750'                             U4
161 000746  177777                              -1
```

```
TESTP - TEST PARSER     MACRO D1013  24-AUG-77 12:50  PAGE 2-2


   162 000750  000003                    U4:     KEY.
   163 000752     135      000                   .BYTE   ']',0
   164 000754  000000G                           NULL.
   165 000756  000762'                           U5
   166 000760  177777                            -1
   167 000762  000010                    U5:     ENDX.
   168 000764  000000                    ENDIT:  END.
   169                                   ;
   170         000000'                           .END    TESTP
```

```
TESTP - TEST PARSER      MACRO D1013  24-AUG-77 12:50  PAGE 2-3
SYMBOL TABLE

ALC     000600R         EXIT    000132R         N3      000450R         Q.IOFN= 000002          SUXMES  000210R
ALPH.   = 000001        IE.EOF= ****** GX       N4      000500R         Q.IOLU= 000004          TESTP   000000R
ANY     = 000006        IOST    000264R         N5      000512R         Q.IOPL= 000014          UIC     000704R
CHS     000270R         IO.RLB= ****** GX       N6      000544R         Q.IOPR= 000007          U1      000716R
CHL     000166R         IO.WVB= ****** GX       OPTS    000524R         Q.IOSB= 000010          U2      000726R
DEV1    000466R         KEY.    = 000003        PARSE = ****** GX       SMS     000232R         U3      000740R
ENDIT   000764R         MTCH.   = 000005        PRMPT   000140R         SPRO    000622R         U4      000750R
ENDX.   = 000010        NULL.   = ****** GX     PRO     000610R         START   000412R         U5      000762R
END.    = 000000        NUMB.   = 000002        PRPT    000162R         SUBX.   = 000007        $$$ARG= 000011
EOF.    = 000004        N1      000430R         Q.IOAE= 000012          SUX     000120R         $$$OST= 000014
ERP     000242R         N2      000440R         Q.IOEF= 000006

  . ABS.    000000      000
            000766      001
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  1094 WORDS  ( 5 PAGES)
DYNAMIC MEMORY:  11961 WORDS  ( 46 PAGES)
ELAPSED TIME:  00:00:12
,LP:=DK1:TESTP.MAC
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50
TABLE OF CONTENTS

    2-  18      INSTRUCTIONS FOR USE.
    3-  53      SYNTACTIC TYPES.
    4-  111     DEFINITIONS
    4-  124     CODE
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 1


 1                              .TITLE  PARSE - GSB PARSER SUBROUTINES
 2                              ;
 3                              ;
 4                              ;
 5                              ; A MACRO PARSER FOR TEXT STRINGS BASED LOOSELY ON .TPARS
 6                              ; DESIGNED PRIMARILY FOR ANALYSIS OF COMMAND-LIKE STRUCTURES
 7                              ; BUT INTENDED TO BE EXTENDABLE FOR ANY GRAMMATICAL ANALYSIS.
 8                              ;
 9                              ;
10                              ;
11                              ; WRITTEN BY G.S. BRIMBLE  28 SEPT 1976
12                              ;
13                              ; MODIFIED:
14                              ;
15                              ; 26/1/77       SYNTACTIC TYPE SYMBOLS CHANGED FOR UNIFORMITY
16                              ;               WITH NOVA PROGRAM.
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 2
INSTRUCTIONS FOR USE

                                .SBTTL  INSTRUCTIONS FOR USE.
                                ;
                                ; TO CAUSE ANALYSIS TO BE CARRIED OUT,A SUBROUTINE CALL
                                ;       JSR     PC,PARSE
                                ; IS USED REGISTER R0 WILL CONTAIN THE RESULT OF THE PARSE
                                ; ON RETURN - R0=0 IF SUCCESSFUL, =-2 IF FAILED
                                ; REGISTERS R3,R4,R5,R6 ARE UNAFFECTED BY THE PARSE.
                                ; R1 MUST POINT TO THE TEXT STRING TO BE ANALYSED.IF THE
                                ; PARSE FAILED,R1 WILL BE POINTING TO THE BYTE(S)
                                ; WHICH CAUSED THE FAILURE.
                                ; R2 MUST POINT TO THE ENTRY STATE OF A STATE TABLE
                                ; WHICH DEFINES THE STRUCTURE WHICH THE TEXT MUST MATCH.
                                ; THE STATE TABLE CONSISTS OF A SET OF TRANSITIONS
                                ; WHICH ARE SO ORDERED AS TO DEFINE THE ALLOWABLE STRUCTURE
                                ; OF THE TEXT.
                                ; THE TRANSITIONS CONSIST OF THREE ENTRIES:
                                ;       SYNTACTIC TYPE (PLUS ANY TRAILING ARGUMENTS)
                                ;       ACTION SUBROUTINE POINTER
                                ;       TARGET STATE POINTER
                                ;
                                ; THE ACTION SUBROUTINES ARE EXECUTED IF THE TRANSITION
                                ; SUCCEEDS,I.E. THE SYNTACTIC TYPE MATCHES.  THEY ARE
                                ; CALLED FROM THE PARSER BY 'JSR PC,@POINTER' SO MUST
                                ; RETURN TO THE PARSER BY 'RTS PC'.REGISTERS R1,R2,R6 MUST BE
                                ; PRESERVED BY THE SUBROUTINES.
                                ; IF NO ACTION IS NEEDED WHEN A TRANSITION IS TAKEN,
                                ; A 'DO NOTHING' SUBROUTINE IS PROVIDED BY THE PARSER
                                ; CALLED 'NULL.'  THIS IS SPECIFIED AS THE ACTION
                                ; SUBROUTINE POINTER FOR NO ACTION.
                                ; THE TARGET STATE POINTER POINTS TO THE TRANSITION
                                ; TO BE ATTEMPTED IF THE CURRENT ONE SUCCEEDS.  IF THIS
                                ; ONE FAILS,THE FOLLOWING ONE IS ATTEMPTED.THE END OF A
                                ; STATE IS INDICATED BY A PSEUDO-TYPE -1.IF THIS IS
                                ; ENCOUNTERED AS A TYPE THE PARSE FAILS.
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 3
SYNTACTIC TYPES

                                .SBTTL  SYNTACTIC TYPES
                                ;
                                ; THE SYNTACTIC TYPE ENTRY IN THE TRANSITION BLOCK
                                ; MAY BE ONE OF THE FOLLOWING:
                                ;
                                ; ALPH. DEFINED ALPH.=1
                                ;       THIS MATCHES ALL FOLLOWING ALPHABETIC CHARACTERS
                                ;       UNTIL A NON-ALPH. CHAR. IS FOUND. IT AMOUNTS TO
                                ;       AN 'IGNORE TEXT' SPECIFICATION. THE ENTRY HAS A
                                ;       TRAILING ONE-WORD ARGUMENT;THE LOWER BYTE IS A
                                ;       MAXIMUM BYTE COUNT TO LIMIT THE AMOUNT OF TEXT
                                ;       TO BE IGNORED,AND THE UPPER BYTE IS A FLAG
                                ;       =0 IF SPACES(AND TABS) ARE TO BE TREATED AS ALPHA,
                                ;       =1 IF SPACES CAN BE USED AS TERMINATORS.
                                ;       THUS THIS TYPE ALWAYS SUCCEEDS UNLESS THE BYTE
                                ;       COUNT IS EXCEEDED. NOTE THAT THIS TYPE SUCCEEDS IF
                                ;       THERE ARE NO ALPHABETIC CHARS.
                                ; NUMB.        DEFINED NUMB.=2
                                ;       THIS MATCHES A DECIMAL INTEGER WHOSE VALUE IS
                                ;       STORED IN THE PARSER-DEFINED LOCATION 'NUM.'.
                                ;       CONVERSION STOPS AT FIRST NON-NUMERIC CHAR.
                                ;       IT ALWAYS SUCCEEDS - IF NO NUMERALS,NUM.=0
                                ; KEY.         KEY.=3
                                ;       MATCHES ONE OR MORE ASCII CHARS WHICH FOLLOW THE
                                ;       TYPE SPEC. AS TRAILING PARAMETERS. THESE KEY
                                ;       CHARS MUST TERMINATE WITH A NULL BYTE. THEY ARE
                                ;       EASILY DEFINED USING THE '.ASCIZ' OPERATOR BUT
                                ;       THIS MUST BE FOLLOWED BY '.EVEN' TO RETURN TO
                                ;       WORD BOUNDARIES.
                                ; EOF.         EOF.=4
                                ;       MATCHES ESC,ALT MODE,FF,RUBOUT,CR(AND LF IF FOLLOWS).
                                ;       ON ENTRY TO ACTION SUBROUTINE,R3 HAS THE CHAR.
                                ; MTCH.        MTCH.=5
                                ;       THIS CAUSES AN UNCONDITIONAL MATCH - ALWAYS SUCCEEDS.
                                ;       IT FORCES ACTION AND/OR NEW STATE.
                                ; ANY.         ANY.=6
                                ;       PUTS NEXT CHAR. INTO PARSER-DEFINED LOCATION 'CHAR.'.
                                ;       SUCCEEDS UNLESS NEXT CHAR IS EOF OR RUBOUT(377).
                                ; SUBX. SUBX.=7
                                ;       THIS ASKS THE PARSER TO MATCH A SUB-EXPRESSION,
                                ;       I.E. TO ATTEMPT TO MATCH A STRUCTURE DEFINED BY A
                                ;       SUBSIDIARY STATE TABLE. THE TYPE ENTRY IS FOLLOWED
                                ;       BY A TRAILING ARGUMENT OF A SINGLE WORD CONTAINING
                                ;       THE ADDRESS OF THE ENTRY STATE OF THE SUBEXPRESSION.
                                ;       THIS SUBEXPRESSION STATE TABLE MUST CONTAIN A
                                ;       STATE WITH THE TYPE 'ENDX.' AS THE SUCCESS EXIT.
                                ; ENDX. ENDX.=10
                                ;       SUCCESS EXIT FROM SUBEXPRESSION. THIS TYPE CAUSES
                                ;       THE PARSER TO CARRY OUT THE SUCCESS ACTION AND
                                ;       TARGET IN THE TRANSITION WHICH CALLED THE
                                ;       SUBEXPRESSION. IT HAS NO ACTION OR TARGET ENTRIES
                                ;       ASSOCIATED WITH IT.
                                ; END.         END.=0
                                ;       THIS TYPE IS A SPECIAL CASE. IT INDICATES SUCCESSFUL
                                ;       PARSE AND CAUSES THE PARSER TO RETURN CONTROL TO
                                ;       THE CALLING PROGRAM WITH THE SUCCESS CODE IN R0.
                                ;       IT HAS NO ACTION OR TARGET ENTRIES.
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 4
DEFINITIONS

                                        .SBTTL  DEFINITIONS
                                        ;
                000000                          END.=0
                000001                          ALPH.=1
                000002                          NUMB.=2
                000003                          KEY.=3
                000004                          EOF.=4
                000005                          MTCH.=5
                000006                          ANY.=6
                000007                          SUBX.=7
                000010                          ENDX.=10
                                        ;
                                        ;
                                        .SBTTL  CODE
                                        ;
000000                                  .PSECT  PARS$           ;MAKE PSECT TO AVOID SYMBOL CLASH.
                                        ;
000000  010346                 PARSE::MOV      R3,-(SP)        ;SAVE WORKING REGS
000002  010446                         MOV     R4,-(SP)
000004  010546                         MOV     R5,-(SP)
000006  010167  000060         PARS$G: MOV     R1.TXTPT$       ;SAVE CURRENT TEXT PTR
000012  012200                         MOV     (R2)+,R0        ;GET TYPE
000014  006300                         ASL     R0              ;MAKE IT WORD ADDRESS
000016  000170  000050'               JMP     @VECT$(R0)      ;VECTOR TO ITS ROUTINE
000022  004732                 SUXS$:  JSR     PC,@(R2)+       ;ON SUCCESS,DO ACTION
000024  011202                         MOV     (R2),R2         ;SET TARGET POINTER
000026  000167  177754                 JMP     PARS$G          ;REPEAT
000032  016701  000034         FAYL$:  MOV     TXTPT$,R1       ;RESTORE TEXT PTR TO AS BEFORE FAIL
000036  005732                         TST     @(R2)+          ;IGNORE ACTION
000040  005732                         TST     @(R2)+          ;AND TARGET
000042  000167  177740                 JMP     PARS$G          ;REPEAT.
                                        ;
000046  000102'                          .WORD   XIT$
000050  000112'                 VECT$:  .WORD   END$
000052  000302'                          .WORD   ALPH$
000054  000360'                          .WORD   NUM$
000056  000224'                          .WORD   KEY$
000060  000124'                          .WORD   EOF$
000062  000120'                          .WORD   MTCH$
000064  000200'                          .WORD   ANY$
000066  000470'                          .WORD   SUBX$
000070  000524'                          .WORD   ENDX$
                                        ;
000072  000000                 TXTPT$: .WORD   0
000074  000000                 CHAR.:: .WORD   0
000076  000000                 NUM.::  .WORD   0
000100  000207                 NULL.:: RTS     PC
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 5
CODE

159                                     ; ROUTINES TO MATCH SYNTACTIC TYPES.
160                                     ;
161 000102  012605                      XIT$:   MOV     (SP)+,R5        ;RESTORE REGS
162 000104  012604                              MOV     (SP)+,R4
163 000106  012603                              MOV     (SP)+,R3
164 000110  000207                              RTS     PC
165                                     ;
166 000112  005000                      END$:   CLR     R0              ;FLAG SUCCESS
167 000114  000167  177762                      JMP     XIT$
168                                     ;
169 000120  000167  177676              MTCH$:  JMP     SUXS$
170                                     ;
171 000124  012703  000164'             EOF$:   MOV     #40$,R3         ;POINT TO EOF TABLE
172 000130  121123                      30$:    CMPB    (R1),(R3)+
173 000132  001405                              BEQ     10$             ;DOES IT MATCH?
174 000134  020327  000176'                     CMP     R3,#50$         ;NO - END OF TABLE?
175 000140  101773                              BLOS    30$             ;NO - TRY ANOTHER
176 000142  000167  177664                      JMP     FAYL$           ;YES - NO MATCH SO FAIL
177 000146  005201                      10$:    INC     R1              ;PUSH POINTER IF MATCHES
178 000150  121127  000012                      CMPB    (R1),#12        ;FOLLOWED BY LF?
179 000154  001001                              BNE     20$
180 000156  005201                              INC     R1              ;IF SO, PUSH TEXT PTR
181 000160  000167  177636              20$:    JMP     SUXS$           ;THEN SUCCEED
182 000164  000015                      40$:    .WORD   15
183 000166  000377                              .WORD   377
184 000170  000176                              .WORD   176
185 000172  000033                              .WORD   33
186 000174  000032                              .WORD   32
187 000176  000014                      50$:    .WORD   14
188                                     ;
189 000200  121127  000377              ANY$:   CMPB    (R1),#377       ;IF RUBOUT
190 000204  001411                              BEQ     11$
191 000206  121127  000032                      CMPB    (R1),#32        ;OR END OF FILE,
192 000212  001406                              BEQ     11$             ;THIS FAILS.
193 000214  005067  177654                      CLR     CHAR.           ;OTHERWISE CLEAR WORD TO
194 000220  112167  177650                      MOVB    (R1)+,CHAR.     ;STORE BYTE
195 000224  000167  177572                      JMP     SUXS$           ;AND SUCCEED.
196 000230  000167  177576              11$:    JMP     FAYL$
197                                     ;
198 000234  105712                      KEY$:   TSTB    (R2)            ;END OF KEYS?
199 000236  001412                              BEQ     12$             ;THEN SUCCEED
200 000240  122122                              CMPB    (R1)+,(R2)+     ;MATCH?
201 000242  001774                              BEQ     KEY$            ;YES - DO ANOTHER
202 000244  105722                      22$:    TSTB    (R2)+           ;FAILED SO PUSH PTR OVER KEYS
203 000246  001376                              BNE     22$             ;UNTIL ZERO IS FOUND
204 000250  005202                              INC     R2              ;ALIGN TO WORD BOUNDARY
205 000252  006002                              ROR     R2
206 000254  000241                              CLC
207 000256  006102                              ROL     R2
208 000260  000167  177546                      JMP     FAYL$
209 000264  005202                      12$:    INC     R2              ;SUCCESS - ALIGN TO WORD BOUNDARY
210 000266  005202                              INC     R2
211 000270  006002                              ROR     R2
212 000272  000241                              CLC
213 000274  006102                              ROL     R2
214 000276  000167  177520                      JMP     SUXS$
215                                     ;
```

```
PARSE - GSB PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 5-1
CODE

216 000302  112203                  ALPH$:  MOVB    (R2)+,R3        ;GET NO. OF CHARS
217 000304  112204                          MOVB    (R2)+,R4        ;AND SPACE FLAG
218 000306  005704                  43$:    TST     R4              ;COUNT SPACES AS ALPHA?
219 000310  001006                          BNE     13$
220 000312  121127  000040                  CMPB    (R1),#40        ;YES - ANY SPACES?
221 000316  001411                          BEQ     23$             ;YES - GO AGAIN
222 000320  121127  000011                  CMPB    (R1),#11        ;TRY TABS
223 000324  001406                          BEQ     23$
224 000326  121127  000101                  13$:    CMPB    (R1),#'A        ;IS BYTE < A?
225 000332  103410                          BLO     33$             ;IF SO IT IS A BREAK CHAR
226 000334  121127  000132                  CMPB    (R1),#'Z        ;IS IT > Z?
227 000340  101005                          BHI     33$             ;IF SO BREAK
228 000342  005201                  23$:    INC     R1              ;MOVE TO NEXT BYTE
229 000344  005303                          DEC     R3              ;DONE ENOUGH TEXT?
230 000346  002357                          BGE     43$             ;NOT YET - DO NEXT BYTE
231 000350  000167  177456                  JMP     FAYL$           ;YES - FAIL
232 000354  000167  177442          33$:    JMP     SUXS$           ;FOUND BREAK SO SUCCEED.
233                                 ;
234 000360  005003                  NUM$:   CLR     R3              ;CLEAR SIGN FLAG
235 000362  005067  177510                  CLR     NUM.            ;AND SUM WORD
236 000366  121127  000053                  CMPB    (R1),#'+        ;PLUS SIGN?
237 000372  001404                          BEQ     14$
238 000374  121127  000055                  CMPB    (R1),#'-        ;MINUS?
239 000400  001001                          BNE     14$             ;NO SIGN SO ASSUME +
240 000402  005203                          INC     R3              ;FLAG MINUS
241 000404  121127  000060          14$:    CMPB    (R1),#'0        ;IF CHAR < 0
242 000410  103421                          BLO     24$
243 000412  121127  000071                  CMPB    (R1),#'9        ;OR > 9
244 000416  101016                          BHI     24$             ;THEN BREAK AND FINISH
245 000420  112104                          MOVB    (R1)+,R4        ;OTHERWISE GET NUMERAL
246 000422  162704  000060                  SUB     #'0,R4          ;MAKE A NUMBER
247 000426  016700  177444                  MOV     NUM.,R0
248 000432  006300                          ASL     R0              ;MULT. BY 10 THE HARD WAY
249 000434  006300                          ASL     R0              ;SO THIS CAN RUN ON PDP11/10
250 000436  060067  177434                  ADD     R0,NUM. ;2*(NO.+(2*(2*NO.)))=10*NO.
251 000442  006367  177430                  ASL     NUM
252 000446  060467  177424                  ADD     R4,NUM. ;ADD IN NEW DIGIT
253 000452  000754                          BR      14$             ;GET ANOTHER DIGIT
254 000454  005703                  24$:    TST     R3              ;BREAK SO APPLY SIGN
255 000456  001402                          BEQ     34$
256 000460  005467  177412                  NEG     NUM.
257 000464  000167  177332          34$:    JMP     SUXS$
258                                 ;
259 000470  010246                  SUBX$:  MOV     R2,-(SP)        ;SAVE CURRENT STATE PTR
260 000472  011202                          MOV     (R2),R2         ;GET NEW ONE
261 000474  012767  000506' 177344          MOV     #SUBXT$,VECT$-2 ;ALTER ERROR PTR IN TABLE
262 000502  000167  177300                  JMP     PARS$G          ;SO IF SUBEX FAILS IT COMES HERE.
263 000506  012602                  SUBXT$: MOV     (SP)+,R2        ;RESTORE STATE PTR
264 000510  005722                          TST     (R2)+           ;SKIP TRAILING ARGUMENT
265 000512  012767  000102' 177326          MOV     #XIT$,VECT$-2   ;RESTORE ERROR POINTER
266 000520  000167  177306                  JMP     FAYL$           ;AND TREAT AS NORMAL TRANS FAIL
267 000524  012602                  ENDX$:  MOV     (SP)+,R2        ;SUBEX HAS SUCCEEDED
268 000526  005722                          TST     (R2)+           ;SO RESTORE AS ABOVE
269 000530  012767  000102' 177310          MOV     #XIT$,VECT$-2
270 000536  000167  177260                  JMP     SUXS$           ;AND SUCCEED.
271                                 ;
272         000001                          .END
```

```
PARSE - USE PARSER SUBROUTINES  MACRO D1013  24-AUG-77 12:50  PAGE 5-2
SYMBOL TABLE

ALPH$   000742R     002 ENDX.  = 000010          KEY$    000234R     002 NUM$    000360R     002 SUBX.  = 000007
ALPH.  = 000001         END$    000112R     002 KEY.   = 000003         NUM.    000076RG    002 SUXS$   000022R     002
ANY$    000400R     002 END.   = 000000         MTCH$   000120R     002 PARSE   000000RG    002 TXTPT$  000072R     002
ANY.   = 000006         EOF$    000124R     002 MTCH.  = 000005         PARS$G  000006R     002 VECT$   000050R     002
CHAR    000074RG    002 EOF.   = 000004         NULL.   000100RG    002 SUBXT$  000506R     002 XIT$    000102R     002
ENDX$   000524R     002 FAYL$   000032R     002 NUMB.  = 000002         SUBX$   000470R     002

  ABS   000000      000
        000000      001
PWPS$   000542      002
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  261 WORDS  ( 2 PAGES)
DYNAMIC MEMORY:  11961 WORDS  ( 46 PAGES)
ELAPSED TIME:  00:00:11
.LP:=DK1:PARSER.MAC
```

APPENDIX IV

NOVA PARSER PROGRAM LISTING

```
---
                        .TITL TESTP
                        ; ILLUSTRATION OF PARSER USE.
                        ; G. BRIMBLE  4/3/77
                        ;
              000001            .TXTM   1
                        ;
                        ;  DEFINE GLOBAL SYMBOLS IF NEEDED BY OTHER TASKS
                        ;
                                .ENT    CHAR.,NUM.,PARSI
                                .ENT    TESTP
                        ;
                                .ZREL
  00000-000377  IDMSK:  377               ;USER MUST DEFINE THIS ON P.ZERO
  00001-000000  CHAR.:  0                 ;AND THIS AND THE NEXT ONE
  00002-000000  NUM.:   0
  00003-000367' PARSI:  PARSE
                        ;
                                .NREL
  00000'020444  TESTP:  LDA     0,TTIPT           ;OPEN CH0 TO TTI
  00001'036017          .SYSTM
  00002'014000          .OPEN   0
  00003'063077          HALT                      ;ERROR
  00004'020444          LDA     0,TTOPT           ;OPEN CH1 TO TTO
  00005'036017          .SYSTM
  00006'014001          .OPEN   1
  00007'063077          HALT
  00010'020444  LOOPP:  LDA     0,PRMPT
  00011'036017          .SYSTM
  00012'017001          .WRL    1                 ;INDICATE READY
  00013'000775          JMP     .-3               ;ERROR RETURN
  00014'020444          LDA     0,CML
  00015'036017          .SYSTM
  00016'015400          .RDL    0                 ;GET COMMAND
  00017'000775          JMP     .-3               ;ERROR
  00020'024440          LDA     1,CML
  00021'125220          MOVZR   1,1               ;WORD PTR TO TEXT
  00022'000557          LDA     2,STRPT           ;PREPARE TO PARSE
  00023'006003-         JSR     @PARSI            ;DO IT
  00024'131005          MOV     0,0,SNR           ;WAS IT OK?
  00025'000407          JMP     GOODP             ;YES
  00026'020021          LDA     0,TXPT            ;NO-SAY WHY
  00027'131120          MOVZL   0,0               ;BYTE PTR
  00030'036017          .SYSTM
  00031'017001          .WRL    1
  00032'000756          JMP     LOOPP             ;ERROR
  00033'000755          JMP     LOOPP
  00034'020402  GOODP:  LDA     0,SUXM
  00035'000773          JMP     .-5               ;PRINT "SUCCESS!"
                        ;
  00036'000076" SUXM:   .+1*2
  00037'051525          .TXT/SU
  00040'041503  CC
  00041'042523  ES
  00042'051441  S!
  00043'036400  <15>/
  00044'000112" TTIPT:  .+1*2
  00045'000124          .TXT/ST
  00046'052111  TI
  00047'000000  /
  00050'000122" TTOPT:  .+1*2
```

```
---
  00051'022124            .TXT/$T
  00052'052117  TO
  00053'000000  /
  00054'000132" PRMPT:    .+1*2
  00055'052123            .TXT/TS
  00056'052076  T>
  00057'000000  /
  00060'000142" CML:      .+1*2
        000120            .BLK    80.
                  ;
                  ;  TRANSITION TABLE
                  ;
  00201'000202' STRPT:    START
  00202'000003  START:    KEY.
  00203'052506            .TXT/UF
  00204'042040  D
  00205'000000  /
  00206'000477'           NULL.
  00207'000211'           N1
  00210'177777            -1
  00211'000006  N1:       ANY.
  00212'000477'           NULL.
  00213'000215'           N2
  00214'177777            -1
  00215'000006  N2:       ANY.
  00216'000477'           NULL.
  00217'000221'           N3
  00220'177777            -1
  00221'000002  N3:       NUMB.
  00222'000477'           NULL.
  00223'000230'           DEV1
  00224'000005            MTCH.
  00225'000477'           NULL.
  00226'000230'           DEV1
  00227'177777            -1
  00230'000003  DEV1:     KEY.
  00231'035000            256.*":
  00232'000477'           NULL.
  00233'000235'           N4
  00234'177777            -1
  00235'000001  N4:       ALPH.
  00236'000000            0
  00237'000477'           NULL.
  00240'000242'           N5
  00241'177777            -1
  00242'000007  N5:       SUBX.
  00243'000336'           UIC
  00244'000477'           NULL.
  00245'000247'           OPTS
  00246'177777            -1
  00247'000004  OPTS:     EOF.
  00250'000477'           NULL.
  00251'000366'           ENDIT
  00252'000003            KEY.
  00253'027400            256.*"/
  00254'000477'           NULL.
  00255'000256'           N6
  00256'000003  N6:       KEY.
  00257'040514            .TXT/AL
  00260'046117  LO
```

```
---
  00261'041475  C=
  00262'000000  /
  00263'030477'         NULL.
  00264'030274'         ALC
  00265'000003          KEY.
  00266'050122          .TXT/PR
  00267'047475  O=
  00270'030000  /
  00271'030477'         NULL.
  00272'300300'         PRO
  00273'177777          -1
  00274'030002  ALC:    NUMB.
  00275'030477'         NULL.
  00276'030247'         OPTS
  00277'177777          -1
  00300'030003  PRO:    KEY.
  00301'055400          .TXT/[/
  00302'030477'         NULL.
  00303'030305'         SPRO
  00304'177777          -1
  00305'030003  SPRO:   KEY.
  00306'056400          .TXT/]/
  00307'030477'         NULL.
  00310'030247'         OPTS
  00311'030003          KEY.
  00312'026000          .TXT/,/
  00313'000477'         NULL.
  00314'030305'         SPRO
  00315'030003          KEY.
  00316'051000          .TXT/R/
  00317'000477'         NULL.
  00320'030305'         SPRO
  00321'030003          KEY.
  00322'053400          .TXT/W/
  00323'030477'         NULL.
  00324'030305'         SPRO
  00325'030003          KEY.
  00326'042400          .TXT/E/
  00327'000477'         NULL.
  00330'030305'         SPRO
  00331'030003          KEY.
  00332'042000          .TXT/D/
  00333'030477'         NULL.
  00334'000305'         SPRO
  00335'177777          -1
  00336'030003  UIC:    KEY.
  00337'055400          .TXT/[/
  00340'030477'         NULL.
  00341'000343'         U1
  00342'177777          -1
  00343'030002  U1:     NUMB.
  00344'030477'         NULL.
  00345'000347'         U2
  00346'177777          -1
  00347'030003  U2:     KEY.
  00350'026000          .TXT/,/
  00351'030477'         NULL.
  00352'030354'         U3
  00353'177777          -1
  00354'030002  U3:     NUMB.
```

```
---
  00355'000477'          NULL.
  00356'000360'          U4
  00357'177777           -1
  00360'000003  U4:      KEY.
  00361'056400           .TXT/1/
  00362'000477'          NULL.
  00363'000365'          U5
  00364'177777           -1
  00365'000010  U5:      ENDX.
  00366'000000  ENDIT:   END.
                ;
                ; PARSER MODULE
                ;
                ; DEFINITIONS
        000020          STPT=20
        000021          TXPT=21
        000030          STACK=30
        000000          END.=0
        000001          ALPH.=1
        000002          NUMB.=2
        000003          KEY.=3
        000004          EOF.=4
        000005          MTCH.=5
        000006          ANY.=6
        000007          SUBX.=7
        000010          ENDX.=10
                ;
        000001          .TXTM   1.
                ;
  00367'044021  PARSE:  STA     1,TXPT  ;SET UP AUTO-INC PTRS
  00370'014021          DSZ     TXPT    ;DECR FOR AUTOINC PTR
  00371'044462          STA     1,TSAVE
  00372'014461          DSZ     TSAVE
  00373'050020          STA     2,STPT
  00374'014020          DSZ     STPT
  00375'054416          STA     3,VECTAB+1  ;SET UP ERROR RETURN
  00376'126400          SUB     1,1
  00377'044452          STA     1,DTEM  ;CLEAR OLD BYTE
  00400'024411          LDA     1,STKPT
  00401'044030          STA     1,STACK
  00402'020447  PARSG:  LDA     0,DTEM  ;SAVE PRESENT BYTE
  00403'040447          STA     0,DSAVE
  00404'024406          LDA     1,VECTAB
  00405'032020          LDA     2,@STPT ;GET A TRANSITION TYPE
  00406'141000          MOV     2,0     ;IF -1 WILL BE ERROR CODE
  00407'133000          ADD     1,2     ;MAKE AN ADDRESS
  00410'003000          JMP     @0,2    ;VECTOR TO MATCHING TYPE
                ;
  00411'000736' STKPT:  STAK
  00412'000414' VECTAB: .+2
  00413'000000          0
  00414'000425'         END
  00415'000500'         ALPH
  00416'000621'         DNUMB
  00417'000551'         KEYWD
  00420'000576'         EOF
  00421'000575'         LAMDA
  00422'000615'         ANY
  00423'000674'         SUBX
  00424'000706'         ENDX
```

```
---
                        ;
  00425'102400  END:    SUB     0,0     ;SUCCESSFUL PARSE
  00426'002765          JMP     @VECTAB+1  ;RETURN FROM PARSE
                        ;
                        ; NXDAT GETS NEXT DATA BYTE IGNORING SPACES AND NULLS
                        ; RETURNS BYTE IN AC1
                        ;
  00427'000000          0
  00430'054777  NXDAT:  STA     3,.-1
  00431'024420          LDA     1,DTEM
  00432'044416          STA     1,LASTD
  00433'176400          SUB     3,3
  00434'054415          STA     3,DTEM  ;GET,THEN CLEAR,DTEM.
  00435'125014          SKPZR   1,1     ;IS IT ZERO?
  00436'002771          JMP     @NXDAT-1  ;NO-LEGIT. CHAR
  00437'026021          LDA     1,@TXPT ;YES-GET A NEW WORD,
  00440'034000-         LDA     3,IDMSK
  00441'137400          AND     1,3     ;MASK OFF LS BYTE
  00442'054407          STA     3,DTEM  ;AND SAVE IT
  00443'125300          MOVS    1,1     ;SWAP MS BYTE LOW
  00444'034000-         LDA     3,IDMSK
  00445'167405          AND     3,1,SNR ;MASK IT OFF AND TEST FOR NULL
  00446'000763          JMP     NXDAT+1 ;IF NULL,GET ANOTHER.
  00447'002760          JMP     @NXDAT-1  ;ELSE AC1 IS NEXT BYTE
  00450'000000  LASTD:  0
                        ;
                        ; SUCCESS ROUTINES: SUXEX(SUXX)RESTORES THE LAST BYTE
                        ; TAKEN BY NXDAT,SUXS(SUX) DOES NOT. BOTH CAUSE
                        ; EXECUTION OF THE ACTION ROUTINE AND BRANCH TO TRANS.
                        ;
                        ;
                        ; STORAGE COMMON TO NXD AND SUX,FALE
                        ;
  00451'000000  DTEM:   0
  00452'000000  DSAVE:  0
  00453'000000  TSAVE:  0
                        ;
  00454'034774  SUXEX:  LDA     3,LASTD ;RESTORE LAST BYTE TAKEN.

  00455'054774          STA     3,DTEM
  00456'175005          MOV     3,3,SNR
  00457'014021          DSZ     TXPT    ;IF DTEM=0,PUSH THE PTR BACK
  00460'034021  SUXS:   LDA     3,TXPT  ;IF NEXT MATCH FAILS,
  00461'054772          STA     3,TSAVE ;RETURN TO HERE.
  00462'036020          LDA     3,@STPT
  00463'005400          JSR     0,3     ;DO ACTION
  00464'022020          LDA     0,@STPT ;GET ADDR OF NEXT TRANS
  00465'040020          STA     0,STPT  ;AND SET IT UP
  00466'014020          DSZ     STPT    ;ALLOW FOR AUTO INC
  00467'002531          JMP     @PARET  ;RETURN TO PARSE
  00470'034762  FAYL:   LDA     3,DSAVE ;NO MATCH- RESTORE TEXT POINTERS
  00471'054760          STA     3,DTEM  ;TO AS BEFORE ATTEMPTED MATCH.
  00472'034761          LDA     3,TSAVE
  00473'054021          STA     3,TXPT
  00474'036020          LDA     3,@STPT
  00475'036020          LDA     3,@STPT ;IGNORE ACTION AND TRANS
  00476'002522          JMP     @PARET  ;GO BACK TO PARSE
                        ;
                        ; NULL ACTION ROUTINE FOR OTHER TASKS
  00477'001400  NULL.:  JMP     0,3
                        ;
```

```
---
                ; TYPE MATCHING ROUTINES ENTERED BY VECTOR TABLE.
                ;
00530'022020  ALPH:   LDA     0,@STPT ;GET ARGUMENT
00531'024000-         LDA     1,IDMSK
00532'107400          AND     0,1     ;MASK OFF BYTE COUNT
00533'044432          STA     1,BCNT
00534'101300          MOVS    0,0
00535'024000-         LDA     1,IDMSK
00536'123400          AND     1,0     ;GET SPACE FLAG
00537'030404          JMP     .+4
00540'014425  STRNG:  DSZ     BCNT    ;DONE BYTE COUNT?
00541'030402          JMP     .+2
00542'000756          JMP     FAYL    ;IF SO,FAILURE
00543'006456          JSR     @NXD    ;GET A BYTE SAVING AC0
00544'034456          LDA     3,ASCA
00545'136032          SKPGE   1,3
00546'000404          JMP     ENDST   ;FINISH IF <A
00547'034454          LDA     3,ASCZ
00550'136432          SKPGT   1,3     ;FINISH IF >Z
00551'000767          JMP     STRNG   ;CHAR WAS ALPH. SO DO ANOTHER
00552'101004  ENDST:  MOV     0,0,SZR ;ARE SPACES ALPHA?
00553'002443          JMP     @SUXX   ;RESTORE UNMATCHED BYTE AND END
00554'034407          LDA     3,ASCSP ;YES-IS THIS SPACE OR TAB?
00555'166415          SKPNE   3,1
00556'000762          JMP     STRNG   ;IF SO,GET ANOTHER ALPH
00557'034405          LDA     3,ASCTB
00560'166415          SKPNE   3,1
00561'000757          JMP     STRNG
00562'002434          JMP     @SUXX   ;NOT ALPHA SO SUCCEED
00563'000040  ASCSP:  40
00564'000011  ASCTB:  11
00565'000000  BCNT:   0
                ;
00566'020436  NXKEY:  LDA     0,KTEM  ;ALGOR. SIM TO NXD GETS
00567'152400          SUB     2,2     ;NEXT KEY BYTE IN AC0.
00570'050434          STA     2,KTEM
00571'101014          SKPZR   0,0
00572'000404          JMP     .+4     ;MATCH A BYTE
00573'022020          LDA     0,@STPT
00574'040430          STA     0,KTEM  ;IF NULL,GET AND SAVE ANOTHER
00575'101300          MOVS    0,0     ;SWAP MS BYTE LOW
00576'030000-         LDA     2,IDMSK ;MASK OFF THE NEXT BYTE
00577'143400          AND     2,0
00600'001400          JMP     0,3     ;CARRY BACK IN AC0
00601'034765 .KEYWD:  JSR     NXKEY   ;GET A KEY
00602'101004          MOV     0,0,SZR ;IS IT END(NULL)?
00603'000403          JMP     MCHKY   ;NO-MATCH IT
00604'040420          STA     0,KTEM  ;YES-RESET STORE
00605'002412          JMP     @SUX    ;IF NULL, SUCCESS!
00606'006413  MCHKY:  JSR     @NXD    ;GET A DATA BYTE
00607'106415          SKPNE   0,1     ;MATCH?
00610'000771          JMP     KEYWD   ;YES-DO ANOTHER
00611'034755          JSR     NXKEY   ;NO-FAIL MATCH
00612'101004          MOV     0,0,SZR ;IGNORE KEYS UNTIL NULL
00613'000776          JMP     .-2
00614'040410          STA     0,KTEM  ;CLEAR STORE
00615'002403          JMP     @FALE   ;FAIL MATCH
                ;
                ; INDIRECT POINTERS AND CONSTANTS
00616'000454' SUXX:   SUXEX
```

```
---
  00567'000460' SUX:    SUXS
  00570'000470' FALE:   FAYL
  00571'000430' NXD:    NXDAT
  00572'000101  ASCA:   "A
  00573'000132  ASCZ:   "Z
  00574'000000  KTEM:   0
                ;
                ; REST OF MATCH ROUTINES
                ;
  00575'002772  LAMDA:  JMP     @SUX    ;ALWAYS SUCCEED
                ;
  00576'006773  EOF:    JSR     @NXD    ;GET NEXT BYTE
  00577'030410          LDA     2,EOFT
  00600'151400  ELOOP:  INC     2,2
  00601'021000          LDA     0,0,2
  00602'100015          SKPNM   0,0     ;END OF POSSIBILITIES?
  00603'002765          JMP     @FALE   ;THEN FAIL
  00604'106415          SKPNE   0,1     ;WAS IT A MATCH?
  00605'002762          JMP     @SUX    ;YES
  00606'000772          JMP     ELOOP   ;NO
  00607'000607' EOFT:   .
  00610'000015          15              ;CR
  00611'000033          33              ;ESC
  00612'000176          176             ;ALT MODE
  00613'000014          14              ;FF
  00614'177777          -1              ;END OF LIST
                ;
  00615'006754  ANY:    JSR     @NXD    ;GET A BYTE
  00616'044001-         STA     1,CHAR. ;AND STORE IT
  00617'002750          JMP     @SUX    ;SUCCESSFUL EXIT.
                ;
  00620'000402' PARET:  PARSG
                ;
  00621'102400  DNUMB:  SUB     0,0     ;BORROWED FROM .DBIN
  00622'040444          STA     0,.EC10 ;CLEAR SIGN WORD
  00623'040444          STA     0,.EC11 ;CLEAR SUM WORD
  00624'006745          JSR     @.EC40  ; GET A CHARACTER
  00625'121000          MOV     1,0
  00626'024442          LDA     1,.EC20 ; TEST FOR "+"
  00627'106405          SUB     0,1,SNR
  00630'000405          JMP     .EC97   ; YES
  00631'024440          LDA     1,.EC21 ; NO, TEST FOR "-"
  00632'106404          SUB     0,1,SZR
  00633'000404          JMP     .EC96   ; NO EXPLICIT SIGN
  00634'010432          ISZ     .EC10   ; SET FLAG WORD FOR NEGATIVE
                                        ; NUMBER
  00635'006734  .EC97:  JSR     @.EC40  ; GET ANOTHER CHARACTER
  00636'121000          MOV     1,0
  00637'024433  .EC96:  LDA     1,.EC22 ; ASCII "0"
  00640'030433          LDA     2,.EC23 ; ASCII "9"
  00641'142033          ADCZ#   2,0,SNC ; SKIP IF > 9
  00642'106032          ADCZ#   0,1,SZC ; SKIP IF >= 0
  00643'000406          JMP     .EC95   ; NOT A DIGIT, THERFORE A BREAK
  00644'122400          SUB     1,0     ; REDUCE DIGIT TO 0-9 BINARY
  00645'024422          LDA     1,.EC11 ; SUM WORD
  00646'004412          JSR     .EC50   ; MULTIPLY BY 10 AND ADD
  00647'044420          STA     1,.EC11 ; SAVE SUM
  00650'000765          JMP     .EC97   ; GET NEXT CHARACTER
  00651'024416  .EC95:  LDA     1,.EC11 ; RESULT TO AC1
  00652'125120          MOVZL   1,1
```

```
---
  00653'014413           DSZ     .EC10   ; TEST SIGN
  00654'125221           MOVZR   1,1,SKP ; POSITIVE
  00655'124640           NEGOR   1,1     ; NEGATIVE
  00656'044002-          STA     1,NUM.
  00657'002707           JMP     @SUXX   ;RESTORE BREAK CHAR.
                 ; ROUTINE TO MULTIPLY AC1 BY 10 AND ADD AC0
  00660'131120 .EC50:    MOVZL   1,2     ; N*2
  00661'151120           MOVZL   2,2     ; N*4
  00662'147000           ADD     2,1     ; N*5
  00663'125120           MOVZL   1,1     ; N*5*2 = N*10
  00664'137000           ADD     0,1     ; ADD AC0
  00665'001400           JMP     0,3     ; SUCCESS RETURN
                 ;
  00666'000000 .EC10:    0               ; FLAG WORD FOR SIGN OF RESULT
  00667'000000 .EC11:    0               ; RUNNING SUM WORD
  00670'000053 .EC20:    "+              ; ASCII "+"
  00671'000055 .EC21:    "-              ; ASCII "-"
  00672'000060 .EC22:    "0              ; ASCII "0"
  00673'000071 .EC23:    "9              ; ASCII "9"
       000571' .EC40=NXD                 ; ADDRESS OF GET CHARACTER
                                         ; ROUTINE
                 ;
                 ;
                 ;
  00674'026020 SUBX:     LDA     1,@STPT         ;GET NEW STATE PTR
  00675'030020           LDA     2,STPT          ;STACK CURRENT STATE PTR
  00676'052030           STA     2,@STACK
  00677'044020           STA     1,STPT
  00700'014020           DSZ     STPT            ;SET NEW STATE PTR
  00701'026422           LDA     1,@VCTP
  00702'046030           STA     1,@STACK        ;SAVE OLD ERROR RETURN
  00703'024417           LDA     1,SXTP
  00704'046417           STA     1,@VCTP         ;NOW ERRORS COME HERE
  00705'002713           JMP     @PARET          ;TRY TO PARSE SUBEX
                 ;
  00706'126400 ENDX:     SUB     1,1             ;FLAG SUCCESS
  00707'034030 SUBXT:    LDA     3,STACK
  00710'021400           LDA     0,0,3           ;GET OLD ERROR RETN
  00711'042412           STA     0,@VCTP
  00712'175400           INC     3,3
  00713'031400           LDA     2,0,3           ;GET OLD STATE PTR
  00714'050020           STA     2,STPT
  00715'175400           INC     3,3
  00716'054030           STA     3,STACK         ;TIDY STACK
  00717'125004           MOV     1,1,SZR         ;TEST FOR FAIL
  00720'002650           JMP     @FALE
  00721'002646           JMP     @SUX
  00722'000707' SXTP:    SUBXT
  00723'000413' VCTP:    VECTAB+1
       000012            .BLK    10.
       000736'           STAK=.
                 ;
                 ;
       000000'           .END    TESTP
```

```
---
ALC       000274'
ALPH      000500'
ALPH.     000001
ANY       000615'
ANY.      000006
ASCA      000572'
ASCSP     000533'
ASCTB     000534'
ASCZ      000573'
BCNT      000535'
CHAR.     000001-
CM        000000U
CML       000060'
DD        000000U
DEVI      000230'
DNUMB     000621'
DSAVE     000452'
DTEM      000451'
DZ        000000U
ELOOP     000600'
END       000425'
ENDIT     000366'
ENDST     000522'
ENDX      000706'
ENDX.     000010
END.      000000
EOF       000576'
EOFT      000607'
EOF.      000004
FALE      000570'
FAYL      000470'
GOODP     000034'
IDMSK     000000-
KEYWD     000551'
KEY.      000003
KE.       000000U
KTEM      000574'
LAMDA     000575'
LASTD     000450'
LOOPP     000010'
MCHKY     000556'
MTCH.     000005
N1        000211'
N2        000215'
N3        000221'
N4        000235'
N5        000242'
N6        000256'
NULL.     000477'
NUMB.     000002
NUM.      000002-
NXD       000571'
NXDAT     000430'
NXKEY     000536'
OPTS      000247'
ORE       000000U
PARET     000620'
PARSE     000367'
PARSG     000402'
PARSI     000003-
```

```
---
PRMPT   000054'
PRO     000300'
SPRO    000305'
STACK   000030
STAK    000736'
START   000202'
STKPT   000411'
STPT    000020
STRNG   000510'
STRPT   000201'
SUBX    000674'
SUBXT   000707'
SUBX.   000007
SUX     000567'
SUXEX   000454'
SUXM    000036'
SUXS    000460'
S
 UXX    000566'
SXTP    000722'
TESTP   000000'
TSAVE   000453'
TTIPT   000044'
TTOPT   000050'
TXPT    000021
U1      000343'
U2      000347'
U3      000354'
U4      000360'
U5      000365'
UIC     000336'
ULL.    000000U
VCTP    000723'
VECTA   000412'
.EC10   000666'
.EC11   000667'
.EC20   000670'
.EC21   000671'
.EC22   000672'
.EC23   000673'
.EC40   000571'
.EC50   000660'
.EC95   000651'
.EC96   000637'
.EC97   000635'
```

APPENDIX V

GLOSSARY OF TERMS

BNF:	Backus-Naur Form, a method to describe languages.
FINITE-STATE GRAMMAR:	A set of rules which define a language in which there are a finite number of combinations of elements.
FINITE-STATE PARSER:	A mechanism to determine whether input data conforms with a given finite-state grammar.
FORMALISM:	Formal structure.
GRAMMAR:	Rules defining a language.
META-COMPONENT:	Parts of a language being defined in BNF.
META-LANGUAGE:	A language which can be used to describe languages.
OBJECT:	A mark or symbol which is a basic undefinable element of the language being described; in particular, a string of letters may become a basic symbol independent of the individual letters from which it is composed.
PARSER:	A mechanism for deciding whether input data conforms to a particular grammar.
PHRASE-STRUCTURE GRAMMAR:	A set of rules which define a language by building more complex structures from aggregations of elements and other structures.
PSEUDO-OBJECT:	A meta-component which, although built up from objects, is a useful conceptual unit and can be treated as though it was itself an object.
REGULAR GRAMMAR:	A finite-state grammar.
SEMANTICS:	The meaning of constructs in a grammar; their significance in the context in which they are used.
STATE TABLE:	A data table which can direct a finite-state parser by specifying how the elements of the language must be combined.
SYNTACTIC TYPE:	An object or pseudo-object.
SYNTAX:	The arrangement of elements of a language according to its grammar.
TRANSITION TABLE:	State table

```
1  :  <letter>          ; meta-component
        2               ; target
      <anything else>   ; next meta-component
        5               ; its target
2  :    =               ; first meta-component of
        3               ; new state
      <anything else>
        5
3  :  <letter>
        4
      <anything else>
        5
4  :  <operator>
        3
      <null>
        6
      <anything else>
        5
5  :  ERROR
6  :  SUCCESS
```

Figure 1(a)

```
1  :  <letter>          ; meta-component
        2               ; target
        -1              ; end of state
2  :    =
        3
        -1
3  :  <letter>
        4
        -1
4  :  <operator>
        3
      <null>
        6
        -1
6  :  SUCCESS
```

Figure 1(b)

Figure 1. Evolution of list structure

DISTRIBUTION

	Copy No.
EXTERNAL	
Chief Defence Scientist	1
Executive Controller, Australian Defence Scientific Service	2
Superintendent, Defence Science Administration	3
Assistant Secretary, Defence Information Services (for microfilming)	4
Defence Library, Campbell Park	5
Library, Aeronautical Research Laboratories	6
Library, Materials Research Laboratories	7
Director, Joint Intelligence Organisation (DDSTI)	8
Dr R. Vincent, Physics Department, University of Adelaide	9
Director, Mawson Institute for Antarctic Research	10
Documents distributed through ASDIS	
United Kingdom, for Ministry of Defence, Defence Research Information Centre (DRIC)	11
United States, for Department of Defense, Defense Documentation Center	12 - 24
Canada, for Ministry of Defence, Defence Science Information Service	25
New Zealand, for Ministry of Defence	26
Australian National Library	27
INTERNAL	
Director	28
Chief Superintendent, Applied Physics Wing	29
Superintendent, Electronics Division	30
Principal Officer, Cybernetic Electronics Group	31
Principal Officer, Radar and Electronic Tracking Group	32
Principal Officer, Jindalee Group	33
Principal Officer, Radio Group	34
Principal Officer, Electro Optics Group	35
Principal Officer, Laser Group	36
Principal Officer, Underwater Detection Group	37
Principal Officer, Systems Integration Group	38
Principal Officer, Communications Technology Group	39
Principal Officer, Central Test House	40
Principal Officer, Computer Aided Processes Group	41
Principal Officer, Microelectronics and Computer Applications Group	42
Principal Officer, Computing Services	43
Principal Officer, Planning and Data Analysis Group	44

	Copy No.
Mr. P.C. Drewer, Cybernetic Electronics Group	45
Mr. J.C. Mackenzie, Cybernetic Electronics Group	46
Mr. W.J. Rundle, Cybernetic Electronics Group	47
Mr. J.F. Duffield, Cybernetic Electronics Group	48
Author	49 - 50
Library, W.R.E.	51 - 52
Spares	53 - 69