AN EVALUATION OF ML/I (EPS) MACROS FOR STRUCTURED FORTRAN EXTENSIONS

by

Soo Kyung Park

B.A., Ewha Womans University, 1968

A MASTER'S REPORT

Submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas
1977

Approved by:

William Hankley
Major Professor

TABLE OF CONTENTS

I. Introduction

A. Purpose of Paper 1

B. Organization 2

II. Macro Preprocessor for FORTRAN Extensions

A. Design Considerations 4

B. Control Structures 6

C. Use of the ML/I Macro Preprocessor 10

III. Implementation

A. Introductory Features of ML/I 13

B. Definition of Macros 21

C. How to Execute the Preprocessor 32

D. User Constraints 37

IV. Evaluation

A. Problems of Macro Definition 44

B. Time and Size of Macros 56

C. Conclusions 56

APPENDIX

A. Sample Structured FORTRAN program(TEST SFORT) . A- 1

B. Macro Listings(SOOMACRO EPS) .... A- 3

C. Listing of SOO EXEC procedure .... A- 5

D. Listing of a Sample EPSIN EPS .... A- 7

E. Listings of Sample Structured FORTRAN output from EPS II A-10

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

FIGURES

Figure II.1 For Use of ML/I Macro Preprocessor 11

Figure III.1 The Description of the File EPSIN EPS 34

Figure III.2 Files Processed by SOO EXEC Using EPS II ... 35

Figure IV.1 NEXT/QUIT Examples 46

Figure IV.2 IF...FI Examples 52

Figure IV.3 Examples for CASE...ENDCASE 54

I. INTRODUCTION

A. PURPOSE OF PAPER

The objective of this project is to investigate the use of a general purpose macro processor to implement structured programming extensions to FORTRAN.

The use of macro processors has developed since the 1950's. Using macro processors to modify or extend a compiler language has since occured to many programmers. Text replacement has been the most distinguishing property of macro processors.

ML/I (Bro67) is a powerful macro processor for conveniently extending source languages. It has been used as a preprocessor to several compilers and assemblers. Its operation is to interprete macro definitions and translate input text to output text. Input to the macro processor is in the form of macro definitions and source text. The output text is derived from the source text by replacing all the macro calls that occur in it.

A version of ML/I, EPS II, is now available at KSU. This system is a load module written in IBM system/360 assembler language. EPS II can be run interactively under CMS.

The idea of introducing structured programming extensions of FORTRAN is not new. There has been a growing awareness of the need to improve unstructured FORTRAN since the 'structured programming' became an important issue in the computer world.

Many well-formed FORTRAN extensions have been defined by eliminating the GO TO and using only sequential statements and control structures in the form of block structures. By using ML/I, structured programming can be implemented to FORTRAN without changing over to a completely new compiler.

For this study, a set of macro extensions to FORTRAN will be defined and tested through EPS II. The main study area for structured programming will be focussed on IF THEN ELSE, CASE, WHILE, etc. Also, the efficiencies in terms of time using the macro processor will be investigated and evaluated.

B. ORGANIZATION

The purpose of this paper has been briefly introduced at the beginning. The remainder of this paper is organized as follows. The second section presents the design impact of structured extension to FORTRAN. The extended control structures are described with the use of the macro preprocessor. The third section discusses the implementation procedures which could be viewed as the documentation for the user. Included is explanation of selected features of ML/I. All the macro definitions will be displayed and the process of execution will be shown. In the fourth section, use of ML/I will be evaluated. The problems in defining macros, timing and size, etc, will be topics of discussion. The possibility of further development for FORTRAN extensions using ML/I and future trends will also be mentioned. The last part of this paper is an appendix which includes a list of macros defined and a test program listing.

II. MACRO PREPROCESSOR FOR FORTRAN EXTENSIONS

A. DESIGN CONSIDERATIONS

Since the term 'structured programming' was first used by Dijkstra (Dij72), the trend has been away from the study of low level languages towards the study of higher levels of programming language structures. A great deal has been published recently about the theory of structured programming.

A broadly drawn list of ideas that have been considered to be aspects of structured programming was given by Abrahams (Abr75). Among those ideas, the notion that GO TO statements must be eliminated became one of the vital points in structured programming. In other words, a high density of GO TO's in a program generally indicates poor programming. So, there has been considerable interest in the possibility of replacing GO TO statements in a program with structured control statements such as IF THEN ELSE, CASE, DO WHILE, to make programs easier to compose, understand and modify.

Without exception, the elimination of GO TO movement has had a strong effect on FORTRAN. Many efforts have been made to define a well-formed FORTRAN through modification or extension. So, instead of attempting the extensive modification of a existing FORTRAN compiler, many language designers invented a FORTRAN-like structured language. By producing a preprocessor or a translator, programs written in this structured language are converted into statements that any existing FORTRAN compiler will accept.

A number of preprocessors and other extensions of FORTRAN have been implemented, such as MORTRAN (Coo76), a structured FORTRAN translator (Hig75), and SFOR which is a precompiler for the implementation of a FORTRAN-based structured language (O'n74). Many attempts have been made to implement the FORTRAN extensions using a macro processor.

ML/I is a macro preprocessor designed for portability. It is written in the descriptive language, LOWL, which is similar to a high-level language. It can be translated into the assembly language of any computer or into a high level language. ML/I was designed for transportability between different computers with differing architectures. Using the bootstrapping technique ML/I has been implemented on a large number of machines. One of these implementations is EPS II on IBM system/360.

ML/I, a general purpose macro processor, is intended to allow the user to extend any language. The fact that ML/I is independent of any base language provides the possibility that it could be used as a preprocessor to the FORTRAN compiler.

The main consideration in this paper is to develop the well-formed structured FORTRAN extensions and to determine the suitability of ML/I for FORTRAN extensions. ML/I is the appropriate preprocessor to use for this study because of its base language independence.

B. CONTROL STRUCTURES

The major constructs of structured FORTRAN extensions which will be implemented by ML/I fall into two categories. One is looping control structures such as LOOP...ENDLOOP, QUIT...LUP and NEXT...LUP. The second category is selection control structures such as IF...FI, SIF...FI and CASE...ENDCASE. The design of these structures is effected by macro definitions. The listing of a sample structured FORTRAN program is included in the Appendix A. The following terms are used:

Li --- statement label, i=1,2,...,n

Lexpi --- logical expression, i=1,2,...,n

Si --- block of statements, i=1,2,...,n

Looping control structures:

The repetition statements are tested within looping structure. If the value of the logical expression is changed within the block, the loop immediately terminates. An abnormal exit is also provided. The statement has the following form with the right side target FORTRAN code being generated by the left side statements.

1. LOOP...ENDLOOP:

Source Pattern	Target FORTRAN
LOOP L1 WHILE Lexp1 DO S1 ENDLOOP	L1 IF (.NOT.(Lexp1)) GO TO L2 S1 GO TO L1 L2 CONTINUE

The keyword delimiter pattern, 'LOOP...WHILE...DO', defines the beginning of a repetition loop. The logical expression, Lexp1, will be evaluated before entering the loop which will be executed as long as the logical expression is true. The ENDLOOP forms a boundary between the preceding and following groups of statements. Any other sequential statement, selection structure or loop structure may be nested within this loop.

2. QUIT...LUP:

Source Pattern	Target FORTRAN
QUIT L1 LUP	GO TO L2

Where L1 and L2 are the same labels in LOOP...ENDLOOP. The above statement should be nested within the loop structure, LOOP...ENDLOOP. LUP is used instead of LOOP because LOOP is the macro name in LOOP...ENDLOOP and the macro name can not be defined as the delimiter within another structure. This control statement should be nested within selection structure. This statement could be defined for the abnormal termination of the loop in which it is nested. The flow of control always points to ENDLOOP. So, the LOOP...ENDLOOP could have two different exit points. This, QUIT...LUP, statement is very useful to immediately jump to the outside of the loop.

3. NEXT...LUP:

Source Pattern	Target FORTRAN
NEXT L1 LUP	GO TO L1

The label L1 should be the same as the one at the loop entry point, LOOP...ENDLOOP. The statement above is used to pass the flow of control to the entry point of the loop structure, LOOP...ENDLOOP. The rest of the statements following the NEXT...LUP, within the LOOP...ENDLOOP, will be ignored whenever this statement executes.

Selection control structures:

These structures allow the programmer to test some logical conditions and perform a block of code depending on the truth value of the condition.

4. IF...FI:

Source Pattern	Target FORTRAN
IF Lexp1 THEN S1 ELSE S2 FI	IF (Lexp1) GO TO L1 S2 GO TO L2 L1 S1 L2 CONTINUE

A structured IF statement contains a group of executable statements and one of two blocks of code to be performed. The keyword, IF, followed by a logical expression causes a transfer of control to the next statement which is followed by THEN, if the expression is true. Otherwise, it causes a transfer of control to the statement following ELSE. The structure ends with a FI statement.

5. SIF...FI:

Source Pattern	Target FORTRAN
SIF Lexp1 THEN S1	IF (.NOT.(Lexp1)) GO TO L1
FI	S1
	L1 CONTINUE

If the expression is true, SIF causes a transfer of control to the statement following THEN. Otherwise, the false path consists of transferring control directly from the SIF to the statement following FI. SIF stands for Small IF.

6. CASE...ENDCASE:

Source Pattern	Target FORTRAN
CASE L1	IF (.NOT.(Lexp1)) GO TO L2
GUARD Lexp1 DO	S1
S1	GO TO L1
GUARD Lexp2 DO	L2 IF (.NOT.(Lexp2)) GO TO Ln
S2	S2
GUARD Lexpn DO	GO TO L1
Sn ENDCASE	Ln IF (.NOT.(Lexpn)) GO TO L1
	Sn
	L1 CONTINUE

A case structure begins with a CASE statement containing a label. Each block of statements must be preceeded by a GUARD statement which is followed the logical expression to be evaluated. If the comparison is not true, the control transfers to the next GUARD. If no match has occured after all the logical expressions are examined, control passes to the ENDCASE point. Any other control structures and selection structures may be nested within a CASE structure.

C. USE OF THE ML/I MACRO PREPROCESSOR

The use of macro processors has developed since the early days of programming starting with very simple text replacement facilities and usually in conjunction with assembler language programs. Macros are a rather new features in high-level languages. A number of macro processors have been developed for use with particular high-level languages. In these systems, the macro processor is used as a prepass to the compiler. The general purpose macro processor has been used as a tool to implement high-level language extensions.

Among several different macro processing systems, the macro processor used in work is EPS II, a version of ML/I which is a general purpose macro processor. The ML/I macro processor is essentially designed to be independent of any particular compiler, and thus is useful as a preprocessor for many different languages. ML/I has been used in a variety of different applications, the most common are the extension of existing programming languages and for systematic editing. ML/I is a string handling processor and it is designed to be bootstrapped on to different computer systems.

ML/I could be implemented as a preprocessor to the FORTRAN compiler for the target language, FORTRAN. Figure II.1 shows a general description for use of the ML/I macro preprocessor. The input to the macro preprocessor is a source program written in extension FORTRAN with macro definitions and calls. The output from the macro preprocessor is the FORTRAN program with the macro definitions deleted and the macro calls expanded. This FORTRAN source program is input to the FORTRAN compiler for execution.

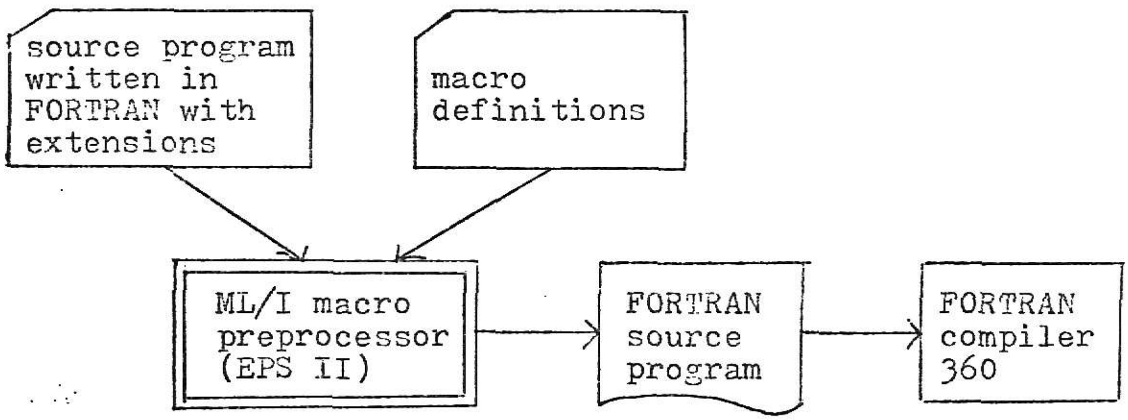


Figure II.1. For use of ML/I macro preprocessor

ML/I interprets its input as a stream of atoms and produces as its output another stream of atoms if no macros are invoked. An exception occurs when macro calls are in the input stream, as they are evaluated and the translated tokens are put into the output stream.

There are many useful features in ML/I. This system is intended to allow the user to define his own notation for writing macro calls in order to extend a language (Bro67). Macro calls must commence with the macro name. ML/I organizes a macro by the occurrence of its name and a macro call is taken as the text from the macro name up to its closing delimiter. The user could specify any sequence of characters for each delimiter. The user could define a complex delimiter structure specifies for each delimiter a successor or set of alternative successors. It is possible to have nested macro calls within the arguments of other macro calls. The primary use of ML/I is to allow any existing language to be extended to suit a particular users' requirements. The detailed description of ML/I with its instructions will be presented in the next section.

III. IMPLEMENTATION

A. INTRODUCTORY FEATURES OF ML/I

This section will describe the main features of ML/I with some examples and explain some of the ML/I instructions which will be used for the macro definitions in this paper. For details refer to the EPS II Users Manual (EPSUM).

ML/I terminology:

The user inputs to ML/I some text and definition macros. ML/I performs textual changes; the text generated as a result of the changes is called the value text. The text being evaluated is called the scanned text.

Character set:

ML/I contains the character set for letters, numbers, and some punctuation characters. Space (blank) is treated as a punctuation character. ML/I acts on atoms rather than individual characters. An atom is defined as a single punctuation character or a sequence of letters and/or numbers surrounded by punctuation characters.

Macros and delimiter structure:

System defined macros are called operation macros. The user defines other macros. Each macro must be defined before it is called. When defining a macro the user specifies starting and stopping delimiters and definitions for arguments. Any sequence of atoms could be used for each delimiter. The macro name, that is, the name delimiter, is called the zeroth delimiter, and the remaining delimiters are called secondary delimiters and closing delimiter. A macro call consists of a macro name and a list of arguments and delimiters. This can be shown as a structure representation:

IF arg1 THEN arg2 ELSE arg3 FI

The delimiter structure of this macro consists of IF as the name delimiter, and THEN, ELSE and FI as the secondary delimiters, and FI is also the closing delimiter. Macro calls could be expanded to several lines of text.

<u>Inserts:</u>

This construction is used to insert a particular argument at the appropriate point. An insert definition consists of an insert name and a closing delimiter, as:

%A2.

In this example the atom '%' is an insert name with the atom '.' as its closing delimiter. The value text must consist of a flag, which is 'A' in the above example, followed by a macro expression '2'. The various flags used for the macro definition are as follows:

A --- This flag is used within the replacement text of a macro to evaluate and insert the Nth argument of a call of the macro.

D --- The Nth delimiter is inserted.

L --- This is used to place a macro label which is local to the piece of text in which it occurs. This is the subject of macro-time GO TO statement and its value is null.

Skips:

Skips are used to inhibit macro replacement within the required context and to take certain strings as literals. A skip definition consists of a skip name and a closing delimiter. There is only one argument, which is treated as a single literal string. Three kinds of option could be defined within skips:

M --- Matched option. This is applied where it is desirable for nested skips to be recognized.

D --- Delimiter option. The delimiters of the skip are copied over to the value text.

T --- Text option. The arguments of the skip are copied over to the value text.

Depending on how the options are set up, the value text may appear in the output text. As an example the macro '< >' is defined with option MT. If the scanned text is given as follows:

<HELLO>

The skip name is '<' and the closing delimiter is '>'. The argument 'HELLO' is copied over to the value text. This special skip name and closing delimiter are called as literal brackets.

Macro variables:

These variables are macro-time integer variables. The user may perform arithmetic on these variables and insert their values into the output text. The two kinds of macro variables are described below:

Permanent variables --- called P1, P2, ...

These have global scope and can be referred to anywhere. They are reserved at the start of each process and remain in existance throughout.

Temporary variables --- called T1, T2, ...

These have a local scope. Each time a user-defined macro is called, a number of temporary variables is allocated. These are local to the current call. The initial values of three temporary variables are defined by ML/I as for each call:

T1 --- The number of arguments in this call.

T2 --- The total number of all macro calls to this point. (including operation macros)

T3 --- The current depth of nesting of macro calls. (excluding operation macros)

Operation macros:

A number of built-in macros form an integral part of ML/I. The names of all operation macros begin with the letters 'MC' to minimize the confusion with the user-defined macros. A call of an operation macro causes a definition of new constructions or a performance of macro-time arithmetic, etc. The primary operation macros are the followings:

1. MCDEF --- Definition of a local macro, as:

MCDEF arg1 AS arg2

Where arg1 must be in the form of a structure representation which specifies delimiter structure, and arg2 specifies the replacement text of the macro being defined.

Example:

MCDEF HOUSE AS HOME

By this definition all the occurrences of 'HOUSE' in the source text will be replaced as 'HOME'.

2. MCINS --- Definition of a local insert, as:

MCINS arg1

Where arg1 must be a structure representation.

Example:

MCINS /*

'/' defines the insert delimiter and '*' is the closing delimiter. Calling this insert macro adds a new local insert definition to the current environment.

3. MCSKIP --- Definition of a local skip, as:

MCSKIP [arg1,] arg2

Where arg1 is represented as M, D, or T and it is optional, and arg2 must be a structure representation.

Example:

MCSKIP OLD

This call of macro deletes all occurrences of 'OLD'.

4. MCSET --- Macro-time assignment statement, as:

    MCSET arg1 = arg2

Where arg1 must be the name of a macro variable in the current text. Arg2 is a macro expression.

Example:

    MCSET T1 = /A*

The value of T1 is set to the value of inserted argument A1.

5. MCGO --- Macro-time GO TO statement, as:

    MCGO arg1
    MCGO arg1 IF arg2 = arg3

Where arg1 must consist of the 'L' followed by a macro expression. MCGO can be used to form macro-time loops. A true value results if arg2 and arg3 are identical strings of characters.

Example:

    MCGO L1

This statement is the same as GO TO L1 in macro-time.

    MCGO L4 IF /D1* = NEW

If the value of inserted delimiter 1 is identical to 'NEW', then the control goes to L4.

6. MCLISTS --- This operation macro enables the programmer to get a complete listing of the source program.

7. MCLISTT --- The programmer can get a complete listing of the target program.

8. MCSTOP --- Terminate ML/I processing. The MCSTOP macro causes the control to return to the calling program.

Keywords:

Within a structure representation the certain keywords are used to stand for layout characters, for example spaces, newlines, tabs. The layout keyword could be specified as a delimiter within structure representations. These are SPACE, TAB, SPACES, and NL. There are other keywords such as WITH, WITHS, OPT, OR, ALL and any atom commencing with the letter 'N' followed by a digit, none of which can be used as delimiters in structure representations.

Complex structure representation:

In order to define a complicated delimiter structure, there is a mechanism for specifying successors, namely option lists and nodes. Option lists are used to specify that a delimiter has several optional alternatives as successor. The essential form is:

OPT branch1 OR branch2 OR ... OR branchN ALL

The branch is one of the alternative successors following the delimiter which is defined right before this option list. Nodes are used for defining the successor of a delimiter to be a delimiter or option list elsewhere in the structure representation. The following example illustrates this:

Example:

IF N1 OPT THEN N1 OR ELSE N1 OR FI ALL

In this structure representation, the first N1 before the option list is the nodeplace. A node is placed by writing its name before any delimiter name or option list. The second and the third N1 are the nodego. The nodego is placed after the end of a branch of an option list or after an option list.

The components of structure representation will be described as follows:

Nodeplace --- The placing of a node.

Nodego --- The action of going to a node.

Delspec --- The specification of a delimiter or an option list.

The notations which are used in the EPS II User Manual indicate parts of syntactic forms:

* --- Constituents may be repeated.

? --- Constituents may be omitted.

*? --- Constituents may be repeated or omitted.

Structure representation of Delspec:

```
                  [delimiter name]
[nodeplace ?]
                  [OPT branch  [OR  [nodeplace ?] branch *?]  ALL]
```

branch:

```
        delimiter name  [delspec *?] [nodego ?]
```

This structure representation will be used for the macro definitions following this part.

B. DEFINITION OF MACROS

The following macro definitions are made to facilitate structured FORTRAN programming. Each of the macro definitions will apply an operation macro at the beginning. The replacement text also includes a number of operation macros. Ten macro definitions will be explained thoroughly with some examples. The listing of macros is included in the Appendix B.

1. MCINS %.

This macro is used to add a new local insert definition to the current environment. '%' defines the insert delimiter and '.' is the closing delimiter. The insert macro must be in replacement text. Whenever this macro appears within replacement text, a new value is generated and inserted.

Example:

%A2.

The second argument (A2) within the structure representation will be inserted to the value text.

%D1.

The second delimiter (D1) which is the first secondary delimiter in the structure representation will be inserted.

2. MCSKIP MT, < >

The MCSKIP macro is used to ignore some of the macro names or to skip the scanning of some character strings. The matched and text options are set. The skip name '<' with closing delimiter '>' is defined as a pair of literal brackets.

If this matched option is on, the nested brackets can be scanned. The text option will literally copy a piece of text over to the value text and the delimiters, ' ' and ' ', will be deleted.

Example:

```
MCDEF <NEXT LUP> AS <MCSET T1 = 100
<GO TO> %T1.>
```

The structure representation of the macro definition following MCDEF will be enclosed within the brackets from now on. This saves confusion with the macro name whenever it needs to be redefined or modified. This is discussed later in section IV.

In the example, the second '<' matches with the last '>' and the nested '<' matches with '>' following GO TO. The character string GO TO will be copied over to the value text as a literal without '< >'. The value text will be 'GO TO 100'. The replacement text can involve one or more newlines by using these literal brackets. To obtain some literal string in the output text, it is advisable to use the literal brackets around the string in the definition.

3. MCSET P1 = macro expression

The value of the permanent variable will be set to value of expression. The value of P1 remains as a global throughout all of the scanned text.

Example:

```
MCDEF <IF THEN FI> AS <MCSET T1 = P1
MCSET P1 = P1 + 1>
```

The value of the temporary variable T1 will be set to the value of P1 which is already defined. The value of P1 will be incremented by 1 by the second macro-time assignment statement.

4. MCDEF ⟨;⟩ AS⟨
b̸b̸b̸b̸b̸⟩

Where b̸ denotes a blank. This macro is defined in order to write more than one statement per line of source text. The macro name, semicolon, is replaced by a newline with five blanks. Whenever the semicolon appears with a statement in the source text, the next statement following the semicolon will be printed on the next line of the output text.

Example:

```
col. 7
↓
A = B;b̸B = C;b̸C = D;b̸b̸D = E          (source)
A = B                                  (output)
B = C
C = D
b̸D = E
```

The first statement in the source text starts from column 7 and the rest of the statements follow with a semicolon and a blank except the last one which has two blanks after the semicolon. The output text starts from column 7 by this macro definition, except that the last statement starts in column 8.

Note: Need a blank after the semicolon.

5. QUIT...LUP

Structure:

QUIT -- LUP

Macro definition:

MCDEF <QUIT LUP>

AS <MCSET T1 = %A1. + 1

<GO TO> %T1.>

The delimiter structure of this macro starts from the macro name QUIT with the closing delimiter LUP. Within the replacement text the value of the temporary variable T1 is assigned by the macro-time assignment statement MCSET. This value of T1 is used for the statement label which points to the end of the enclosed loop.

Example:

(source)	(output)
QUIT 500 LUP	GO TO 501

6. NEXT...LUP

Structure:

NEXT -- LUP

Macro definition:

MCDEF <NEXT LUP>

AS <<GO TO> %A1.>

The macro name NEXT with the closing delimiter LUP will be replaced by a GO TO statement. The inserted value of the argument one (A1) points to the entry of the loop in which this NEXT macro is nested.

Example:

(source)	(output)
NEXT 500 LUP	GO TO 500

7. LOOP...ENDLOOP

Structure:

```
SPACE WITHS LOOP -- WHILE -- DO WITHS NL --

  ┌- ENDLOOP ----------┐
--┤                    │
  └- NL WITHS ENDLOOP -┘
```

Macro definition:

```
MCDEF <SPACE WITHS LOOP WHILE DO WITHS NL
OPT ENDLOOP OR NL WITHS ENDLOOP ALL>
AS <MCSET T1 = %A1. + 1
  %A1. <IF> (.NOT.(%A2.)) <GO TO> %T1.
       %A3.
       <GO TO> %A1.
  %T1. CONTINUE>
```

The keywords SPACE WITHS within the macro name SPACE WITHS LOOP specifies an arbitrary number of spaces in front of the atom LOOP. This macro call makes the space adjustment possible at the beginning of the replacement text. It means that the inserted argument %A1. in the second statement of the replacement text can appear in the same column of the source text. The third delimiter DO WITHS NL is always followed by a newline of the source text. The closing delimiter is defined within the option list. ENDLOOP follows the last statement of argument 3 on the same line. NL WITHS ENDLOOP begins from the newline which is followed by the last line of argument 3. Argument 1 is specified for the statement label and argument 2 is specified for the logical expression.

Examples:

```
          (source)                          (output)
a.  LOOP 500 WHILE A.EQ.B DO      500 IF (.NOT.(A.EQ.B)) GO TO 501
    B = C                             B = C
    D = B                             D = B
    ENDLOOP                           GO TO 500
                                  501 CONTINUE

b.  LOOP 500 WHILE A.EQ.B DO      500 IF (.NOT.(A.EQ.B)) GO TO 501
    B = C                             B = C
    D = B  ENDLOOP                    D = B
                                      GO TO 500
                                  501 CONTINUE
```

8. IF...FI

Structure:

```
        ┌- THEN ----------┐ ┌- ELSE ----------┐
  IF  --┤                 ├-┤                 ├--
        └- NL WITHS THEN -┘ └- NL WITHS ELSE -┘

      ┌- FI ----------┐
    --┤               │
      └- NL WITHS FI -┘
```

Macro definition:

```
MCDEF ⟨IF OPT THEN OR NL WITHS THEN ALL
OPT ELSE OR NL WITHS ELSE ALL
OPT FI OR NL WITHS FI ALL⟩
```

```
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
MCSET P1 = P1 + 1
MCSET T2 = P1
%WDO. (%A1.) <GO TO> %T1.
      %A3.
      <GO TO> %T2.
  %T1. %A2.
  %T2. CONTINUE>
```

All the secondary delimiters in this IF macro have an alternative successor which is defined within the option list. This IF macro can be written in one line of the source text or written over several lines each beginning with a secondary delimiter. Within the replacement text, the permanent variable P1 is updated to keep track of the value of the statement labels which will be unique throughout the source text. The values of T1 and T2 are temporarily assigned the value of P1 and used for the statement label within the current scanned text. 'W' in %WDO. stands for 'Written'. DO is the delimiter zero which is the macro name. If W is prefixed to D, the inserted text which is the macro name in this case is not evaluated but is inserted literally. (This insert is identical to that of the character string IF, which could have been inserted directly with using the %WDO..)

Examples:

```
          (source)                              (output)

a. IF A.EQ.B THEN C = B ELSE C = A FI      IF (A.EQ.B) GO TO 101
                                           C = A
                                           GO TO 102
                                       101 C = B
                                       102 CONTINUE

b. IF A.EQ.B                               IF (A.EQ.B) GO TO 103
   THEN C = B                              C = A
   ELSE C = A                              GO TO 104
   FI                                  103 C = B
                                       104 CONTINUE
```

9. SIF...FI

Structure:

```
        r- THEN ----------- r- FI ----------
SIF --[                   ]--[                ]
        L- NL WITHS THEN -- L- NL WITHS FI --
```

Macro definition:

```
MCDEF <SIF OPT THEN OR NL WITHS THEN ALL
OPT FI OR NL WITHS FI ALL>
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
<IF> (.NOT.(%A1.)) <GO TO> %T1.
      %A2.
  %T1. CONTINUE>
```

The macro name SIF stands for Small IF. The reason this SIF is defined seperately from the IF macro will be explained with examples in the next section. The SIF macro definition is similar to the IF macro except the SIF macro doesn't have the alternative statement ELSE.

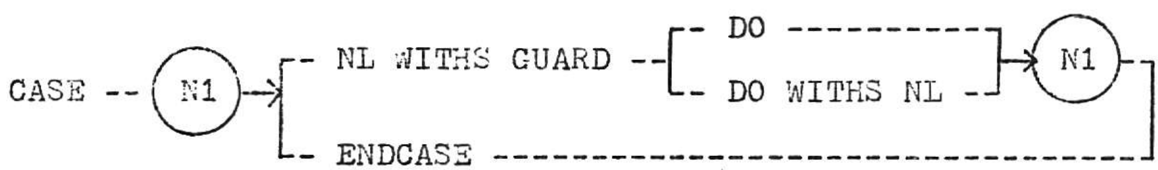
Example:

```
        (source)                        (output)
a. SIF A.EQ.B THEN C = B FI         IF (.NOT.(A.EQ.B)) GO TO 105
                                    C = B
                                105 CONTINUE

b. SIF A.EQ.B                       IF (.NOT.(A.EQ.B)) GO TO 106
   THEN C = B                       C = B
   D = A                            D = A
   FI                           106 CONTINUE
```

10. CASE...ENDCASE

Structure:



Macro definition:

```
MCDEF <CASE N1 OPT NL WITHS GUARD
OPT DO OR DO WITHS NL ALL N1 OR ENDCASE ALL>
AS <MCSET T1 = 1
MCSET T2 = 2
```

```
MCSET T3 = %A1.
<IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
%L1.MCSET T1 = T1 + 2
MCSET T2 = T2 + 2
MCSET T3 = T3 + 1
MCGO L2 IF %DT1+2. = <ENDCASE>
  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
MCGO L1
%L2.  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %A1.
      %AT2+1.
  %A1. CONTINUE>
```

The node N1 before OPT is the nodeplace. All the delimiters within the inner option list return a pointer to this nodeplace to search the next delimiter, NL WITHS GUARD, or the closing delimiter, ENDCASE. The node N1 after ALL is the nodego. It points to the nodeplace N1 to find the successor of the delimiter defined in the nested option list. In the replacement text, the initial values of the temporary variables are given at the beginning. T1 is used to check for the delimiter, NL WITHS GUARD, T2 checks for the argument between NL WITHS GUARD and the nested option list, DO, and T3 looks for the statement label. After testing the first NL WITHS GUARD delimiter, EPS scans iteratively the proper delimiter by the macro-time GO TO statement MCGO L1. This loop points to MCGO L2 if the search of the delimiter ends with ENDCASE. In the above macro definition, if the value of T2 is initially set to 2, the inserted value of %AT2+1. is same as %A3. and the value of argument 3 is inserted in the value text. The closing delimiter ENDCASE is always written in the next line of the last source statement. Following examples demonstrate the above explanation.

Examples:

(source)	(output)
a. CASE 500	IF (.NOT.(A.EQ.B)) GO TO 501
GUARD A.EQ.B DO C = A	C = A
GUARD A.LT.B DO C = B	GO TO 500
GUARD A.LT.C DO B = A ENDCASE	501 IF (.NOT.(A.LT.B)) GO TO 502
	C = B
	GO TO 500
	502 IF (.NOT.(A.LT.C)) GO TO 500
	B = A
	500 CONTINUE
b. CASE 500	IF (.NOT.(A.EQ.B)) GO TO 501
GUARD A.EQ.B DO	C = A
C = A	GO TO 500

```
GUARD A.LT.B DO            501 IF (.NOT.(A.LT.B)) GO TO 502
C = B                          C = B
GUARD A.LT.C DO                GO TO 500
B = A ENDCASE              502 IF (.NOT.(A.LT.C)) GO TO 500
                               B = A
                           500 CONTINUE
```

C. HOW TO EXECUTE THE PREPROCESSOR

The following part of this section will describe five steps to be used for running a structured FORTRAN program. Underlined commands are typed by the user.

Step 1. After logging on, the user should create or edit the structured FORTRAN. The sample structured FORTRAN program listing, TEST SFORT, is included in the Appendix A.

Step 2. All the files needed for the executing the preprocessor are stored in the file manager space for user VM2G8 (Dr. Hankley). The user needs to bring these files from the VM2G8 file space to the user's A-disk by following commands.

FMR SOOMACRO EPS (U VM2G8

FMR EPS MODULE (U VM2G8

FMR SOO EXEC (U VM2G8

The user now has 4 different files on A-disk including the file for the structured FORTRAN program. The file SOOMACRO

EPS contains all the macro definitions which were previously described. The listing of this file is included in the Appendix B. The program written by the user will be run through EPS MODULE for preprocessing. SOO EXEC is the EXEC procedure to combine all the commands used to preprocess the structured FORTRAN program. The listing of SOO EXEC is included in the Appendix C.

Step 3. The next command the user has to type is

S0O fn_ft1_ft2_

For example: 'SOO TEST SFORT WATFIV'

By this command, the EXEC procedure, SOO EXEC, will be executed. fn specifies the filename of the user's structured FORTRAN program, ft1 is the filetype of that input program, and ft2 is the filetype of the output file from EPS. fn, ft1 and ft2 correspond to &1, &2 and &3 respectively within the SOO EXEC procedure. The following is a brief explanation of the SOO EXEC procedure.

The new file, EPSIN EPS, is created by the COPYFILE command that puts the SOOMACRO EPS at the tope of the user's structured FORTRAN program. The Figure III.1 illustrates the file EPSIN EPS. The CMS editor adds an operation macro, MCSTOP, at the end of the EPSIN EPS. This macro will be needed to terminate EPS II processing after EPSIN EPS goes through the EPS II preprocessor and the control returns to the calling program, SOO EXEC. The listing of EPSIN EPS is in the Appendix D.

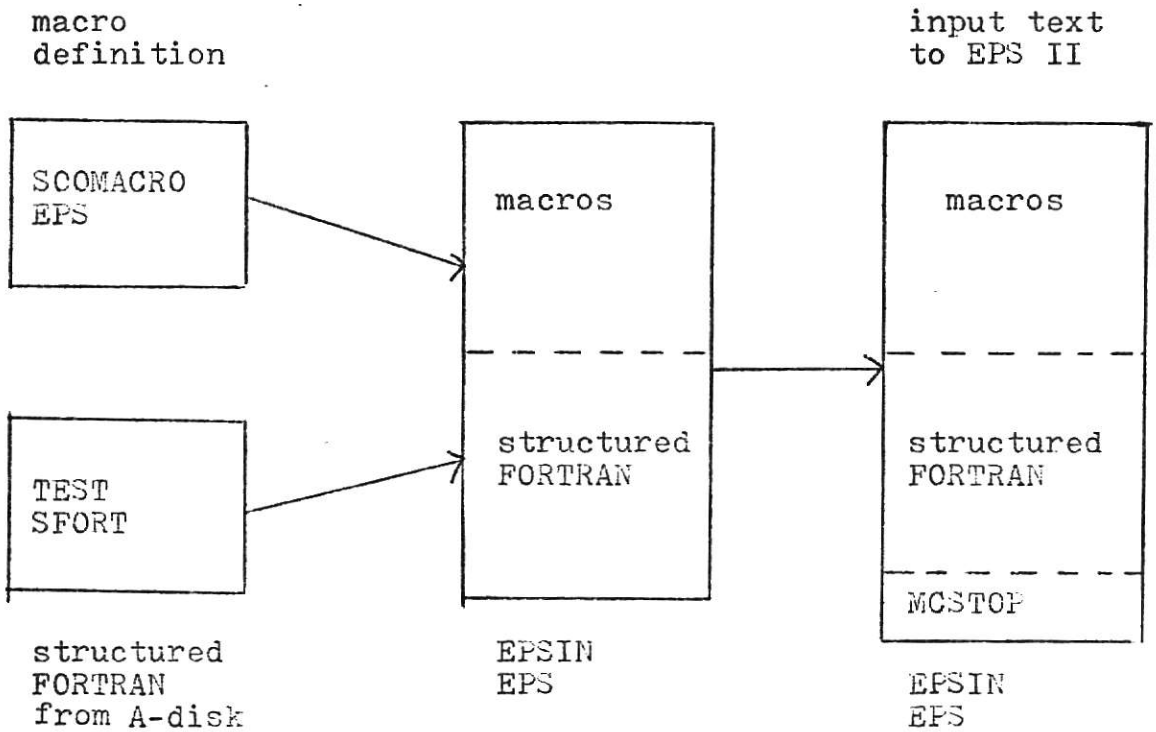


Figure III.1 The description of the file EPSIN EPS

EPS II provides six logical I/O files as illustrated in Figure III.2. One of the data definition names, M000, is as yet undefined. M001 is used for the input text EPSIN EPS. M010 signifies the error messages which will be displayed at the user's terminal whenever the errors are encountered. M011 is the input listing with line numbers which will be placed on the user's A-disk as file '&1 SFORTLST'. M012 is the output listing with line numbers which is defined as '&1 FORTLIST'. F027 designates the output to be used as the input to the FORTRAN or WATFIV compiler. The last three output files will be placed on the user's A-disk after the execution of S00 EXEC.

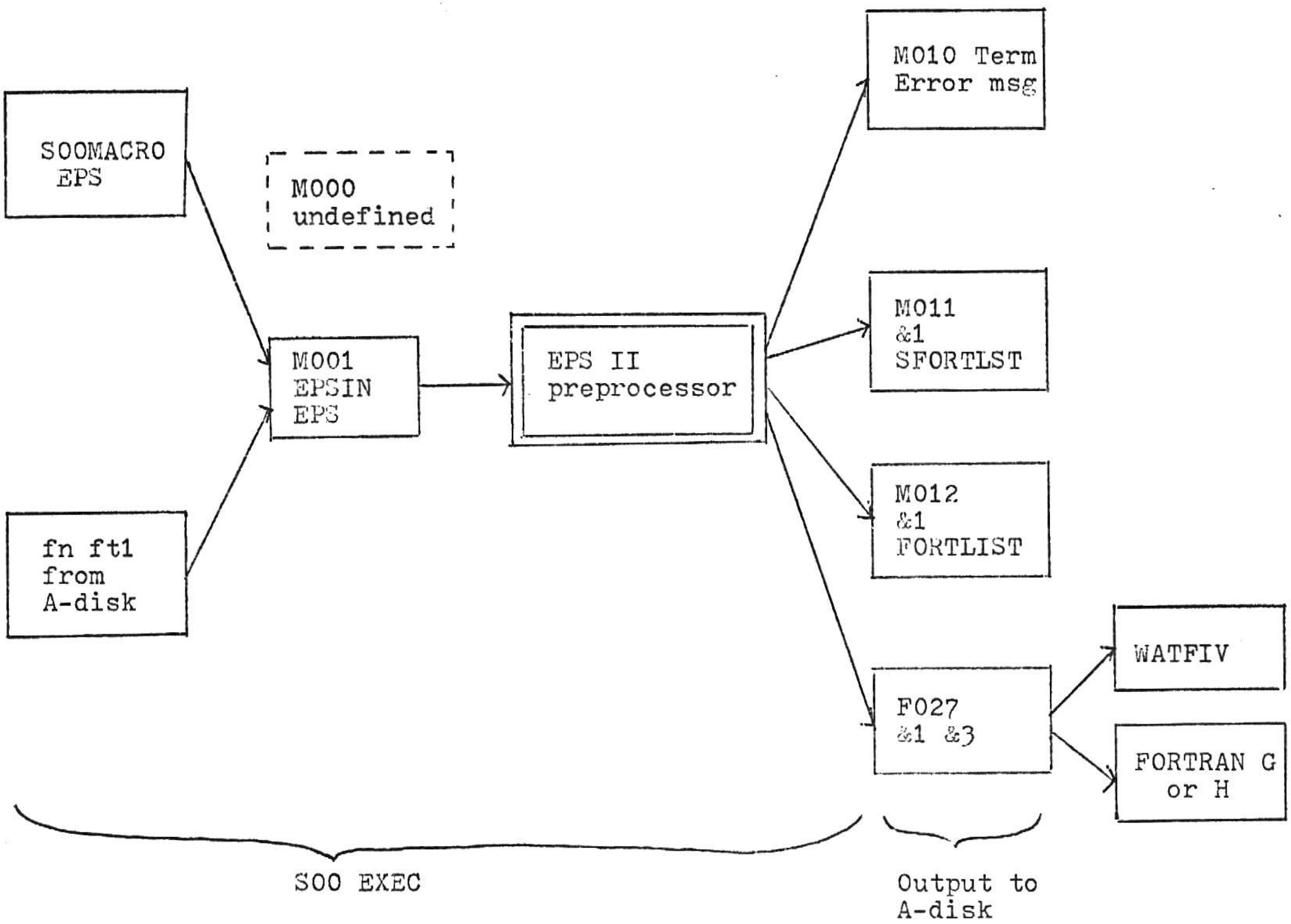


Figure III.2 Files processed by SOO EXEC using EPS II

After these files are defined, EPS executes the input macro program. Timing lines which indicate virtual CPU, real CPU and clock time will be displayed at the user's terminal both before EPS execution and after execution. Also, the error message listing will be displayed. The user may then calculate the CPU time spent for preprocessing his FORTRAN program.

The EXEC procedure will erase the input file EPSIN EPS and close those three output files which were left open after the EPS processing was terminated by MCSTOP. The CMS editor will delete the top part of the input listing containing the macro definitions and it will delete the operation macro, MCSTOP, from the bottom of the input listing. Also, the editor changes C to C$JOB at the first line of the output file &1 &3 and C to C$ENTRY at the bottom line. The reason this editing has to be done in SOO EXEC will be explained in the user constraints part. As the result of the execution of SOO EXEC, the user gets the three output files on the A-disk. File &1 &3 will be ready to compile using the FORTRAN compiler or using WATFIV.

Step 4. The user will be able to run the output program from EPS through the compiler chosen. The following example used the WATFIV compiler:

W̲A̲T̲F̲I̲V̲_T̲E̲S̲T̲

Where TEST was the name of the sample structured FORTRAN program. The FORTRAN G or H compilers could be accessed using the OSJOB command.

Step 5. The user will be able to get the compilation listing after the program is successfully compiled by the WATFIV compiler.

TY_TEST LISTING

Where TEST was the filename specified by the user at the beginning of the run.

D. USER CONSTRAINTS

Presented here are several points the user needs to be concerned with while writing structured FORTRAN. The constraints are mainly caused by EPS II.

1. The user must write C$JOB in the first column of the top line of his program and C$ENTRY on the bottom line. The user may then run his program through WATFIV, FORTRAN G or FORTRAN H compilers. The WATFIV compiler interpretes these two statements as the job control cards, $JOB and $ENTRY. FORTRAN G or H compilers will take the statements as comment statements ignoring the $JOB and $ENTRY. The reason for this constraints is as follows.

In EPS, the punctuation character '$' represents a new line. Whenever this '$' is encountered, the rest of the statement on that line including '$' is deleted and not copied to the output file. This system defined '$' can not be redefined to some other character by MCALTER which is one of the operation macros. This macro is used for the alteration of the secondary delimiters of operation macros or of the keywords used for structure representation. At the time EPS encounters '$' in C$JOB and C$ENTRY, EPS sets $JOB and $ENTRY to null and scans next line of the input text and C is left as the output text from EPS. After EPS preprocessing is done, the CMS editor is invoked to change C to C$JOB and C$ENTRY. This procedure will enable the output file from EPS to run through one of the FORTRAN compilers.

2. One of the constraints is about the statement labels. The user may not use the statement label close to 100. In the macro definition, the global variable P1 is set to 100. P1 is only incremented by the macro calls, IF and SIF, and the user could see the result after the preprocessing by EPS. In order to prevent the program from the confusion, it is better to start the statement label from 200 or over. The statement label used in the sample structured FORTRAN in the Appendix A starts from 500. So, the user needs to keep this restriction in mind when he does the labelling of other loop structures or case statements within the structured FORTRAN program. Otherwise, compile error will be appeared.

3. As part of the restriction on statement labels, the user must use only three digit labels starting from column 3. In the following macro definition, the inserted text, %T2., starts from column 3 and the value of T2 is three digit label.

```
MCDEF <IF THEN FI>
AS <MCSET T2 = 333
ƀƀ%T2.ƀCONTINUE>
```

The output text from EPS always starts from column 3 by this definition.

If the label is two digit number, the last line of replacement text must be written in as the following ways.

bbb%T2.bCONTINUE or bb%T2.bbCONTINUE or b%T2.bbbCONTINUE

The statement CONTINUE enable to start from column 7 by these definitions. It is preferred to use three digit labels because the number is ranged from 100 through 999. The following examples illustrates this.

Examples:

bb%T2.bCONTINUE> (replacement text)

If the value of the inserted text T2 is 333, the output text will be

bb333bCONTINUE

and CONTINUE starts from column 7 which is legal.

If the value of the inserted text is 33, the output text will be

bb33bCONTINUE

and CONTINUE starts from column 6 which is incorrect for FORTRAN convention. If the value of the inserted text T2 is 3333, the output text will be

bb3333bCONTINUE

and the last digit of the statement label is typed on the sixth column which is illegal.

4. Indenting was not implemented. It is recommended that the user start all statements at column 7, except the statement labels and the continuation mark and comments. The examples are in the following pages.

The sequential statement within the macro call is not indented as it is specified in the macro definition if another macro call is nested. Another reason for the constraint is this. When the first statement in the replacement text is copied into the output text, it starts from the same column the source text is indented. For example, SIF macro is illustrated:

```
MCDEF <SIF .....>
AS<  .
     .

col. 1
↓
<IF> (.NOT.(%A1.)) <GO TO> %T1.
     .
     .  >
```

If the source text is

```
col. 7
↓
SIF A.EQ.B THEN B = A FI
```

The output text will be

```
col. 7
↓
IF (.NOT.(A.EQ.B)) GO TO 102
      .
      .
```

If the source text is

```
col. 10
↓
SIF A.EQ.B THEN B = A FI
```

The output text will be

```
col. 10
↓
IF (.NOT.(A.EQ.B)) GO TO 102
      .
```

However, the above example is not always correct as it is. If this SIF macro is nested within another macro, the indented column is changed by the outer macro definition.

If the following indented structured FORTRAN program which contains the continuation card is given by the user,

```
      col. 7
      ↓
      LOOP 515 WHILE I.LE.50 DO
          SIF DROP.EQ.0.
          THEN QUIT 515 LUP FI
          R = R + R * SCOEF
     *    /2.
          SIF C.GT.11.
          THEN NEXT 515 LUP FI
          C = C - C * CCOEF
          I = I + 1
      ENDLOOP
```

The output text from EPS will be

```
      col. 7
      ↓
  515 IF (.NOT.(I.LE.50)) GO TO 516
      IF (.NOT.(DROP.EQ.0.)) GO TO 103
      GO TO 516
  103 CONTINUE
          R = R + R * SCOEF
     *    /2.
          IF (.NOT.(C.GT.11.)) GO TO 104
      GO TO 515
```

```
  104 CONTINUE
          C = C - C * CCOEF
          I = I + 1
      GO TO 515
  516 CONTINUE
```

The second IF starts from column 7 because %A3. in LOOP macro starts from column 7. But the third IF, which is also %A3., starts from the same column the second SIF is indented. The sequential statements followed by another macro calls within LOOP macro start from the indented column as specified in the source text. So, the nested macros and the sequential statements did not follow the definition of LOOP macro.

Another example demonstrates the indented structured FORTRAN.

```
      col. 7
      ↓
      DO 520 I=1,50
          SUM=SUM+C
          CASE 525
              GUARD I.LT.5 DO
              SAVE(1)=SUM*1.
              GUARD I.LE.15 DO
              SAVE(2)=SUM*2.
              GUARD I.LE.25 DO
              SAVE(3)=SUM/2.
      525 ENDCASE
  520 CONTINUE
```

The output text from EPS will be

```
      col. 7
      ↓
      DO 520 I=1,50
          SUM=SUM+C
          IF (.NOT.(I.LT.5)) GO TO 526
      SAVE(1)=SUM*1.
      GO TO 525
  526 IF (.NOT.(I.LE.15)) GO TO 527
      SAVE(2)=SUM*2.
      GO TO 525
  527 IF (.NOT.(I.LE.25)) GO TO 525
      SAVE(3)=SUM/2.
  525 CONTINUE
  520 CONTINUE
```

The beginning column of case statements starts from the same column which is typed by the user even the rest of the statement starts from column 7. So, the group of statements are not indented as the user specified. This looks uglier than a program when all the statements starts from column 7 following the usual FORTRAN convention. This indenting problem can not be corrected.

IV. EVALUATION

A. PROBLEMS OF MACRO DEFINITION

There were many difficulties in defining macros for this paper because the ML/I macro processor has some restrictions on the space and line adjustment and on specifying the delimiter structures. The design of structured FORTRAN extensions and the delimiter structure of the macro definition have been effected by these difficulties. The structure of defined macros could have been better if there had not been such restrictions. In this section, some desirable but illegal delimiter structures for the macro definitions will be described and explained with some examples. Also, the reasons these delimiter structures can not be used will be presented.

1. QUIT...NL and NEXT...NL

Desired structure:

```
QUIT -- NL
```

Macro definition:

```
MCDEF <QUIT NL>
AS <MCSET T1 = %A1. + 1
<GO TO> %T1.
>
```

Desired structure:

```
NEXT -- NL
```

Macro definition:

```
MCDEF <NEXT NL>
AS <<GO TO> %A1.
>
```

These two macro definitions are rather straight forward in writing the source text compared with QUIT...LUP and NEXT...LUP. The layout keyword NL in both macro definitions is replaced by the carriage return within the replacement text. The closing delimiter '>' of the skip macro is placed on the new line of the replacement text. In the source text, the carriage retrun is pressed to specify NL instead of writing NL after the argument 1. The statements in the replacement text, except the NL, are the same as the ones in QUIT...LUP or NEXT...LUP structures. The above macro definitions work properly by themselves in the following exmaples:

(source)	(output)
QUIT 500	GO TO 501
NEXT 500	GO TO 500

However, if these macro calls are nested within a loop such as LOOP...ENDLOOP in the source text, the layout keyword 'NL' of this nested macro call is substituted as a new line on the output text (Figure IV. 1.). If this macro call is followed by a regular statement which is not a macro call, there is no immediate space after the macro call statement. Even though these two macros could be defined as shown in this section (ie. they are not illegal), the irregular spacing of the output text can not be accepted for FORTRAN programs.

(source)	(output)
a. LOOP 500 WHILE A.EQ.B DO	500 IF (.NOT.(A.EQ.B)) GO TO 501
B = C	B = C
QUIT 500	GO TO 501
NEXT 500	GO TO 500
ENDLOOP	↓
	GO TO 500
	501 CONTINUE
b. LOOP 500 WHILE A.EQ.B DO	500 IF (.NOT.(A.EQ.B)) GO TO 501
B = C	B = C
QUIT 500	GO TO 501
NEXT 500	GO TO 500
D = B	D = B
ENDLOOP	GO TO 500
	501 CONTINUE
c. LOOP 500 WHILE A.EQ.B DO	500 IF (.NOT.(A.EQ.B)) GO TO 501
B = C	B = C
QUIT 500	GO TO 501
D = B	D = B
NEXT 500	GO TO 500
ENDLOOP	↓
	GO TO 500
	501 CONTINUE

Figure IV.1. NEXT/QUIT examples

b -- correct output a, c -- output is incorrect.

2. LOOP...ENDLOOP

Desired structure:

```
LOOP -- WHILE -- DO WITHS NL -- NL -- ENDLOOP
```

Macro definition:

```
MCDEF <LOOP WHILE DO WITHS NL NL ENDLOOP>
AS <MCSET T1 = %A1. + 1
%A1. <IF> (.NOT.(%A2.)) <GO TO> %T1.
      %A3.
      <GO TO> %A1.
  %T1. CONTINUE>
```

The delimiter structure of this macro definition is similar to the one already defined in the last section with the exception of the macro name and the secondary delimiter, NL.

This structure is simpler than the previously defined one. However, the difficulty lies on the column adjustment in the output text. The following example demonstrates this spacing problem:

```
        (source)                          (output)

    LOOP 500 WHILE A.EQ.B DO     500 IF (.NOT.(A.EQ.B)) GO TO 501
    B = D                        B = D
    C = B                        C = B
500 ENDLOOP                      GO TO 500
                             501 CONTINUE
```

The first statement label in the output text did not appear at the second column because the macro did not start at the second column. The first statement label always starts from the same column the source text starts. The spacing has to be done properly to match the FORTRAN convention for the statement label.

Another problem is with the NL delimiter. The following example illustrates the difficulty using the delimiter, NL. SPACE WITHS LOOP is used as the macro name.

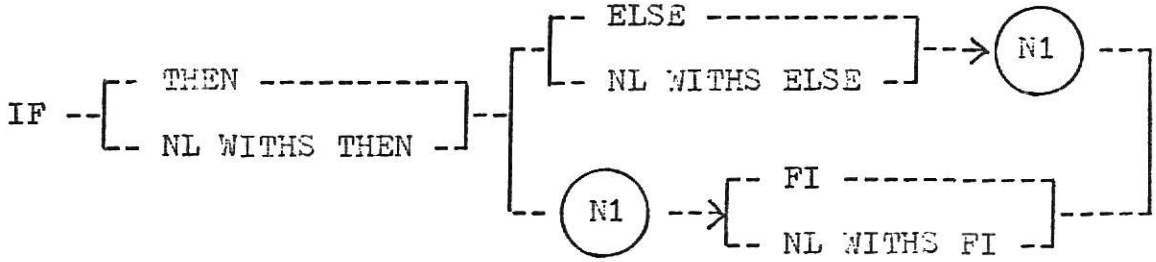
```
        (source)                         (output)
    LOOP 515 WHILE I.LE.50 DO    515 IF (.NOT.(I.LE.50)) GO TO 516
    SIF DROP.EQ.0.                   IF (.NOT.(DROP.EQ.0.)) GO TO 103
    THEN QUIT 515 LUP FI             GO TO 516
    R = R + R* SCOEF             103 CONTINUE
    SIF C.GT.11.                     GO TO 515
    THEN NEXT 515 LUP FI         516 CONTINUE
    C = C - C * CCOEF
    I = I + 1
515 ENDLOOP
```

Those statements which follow any macro call within this loop structure are deleted. The reason for this is not clear.

3. IF...FI and SIF...FI

Instead of designing two seperate delimiter structures, it is better to combine these two structures into one macro name IF (although this seems to be impossible). Two cases of preferred delimiter structures will be described.

Desired structure:



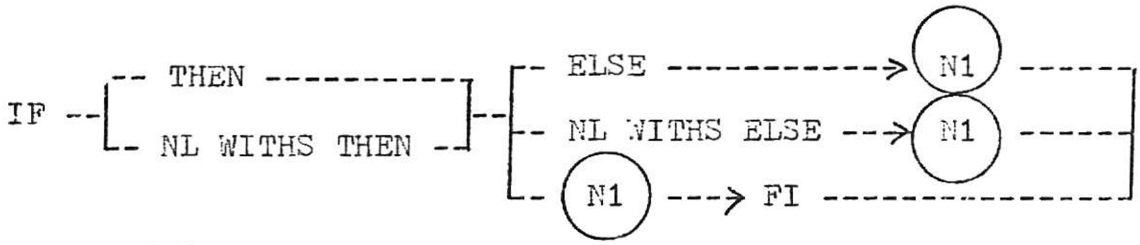
Macro definition:

```
MCDEF ⟨IF OPT THEN OR NL WITHS THEN ALL
OPT OPT ELSE OR NL WITHS ELSE ALL N1
OR N1 OPT FI OR NL WITHS FI ALL ALL ⟩
AS ⟨MCSET P1 = P1 + 1
MCSET T1 = P1
MCSET P1 = P1 + 1
MCSET T2 = P1
MCGO L1 IF %D2. = ⟨ELSE⟩
MCGO L1 IF %D2. = ⟨NL WITHS ELSE⟩
%WDO. (.NOT.(%A1.)) ⟨GO TO⟩ %T2.
      %A2.
MCGO L2
%L1.%WDO. (%A1.) ⟨GO TO⟩ %T1.
      %A3.
      ⟨GO TO⟩ %T2.
  %T1. %A2.
%L2.  %T2. CONTINUE⟩
```

This structure has four option lists. Among them two option lists are nested within a big option list and are chained together by the node N1. Basically, this structure can be written in four different ways such as IF...THEN... ELSE...FI, IF...NL WITHS THEN...NL WITHS ELSE...NL WITHS FI, and IF...NL WITHS THEN...NL WITHS FI. Also it is possible to write a simialr type of delimiter in an option list, ie. substituting NL WITHS THEN to THEN. The node N1 pointed by the arrow is the nodego. The other N1 followed by an option list, FI or NL WITHS FI, is the nodeplace. The replacement text of this macro definition is the combination of two seperate replacement texts which were defined in the previous section. The only differences are that the macro-time GO TO statement, MCGO, and the macro-time labels are used to match and find the proper character string for the delimiter 2.

Even though this delimiter structure has a better form, the macro definition by this structure is illegal. The keyword OPT may not be followed by another OPT. The nodeplace N1 after OR has to be followed by a delimiter name not by the keyword OPT. Another trouble point is that the layout keywords (NL) and the keywords (WITHS) can bot be used within the replacement text. So, there is no way to test the alternative delimiter in the option list if one of them is constructed with keywords.

Another desirable delimiter structure is as follows:



Macro definition:

MCDEF <IF OPT THEN OR NL WITHS THEN ALL

OPT ELSE N1 OR NL WITHS ELSE N1 OR N1 FI ALL>

AS<

The replacement text is same as the one previously defined in this section. >

This structure can be written in the several ways described in the first example above except that the closing delimiter has no alternative but FI. This macro has two option lists one of which includes the nodego and the nodeplace. The delimiter following the nodeplace N1 has to be a closing delimiter within that option list. The delimiter structure of this macro definition is correct but the replacement text, which is identical to the one previously mentioned, contains an illegal conditional statement. Because the test of <NL WITHS ELSE> fails all the time (illegal NL in the replacement text), the control of the replacement text will never go to the inserted value of %L1. as long as the delimiter is specified as <NL WITHS ELSE>. As a result, the output statements will be the ones following the statement of failed test. The following example will demonstrate the above explanation.

(source)	(output)
a. IF A.EQ.B THEN C = A ELSE C = B FI	

```
                                       IF (A.EQ.B) GO TO 101
                                       C = B
                                       GO TO 102
                                   101 C = A
                                   102 CONTINUE
```

```
b. IF A.EQ.B                           IF (.NOT.(A.EQ.B)) GO TO 104
   THEN C = A                          C = A
   ELSE C = B  FI                  104 CONTINUE
```

```
c. IF A.EQ.B THEN C = A FI             IF (.NOT.(A.EQ.B)) GO TO 106
                                       C = A
                                   106 CONTINUE
```

```
d. IF A.EQ.B                           IF (.NOT.(A.EQ.B)) GO TO 108
   THEN C = A FI                       C = A
                                   108 CONTINUE
```

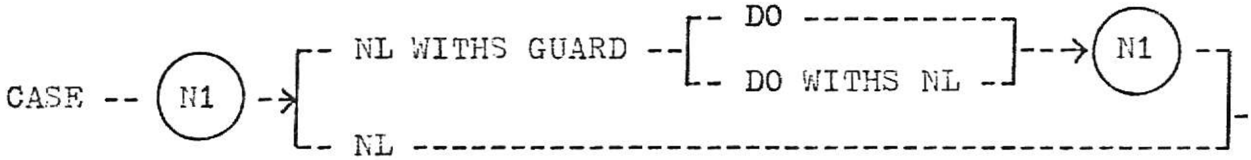
Figure IV.2. IF...FI examples

a --- correct output   b --- output is incorrect.

c --- correct output   d --- correct output

4. CASE...ENDCASE

Desired structure:



Macro definition:

```
      MCDEF <CASE N1 OPT NL WITHS GUARD
      OPT DO OR DO WITHS NL ALL N1 OR NL ALL ENDCASE>
      AS <MCSET T1 = 1
      MCSET T2 = 2
      MCSET T3 = %A1.
      <IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
            %AT2+1.
            <GO TO> %A1.
      %L1.MCSET T1 = T1 + 2
      MCSET T2 = T2 + 2
      MCSET T3 = T3 + 1
      MCGO L2 IF %DT1+3. = <ENDCASE>
        %T3. <IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
            %AT2+1.
            <GO TO> %A1.
      MCGO L1
      %L2.  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %A1.
            %AT2+1.
   %A1. CONTINUE >
```

This CASE macro has NL as the second delimiter. There is the same problem as with the LOOP macro. The NL causes difficulties if other macros are nested within this CASE structure. The following examples are for the CASE macro.

	(source)	(output)
a.	CASE 500	IF (.NOT.(A.EQ.B)) GO TO 501
	GUARD A.EQ.B DO	A = B
	A = B	GO TO 500
	GUARD A.LT.B DO	501 IF (.NOT.(A.LT.B)) GO TO 500
	QUIT 500 LUP	GO TO 501
	C = A	500 CONTINUE
	GUARD A.GT.B DO	
	B = C	
	500 ENDCASE	
b.	CASE 500	ERROR(S)
	GUARD A.EQ.B DO	D6 IS ILLEGAL MACRO ELEMENT
	A = B	.
	IF B.LT.C THEN C = B	.
	ELSE C = A FI	.
	GUARD A.LT.B DO	(error messages deleted)
	C = A	
	GUARD A.GT.B DO	
	B = C	
	500 ENDCASE	

Figure IV.3. Examples for CASE...ENDCASE

The example (a) in Figure IV.3 displays the identical error which was illustrated in the example for LOOP...ENDLOOP macro. Those statements which follow a nested macro call within this CASE macro are deleted. In the second example in Figure IV.3, the error messages are given. It is a very long message and is difficult to figure it out.

5. Brackets around macro definitions:

If a delimiter structure which was defined without the literal brackets is redefined (for example, to change the replacement text), then the original definition is not erased from the run time environment. That causes some errors. The following examples illustrate this:

a. MCDEF NEXT LUP AS ⟨⟨GO TO⟩ %A1.⟩

(source)	(output)
NEXT 500 LUP	GO TO 500

b. MCDEF NEXT LUP AS ⟨⟨JUMP TO⟩ %A1.⟩

(source)	(output)
NEXT 500 LUP	GO TO 500

c. MCDEF NEXT LUP AS ⟨GO TO⟩ %A1.

Error(s)

A1 IS ILLEGAL MACRO ELEMENT

.
.
.

(Error messages deleted)

In the second example (b), the first macro definition (a) is not erased and the output is the same one by the origianl macro definition. The third example shows error message.

B. TIME AND SIZE OF MACROS

The size of macros defined in this paper which is the file, SOOMACRO EPS, is 57 records. EPS TEXT contains 570 records which has the logical record length 80. The size of EPS MODULE is 4 records with the record length 65535.

About the timing, the results coming from EPS execution indicates that it takes about 5 to 6 times of execution time compared to the timing through the compiler. For example, the timing information of the sample structured FORTRAN through EPS preprocessing is as follows:

T=0.23/0.55 10:40:53 (before EPS preprocessing)

T=1.44/1.87 10:41:10 (after EPS preprocessing)

About 1.32 seconds are used for the real CPU time. The compile time by WATFIV took about 0.22 second. It appears that ML/I is not a suitable preprocessor for the high level languages like PL/I or FORTRAN as far as the timing concerns.

C. CONCLUSIONS

This project provides a possibility that a well-structured FORTRAN could be produced by programmers using the preprocessor. It is obvious that the impact of structured programming upon FORTRAN implementing general block structure does not conflict with the features of the existing FORTRAN. Using ML/I as a preprocessor for the study of the structured FORTRAN extensions was a success except for some limited features previously illustrated.

There are several good aspects of ML/I. It has a flexible format and its use of keywords makes it easy to read. The methods of specifying repetitions of delimiters and the branching technique to groups of alternatives is a powerful facility.

However, there has been some difficulties. Defining macros according to the FORTRAN convention was the part of the difficulties. Some of the features which was not clear and undefined by ML/I have some conflict on writing macros and running ML/I. If these bad elements could be discovered in the future, ML/I will be a nice preprocessor for the structured FORTRAN extensions.

As far as considering the concept behind this project, this project was a quite successful one. To overcome the undesirable features described previously, it needs to be more study on ML/I and on the area of structured FORTRAN program.

REFERENCES

Abr75 Abrahams, Paul. "Structured Programming" Considered Harmful, SIGPLAN Notices, Vol. 10, No. 4, April 1975, pp. 13-24.

Bro67 Brown, P.J. The ML/I Macro Processor, Comm. ACM, Vol. 10, No. 10, October 1967, pp. 618-623.

Bro69 Brown, P.J. Using a Macro Processor to Aid Software Implementation, Comput.J, Vol. 12, No. 4, November 1969, pp. 327-331.

Bro74 Brown, P.J. Macro Processors and Techniques for Portable Software. John Wiley & Sons, 1974.

Col76 Cole, A.J. Macro Processors. Cambridge University Press, 1976.

Coo76 Cook, A.James. Experience With Extensible, Portable FORTRAN Extensions, SIGPLAN Notices, Vol. 11, No. 9, September 1976, pp. 10-17.

Dij72 Dahl, O.J., E.W. Dijkstra, and C.A.R. Hoare. Structured Programming. Academic Press, London, 1972, pp. 1-82.

EPSUM EPS II - Users Manual., Internal Document, US Army Computer System Command, Ft. Belvoir, Va., 1975.

Fri74 Friedman, Daniel P., and Struart C. Shapiro. A Case for While-Until, SIGPLAN Notices, Vol. 9, No. 7, July 1974, pp. 7-14.

Hig75 Higgins, Donald S. A Structured FORTRAN Translator, SIGPLAN Notices, Vol. 10, No. 2., February 1975, pp. 42-48.

Kel73 Kelly, M.Campbell. An Introduction to Macros. Macdonald-London and American Elsevier Inc. NewYork, 1973.

Mei74 Meissner, Loren P. A compatible "Structured" Extension to FORTRAN, SIGPLAN Notices, Vol. 9, No. 10, October 1974. pp. 29-36.

Mei75 Meissner, Loren P. On extending FORTRAN Control Structures to Facilitate Structured Programming, SIGPLAN Notices, Vol. 10, No. 9, September 1975, pp. 19-29.

O'n74 O'neill, Dennis M. SFOR - A Precompiler for the Implementation of A FORTRAN-Based Structured Language, SIGPLAN Notices, Vol. 9, No. 12, December 1974, pp. 22-29.

Vau74 Vaughn, W.C.M. Another Look at the CASE Statement, SIGPLAN Notices, Vol. 9, No. 11, November 1974, pp. 32-36.

APPENDIX A

SAMPLE STRUCTURED FORTRAN PROGRAM (TEST SFORT)

```
FILE: TEST     SFORT     A1

C$JOB
      DIMENSION R(51),C(50),SAVE(5)
      DROP=1.; SCOEF=0.01; CCOEF=0.01
      RATIO=6.02/6.; R(6)=6.; I=6
      LOOP 500 WHILE I.GT.1 DO
      R(I-1)=R(I)/RATIO; I=I-1
      ENDLOOP
      DO 505 I=7,51
  505 R(I)=R(I-1)*RATIO
      J=1
      LOOP 510 WHILE J.LE.50 DO
      IF J.LT.6 THEN C(J)=5.
      ELSE C(J)=10. FI
      J=J+1
      ENDLOOP
      I=1
      LOOP 515 WHILE I.LE.50 DO
      SIF DROP.EQ.0.
      THEN QUIT 515 LUP FI
      R(I)=R(I)+(R(I)*SCOEF)
     */2.
      SIF C(I).GT.11.
      THEN NEXT 515 LUP FI
      C(I)=C(I)-(C(I)*CCOEF)
      I=I+1
      ENDLOOP
      SUM=0.
      DO 520 I=1,50
      SUM=SUM+C(I)
      CASE 525
      GUARD I.LT.5 DO
      SAVE(1)=SUM*1.
      GUARD I.LE.15 DO
      SAVE(2)=SUM*2.
      GUARD I.LE.25 DO
      SAVE(3)=SUM/2.
      GUARD I.EQ.30 DO
      SAVE(4)=SUM/3.
      GUARD I.LE.50 DO
      SAVE(5)=SUM/4. ENDCASE
  520 CONTINUE
      SIF SAVE(5).GT.50. THEN DROP=0. FI
      STOP
      END
C$ENTRY
```

APPENDIX B

MACRO LISTINGS (SOOMACRO EPS)

FILE: SOOMACRO EPS A1

```
MCLISTS
MCLISTT
MCINS %.
MCSKIP MT, < >
MCDEF <;> AS <
    >
MCSET P1 = 100
MCDEF <QUIT LUP>
AS <MCSET T1 = %A1. + 1
<GO TO> %T1.>
MCDEF <NEXT LUP>
AS <<GO TO> %A1.>
MCDEF <SPACE WITHS LOOP WHILE DO WITHS NL
OPT ENDLOOP OR NL WITHS ENDLOOP ALL>
AS <MCSET T1 = %A1. + 1
  %A1. <IF> (.NOT.(%A2.)) <GO TO> %T1.
      %A3.
      <GO TO> %A1.
  %T1. CONTINUE>
MCDEF <IF OPT THEN OR NL WITHS THEN ALL
OPT ELSE OR NL WITHS ELSE ALL
OPT FI OR NL WITHS FI ALL>
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
MCSET P1 = P1 + 1
MCSET T2 = P1
%WDO. (%A1.) <GO TO> %T1.
      %A3.
      <GO TO> %T2.
  %T1. %A2.
  %T2. CONTINUE>
MCDEF <SIF OPT THEN OR NL WITHS THEN ALL
OPT FI OR NL WITHS FI ALL>
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
<IF> (.NOT.(%A1.)) <GO TO> %T1.
      %A2.
  %T1. CONTINUE>
MCDEF <CASE N1 OPT NL WITHS GUARD
OPT DO OR DO WITHS NL ALL N1 OR ENDCASE ALL>
AS <MCSET T1 = 1
MCSET T2 = 2
MCSET T3 = %A1.
<IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
%L1.MCSET T1 = T1 + 2
MCSET T2 = T2 + 2
MCSET T3 = T3 + 1
MCGO L2 IF %DT1+2. = <ENDCASE>
  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
MCGO L1
%L2.  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %A1.
      %AT2+1.
  %A1. CONTINUE>
```

APPENDIX C

LISTING OF 300 EXEC PROCEDURE

FILE: SOO EXEC A1

```
&CONTROL OFF NOMSG
COPYFILE SCOMACRO EPS A1 &1 &2 A1 EPSIN EPS A1
&STACK HT
&BEGSTACK LIFO
FILE
INPUT MCSTOP
BOTTOM
&END
EDIT EPSIN EPS
&STACK RT
FILEDEF M000 TERM
FILEDEF M001 DISK EPSIN EPS
FILEDEF M010 TERM
FILEDEF M011 DISK &1 SFORTLST
FILEDEF M012 DISK &1 FORTLIST
FILEDEF FC27 DISK &1 &3
&TIME = &LITERAL &TIME
&TIME TYPE
EPS
&TIME = &LITERAL &TIME
&TIME TYPE
ERASE EPSIN EPS
FINIS &1 SFORTLST
FINIS &1 FORTLIST
FINIS &1 &3
&STACK HT
&BEGSTACK LIFO
FILE
DELETE
BOTTOM
DELETE 59
DO 2
TOP
&END
EDIT &1 SFORTLST
&BEGSTACK LIFO
FILE
CHANGE /C/C$ENTRY
BOTTOM
CHANGE /C/C$JOB
DO 1
TOP
&END
EDIT &1 &3
```

APPENDIX D

LISTING OF A SAMPLE EPSIN EPS

```
FILE: EPSIN    EPS       A1

MCLISTS
MCLISTT
MCINS %.
MCSKIP MT, < >
MCDEF <:> AS <
     >
MCSET P1 = 100
MCDEF <QUIT LUP>
AS <MCSET T1 = %A1. + 1
<GO TO> %T1.>
MCDEF <NEXT LUP>
AS <<GO TO> %A1.>
MCDEF <SPACE WITHS LOOP WHILE DO WITHS NL
OPT ENDLOOP OR NL WITHS ENDLOOP ALL>
AS <MCSET T1 = %A1. + 1
  %A1. <IF> (.NOT.(%A2.)) <GO TO> %T1.
      %A3.
      <GO TO> %A1.
  %T1. CONTINUE>
MCDEF <IF OPT THEN OR NL WITHS THEN ALL
OPT ELSE OR NL WITHS ELSE ALL
OPT FI OR NL WITHS FI ALL>
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
MCSET P1 = P1 + 1
MCSET T2 = P1
%WDO. (%A1.) <GO TO> %T1.
      %A3.
      <GO TO> %T2.
  %T1. %A2.
  %T2. CONTINUE>
MCDEF <SIF OPT THEN OR NL WITHS THEN ALL
OPT FI OR NL WITHS FI ALL>
AS <MCSET P1 = P1 + 1
MCSET T1 = P1
<IF> (.NOT.(%A1.)) <GO TO> %T1.
      %A2.
  %T1. CONTINUE>
MCDEF <CASE N1 OPT NL WITHS GUARD
OPT DO OR DO WITHS NL ALL N1 OR ENDCASE ALL>
AS <MCSET T1 = 1
MCSET T2 = 2
MCSET T3 = %A1.
<IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
%L1.MCSET T1 = T1 + 2
MCSET T2 = T2 + 2
MCSET T3 = T3 + 1
MCGO L2 IF %CT1+2. = <ENDCASE>
  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %T3+1.
      %AT2+1.
      <GO TO> %A1.
MCGO L1
%L2.  %T3. <IF> (.NOT.(%AT2.)) <GO TO> %A1.
      %AT2+1.
  %A1. CONTINUE>
```

```
FILE: EPSIN    EPS      A1

C$JOB
      DIMENSION R(51),C(50),SAVE(5)
      DROP=1.; SCOEF=0.01; CCOEF=0.01
      RATIO=6.02/6.; R(6)=6.; I=6
      LOOP 500 WHILE I.GT.1 DO
      R(I-1)=R(I)/RATIO; I=I-1
      ENDLOOP
      DO 505 I=7,51
  505 R(I)=R(I-1)*RATIO
      J=1
      LOOP 510 WHILE J.LE.50 DO
      IF J.LT.6 THEN C(J)=5.
      ELSE C(J)=10. FI
      J=J+1
      ENDLOOP
      I=1
      LOOP 515 WHILE I.LE.50 DO
      SIF DROP.EQ.0.
      THEN QUIT 515 LUP FI
      R(I)=R(I)+(R(I)*SCOEF)
     */2.
      SIF C(I).GT.11.
      THEN NEXT 515 LUP FI
      C(I)=C(I)-(C(I)*CCOEF)
      I=I+1
      ENDLOOP
      SUM=0.
      DO 520 I=1,50
      SUM=SUM+C(I)
      CASE 525
      GUARD I.LT.5 DO
      SAVE(1)=SUM*1.
      GUARD I.LE.15 DO
      SAVE(2)=SUM*2.
      GUARD I.LE.25 DO
      SAVE(3)=SUM/2.
      GUARD I.EQ.30 DO
      SAVE(4)=SUM/3.
      GUARD I.LE.50 DO
      SAVE(5)=SUM/4. ENDCASE
  520 CONTINUE
      SIF SAVE(5).GT.50. THEN DROP=0. FI
      STOP
      END
C$ENTRY
MCSTOP
```

APPENDIX E

LISTINGS OF SAMPLE STRUCTURED FORTRAN OUTPUT FROM EPS II

```
R:
SOO TEST SFORT WATFIV
T=0.23/0.55 10:40:53
                                        ERROR MESSAGES LISTING


T=1.44/1.87 10:41:10
R:
TY TEST SFORTLST

                                        SOURCE PROGRAM LISTING
          C$JOB
                DIMENSION R(51),C(50),SAVE(5)
                DROP=1.; SCOEF=0.01; CCOEF=0.01
                RATIO=6.02/6.; R(6)=6.; I=6
                LOOP 500 WHILE I.GT.1 DO
                R(I-1)=R(I)/RATIO; I=I-1
                ENDLOOP
                DO 505 I=7,51
            505 R(I)=R(I-1)*RATIO
                J=1
                LOOP 510 WHILE J.LE.50 DO
                IF J.LT.6 THEN C(J)=5.
                ELSE C(J)=10. FI
                J=J+1
                ENDLOOP
                I=1
                LOOP 515 WHILE I.LE.50 DO
                SIF DROP.EC.0.
                THEN QUIT 515 LUP FI
                R(I)=R(I)+(R(I)*SCOEF)
               */2.
                SIF C(I).GT.11.
                THEN NEXT 515 LUP FI
                C(I)=C(I)-(C(I)*CCOEF)
                I=I+1
                ENDLOOP
                SUM=0.
                DO 520 I=1,50
                SUM=SUM+C(I)
                CASE 525
                GUARD I.LT.5 DO
                SAVE(1)=SUM*1.
                GUARD I.LE.15 DO
                SAVE(2)=SUM*2.
                GUARD I.LE.25 DO
                SAVE(3)=SUM/2.
                GUARD I.EQ.30 DO
                SAVE(4)=SUM/3.
                GUARD I.LE.50 DO
                SAVE(5)=SUM/4. ENDCASE
            520 CONTINUE
                SIF SAVE(5).GT.50. THEN DROP=0. FI
                STOP
                END
          C$ENTRY

R:
TY TEST FORTLIST
```

TARGET PROGRAM LISTING

```
000000058      C
000000059           DIMENSION R(51),C(50),SAVE(5)
000000060           DROP=1.
     +              SCOEF=0.01
000000060           CCOEF=0.01
000000061           RATIO=6.02/6.
     +              R(6)=6.
000000061           I=6
000000062       500 IF (.NOT.(I.GT.1)) GO TO 501
     +              R(I-1)=R(I)/RATIO
     +              I=I-1
     +              GO TO 500
000000064       501 CONTINUE
000000065           DO 505 I=7,51
000000066       505 R(I)=R(I-1)*RATIO
000000067           J=1
000000068       510 IF (.NOT.(J.LE.50)) GO TO 511
     +              IF (J.LT.6) GO TO 101
     +              C(J)=10.
     +              GO TO 102
     +          101 C(J)=5.
     +          102 CONTINUE
     +              J=J+1
     +              GO TO 510
000000072       511 CONTINUE
000000073           I=1
000000074       515 IF (.NOT.(I.LE.50)) GO TO 516
     +              IF (.NOT.(DROP.EQ.0.)) GO TO 103
     +              GO TO 516
     +          103 CONTINUE
     +              R(I)=R(I)+(R(I)*SCOEF)
     +             */2.
     +              IF (.NOT.(C(I).GT.11.)) GO TO 104
     +              GO TO 515
     +          104 CONTINUE
     +              C(I)=C(I)-(C(I)*CCOEF)
     +              I=I+1
     +              GO TO 515
000000083       516 CONTINUE
000000084           SUM=0.
000000085           DO 520 I=1,50
000000086           SUM=SUM+C(I)
000000087           IF (.NOT.(I.LT.5)) GO TO 526
     +              SAVE(1)=SUM*1.
     +              GO TO 525
     +          526 IF (.NOT.(I.LE.15)) GO TO 527
     +              SAVE(2)=SUM*2.
     +              GO TO 525
     +          527 IF (.NOT.(I.LE.25)) GO TO 528
     +              SAVE(3)=SUM/2.
     +              GO TO 525
     +          528 IF (.NOT.(I.EQ.30)) GO TO 529
     +              SAVE(4)=SUM/3.
     +              GO TO 525
     +          529 IF (.NOT.(I.LE.50)) GO TO 525
```

```
            SAVE(5)=SUM/4.
        525 CONTINUE
        520 CONTINUE
            IF (.NOT.(SAVE(5).GT.50.)) GC TO 105
            DROP=0.
        105 CONTINUE
            STOP
            END
        C

R;
TY TEST WATFIV

C$JOB
      DIMENSION R(51),C(50),SAVE(5)
      DROP=1.
      SCOEF=0.01
      CCOEF=0.01
      RATIO=6.02/6.
      R(6)=6.
      I=6
  500 IF (.NOT.(I.GT.1)) GO TO 501
      R(I-1)=R(I)/RATIO
      I=I-1
      GO TO 500
  501 CONTINUE
      DO 505 I=7,51
  505 R(I)=R(I-1)*RATIO
      J=1
  510 IF (.NOT.(J.LE.50)) GO TO 511
      IF (J.LT.6) GO TO 101
      C(J)=10.
      GO TO 102
  101 C(J)=5.
  102 CONTINUE
      J=J+1
      GO TO 510
  511 CONTINUE
      I=1
  515 IF (.NOT.(I.LE.50)) GO TO 516
      IF (.NOT.(DROP.EQ.0.)) GC TO 103
      GO TO 516
  103 CONTINUE
      R(I)=R(I)+(R(I)*SCOEF)
     */2.
      IF (.NCT.(C(I).GT.11.)) GO TO 104
      GO TO 515
  104 CONTINUE
      C(I)=C(I)-(C(I)*CCOEF)
      I=I+1
      GO TO 515
  516 CONTINUE
      SUM=0.
      DO 520 I=1,50
      SUM=SUM+C(I)
      IF (.NOT.(I.LT.5)) GO TO 526
      SAVE(1)=SUM*1.
      GO TO 525
  526 IF (.NOT.(I.LE.15)) GO TO 527
      SAVE(2)=SUM*2.
```

```
      GO TO 525
  527 IF (.NCT.(I.LE.25)) GO TO 528
      SAVE(3)=SUM/2.
      GO TO 525
  528 IF (.NCT.(I.EQ.30)) GO TO 529
      SAVE(4)=SUM/3.
      GO TO 525
  529 IF (.NGT.(I.LE.50)) GO TO 525
      SAVE(5)=SUM/4.
  525 CCNTINUE
  520 CONTINUE
      IF (.NCT.(SAVE(5).GT.50.)) GO TO 105
      DROP=0.
  105 CCNTINUE
      STOP
      END
C$ENTRY

R;
WATFIV TEST
R;
TY TEST LISTING

          C$JOB
                DIMENSION R(51),C(50),SAVE(5)
                DROP=1.
                SCOEF=0.01
                CCOEF=0.01
                RATIO=6.02/6.
                R(6)=6.
                I=6
            500 IF (.NOT.(I.GT.1)) GO TO 501
                R(I-1)=R(I)/RATIC
                I=I-1
                GO TC 500
            501 CONTINUE
                DO 505 I=7,51
            505 R(I)=R(I-1)*RATIC
                J=1
            510 IF (.NOT.(J.LE.50)) GO TO 511
                IF (J.LT.6) GO TO 101
                C(J)=10.
                GO TO 102
            101 C(J)=5.
            102 CONTINUE
                J=J+1
                GO TC 510
            511 CCNTINUE
                I=1
            515 IF (.NCT.(I.LE.50)) GO TO 516
                IF (.NOT.(DROP.EQ.0.)) GO TO 103
                GO TC 516
            103 CONTINUE
                R(I)=R(I)+(R(I)*SCOEF)
               */2.
                IF (.NOT.(C(I).GT.11.)) GO TO 104
                GO TO 515
            104 CONTINUE
                C(I)=C(I)-(C(I)*CCOEF)
                I=I+1
```

```
          GO TO 515
      516 CONTINUE
          SUM=0.
          DO 520 I=1,50
          SUM=SUM+C(I)
          IF (.NOT.(I.LT.5)) GO TO 526
          SAVE(1)=SUM*1.
          GO TO 525
      526 IF (.NOT.(I.LE.15)) GO TO 527
          SAVE(2)=SUM*2.
          GO TO 525
      527 IF (.NOT.(I.LE.25)) GO TO 528
          SAVE(3)=SUM/2.
          GO TO 525
      528 IF (.NOT.(I.EQ.30)) GO TO 529
          SAVE(4)=SUM/3.
          GO TO 525
      529 IF (.NOT.(I.LE.50)) GO TO 525
          SAVE(5)=SUM/4.
      525 CONTINUE
      520 CONTINUE
          IF (.NOT.(SAVE(5).GT.50.)) GO TO 105
          DROP=0.
      105 CONTINUE
          STOP
          END
     C$ENTRY
 CORE USAGE       OBJECT CODE=     1840 BYTES,ARRAY AREA=      424 BYTES,TOTAL AREA AVAILABLE=  22096  BYTES
 DIAGNOSTICS         NUMBER OF ERRORS=       0, NUMBER OF WARNINGS=       0, NUMBER OF EXTENSIONS=       0
 COMPILE TIME=     0.22 SEC,EXECUTION TIME=     0.02 SEC,     10.53.05     TUESDAY       22 MAR 77     WATFIV - JAN 1976 V1L5

R;
SPOOL CONSOLE CLOSE STOP
```

AN EVALUATION OF ML/I (EPS) MACROS FOR STRUCTURED FORTRAN EXTENSIONS

by

Soo Kyung Park

B.A., Ewha Womans University, 1968

AN ABSTRACT OF A MASTER'S REPORT

Submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

ABSTRACT

The objective of this project is to investigate use of a general purpose macro processor to implement extensions to FORTRAN.

The macro processor is a software translator which interprets macro definitions and translates input text to output text. Input to the macro processor is in the form of macro definitions and source text. The output text is derived from the source text by replacing all the macro calls that occur in it. Available at KSU is EPS II, a version of ML/I (Bro67) which is a general purpose macro processor system and which can be easily applied to all existing programming languages. EPS II can be run interactively under CMS as a preprocessor for FORTRAN extensions.

For this study, a set of some macro extensions to FORTRAN were defined to facilitate structured programming in FORTRAN. Structures examined were IF THEN ELSE, WHILE, and CASE.