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MACRO ASSEMBLER Reference Manual

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PREFACE

This manual is a reference for the programmer with some knowledge of assemblers and assembly languages.

Using the MACRO assembler effectively involves using other DECSYSTEM-20 facilities: the monitor, the LINK program, the CREF program, a debugging program, a text editor, and machine language. Therefore the following DECSYSTEM-20 documents will prove useful:

User's Guide

AD-4179B-T1

Monitor Calls User's Guide

AA-4166C-TM

LINK Reference Manual

AA-4183B-TM

EDIT User's Guide

DEC-20-UEUGA-A-D

DDT Dynamic Debugging Technique

DEC-10-UDDTA-A-D

BATCH Reference Manual

DEC-20-OBRMA-A-DN3

Hardware Reference Manual

EK-10/20-HR-001

CHAPTER 1
INTRODUCTION TO MACRO

MACRO is the symbolic assembler program for the DECSYSTEM-20. The assembler reads a file of MACRO statements and composes relocatable binary machine instruction code suitable for loading by LINK, the system's linking loader.

MACRO is a statement-oriented language; statements are in free format and are processed in two passes. In processing statements, the assembler:

1. Interprets machine instruction mnemonics
2. Accepts symbol definitions
3. Interprets symbols
4. Interprets pseudo-ops
5. Accepts macro definitions
6. Expands macros on call
7. Assigns memory addresses
8. Generates a relocatable binary program file (.REL file) for input to LINK
9. Generates a program listing file showing source statements, the corresponding binary code, and any errors found
10. Generates a UNIVERSAL file that can be searched by other assemblies

In addition to translating machine instruction mnemonics and special-purpose operators called pseudo-ops, MACRO allows you to create your own language elements, called macros. In this way you can tailor the assembler's functions for each program.

Since the assembler is device independent, you can use any peripheral devices for input and output files. For example, you can use a terminal for your source program input, a line printer for your program listing output, and a disk for your binary program output.

MACRO programs must use the monitor for device-independent input/output services. (See the Monitor Calls User's Guide.)

INTRODUCTION TO MACRO

NOTES

The following conventions are used throughout this manual:

1. All numbers in the examples are octal unless otherwise indicated.
2. All numbers in the text are decimal unless otherwise indicated.
3. The name of the assembler, MACRO, appears in uppercase letters; references to user-defined macros appear in lowercase letters.
4. Examples sometimes show the code generated as it appears in the program listing file. This file is described in Section 6.1.

1.1 HOW THE ASSEMBLER OPERATES

MACRO is a 2-pass assembler; it reads your source program twice. On Pass 1, some symbolic addresses will not be resolved, if they refer to parts of the program not yet read. These symbolic references are entered in the symbol table and will be resolved on Pass 2.

The main purpose of Pass 1 is to build symbol tables and to make a rudimentary assembly of each source statement.

The first task of Pass 1 is initializing all impure data areas that MACRO uses (internally) for assembly. This area includes all dynamic storage areas and all buffer areas.

MACRO then reads a command string into memory. This command string contains specifications for the files to be used during assembly. After scanning the command string for proper syntax, MACRO initializes the specified output files.

As assembly begins, MACRO initiates a routine that retrieves source lines from the proper input file. If no such file is currently open, MACRO opens the next input file specified in the command string. Source lines are assembled as they are retrieved from input files.

Assembly Pass 2 performs the same steps as Pass 1. However, during Pass 2 MACRO writes the object code to the binary (and usually relocatable) output file; it also generates the program listing file, followed by the symbol table listing for the program.

MACRO can also generate a cross-referenced symbol table. (See Chapter 6.)

During Pass 2 MACRO also flags erroneous source statements with single-character error codes. (See Chapter 7.) These error codes appear in the program listing file.

INTRODUCTION TO MACRO

The relocatable binary object file created during Pass. 2 contains all binary code generated; this code is in a form suitable for loading by the LINK program. (See the LINK Reference Manual.)

MACRO processes relocation counters on both passes. If a labeled statement has a different relocation value on the second pass, MACRO generates a phase error.

1.2 ADDRESSES AND MEMORY

The address space of a DECSYSTEM-20 program consists of 512P (1P = 512 words), each word having 36 bits. Since the total number of storage locations is 2 to the 18th power, the address of a location can be expressed in 18 bits, or one halfword.

The left halfword of a storage location is bits 0 to 17; the right halfword is bits 18 to 35.

1.3 RELOCATABLE ADDRESSES

Normally the binary program generated by MACRO is relocatable. This means that when the program is loaded for execution, it can be loaded anywhere in physical memory. (The address for loading is selected at load time, and depends on what has already been loaded.)

Unless you specify otherwise, MACRO assembles your binary program beginning with address 0 (400000 for high-segment code). References to addresses within your program are therefore relative to 0 (400000 for the high segment), and must be changed at loading time. LINK does this by adding the load address to all such relative addresses, resolving them to absolute addresses.

For programs assembled with multiple PSECT counters, each PSECT begins with the relative address 0. At load time, each PSECT has its own relocation constant; PSECT origins must be selected carefully to avoid overlapping of PSECTs in memory.

CHAPTER 2
ELEMENTS OF MACRO

The character set recognized in MACRO statements includes all ASCII alphanumeric characters and 28 special characters (ASCII 040 through 137). Lowercase letters (ASCII 141 through 172) are treated internally as uppercase letters (ASCII 101 through 132).

MACRO also recognizes seven ASCII control codes: horizontal tab (011), linefeed (012), vertical tab (013), formfeed (014), carriage-return (015), CTRL/underscore (037), and CTRL/Z (032).

MACRO accepts any ASCII character in quoted text, or as text arguments to the ASCII and ASCIIZ pseudo-ops.

NOTES

1. The line-continuation character (CTRL/_) is always effective.
2. Delimiters for certain pseudo-ops (such as ASCII, ASCIIZ, and COMMENT) can be any nonblank, nontab ASCII character.

Characters and their codes are listed in Appendix A.

A MACRO program consists of statements made up of MACRO language elements. Separated into general types, these are:

1. Special characters
2. Numbers
3. Literals
4. Symbols
5. Expressions
6. MACRO-defined mnemonics
7. Pseudo-ops
8. Macros

The format of a MACRO statement is discussed in Chapter 4.

ELEMENTS OF MACRO

2.1 SPECIAL CHARACTERS

Characters and combinations that have special interpretations in MACRO are listed in Appendix B. These interpretations apply only in the contexts described. In particular, they do not apply within comment fields or text strings.

2.2 NUMBERS

The two properties of numbers that are important to MACRO are:

1. In what radix (base) the number is given.
2. How the number should be placed in memory.

You can control the interpretation of these properties by using pseudo-ops or special characters to indicate your choices.

2.2.1 Integers

MACRO stores an integer in its binary form, right justified in bits 1 to 35 of its storage word. If you use a sign, place it immediately before the integer. (If you omit the sign, the integer is assumed positive.) For a negative integer, MACRO first forms its absolute value in bits 1 to 35, then takes its two's complement. Therefore a positive integer is stored with 0 in bit 0, while a negative integer has 1 in bit 0.

The largest integer that MACRO can store is 377777 777777 (octal); the smallest (most negative) is 400000 000000 (octal).

2.2.2 Radix

The initial implicit radix for a MACRO program is octal (base 8). The integers you use in your program will be interpreted as octal unless you indicate otherwise.

You can change the radix to any base from 2 to 10 by using the RADIX pseudo-op. (See the pseudo-op RADIX in Chapter 3.) The new radix will remain in effect until you change it.

Without changing the prevailing radix, you can write a particular expression in binary, octal, or decimal. To do this, prefix the integer with [^]B for binary, [^]O for octal, or [^]D for decimal. The indicated radix applies only to the single integer immediately following it.

ELEMENTS OF MACRO

NOTES

1. A single-digit number is always interpreted as radix 10. Thus 9 is seen as decimal 9, even if the current radix is 8.
2. In the notations for ^B , ^D , and ^O , the up-arrow in the text indicates the up-arrow character, not the CONTROL character.

For example, suppose the current radix is 8. Then you can write the decimal number 23 as:

27	octal (current radix)
$\text{^D}23$	decimal
$\text{^B}10111$	binary

But you cannot write decimal 23 as $\text{^D}45-22$ since the ^D applies only to the first number, 45; the 22 is octal. However, you can write decimal 23 as $\text{^D}<45-22>$.

2.2.3 Adding Zeros to Integers in Source Code

You can add zeros to an integer (multiply it by a constant) in your program by suffixing K, M, or G to it.

K adds 3 zeros	(K = "kilo-", thousands)
M adds 6 zeros	(M = "mega-", millions)
G adds 9 zeros	(G = "giga-", billions)

These zeros are suffixed before any conversion, so that in radix 10, 5K means 5000 decimal; in radix 8, 5K means 5000 octal, or 2560 decimal.

2.2.4 Fixed-Point Decimal Numbers

To indicate a fixed-point decimal number, prefix it with ^F , include a decimal point wherever you wish, and suffix Bn to show that you want to place the "assumed point" after bit n in the storage word. If you omit the decimal point, MACRO assumes that it follows the last digit. If you omit the Bn, MACRO assumes B35.

To handle the number, MACRO forms the integer part in a fullword register, and the fractional part in another fullword register. It then places the integer part (right justified) in bits 1 to n (n is from your Bn) of a binary word, and the fractional part (left justified) in the remaining bits. The integer part is truncated at the left, and the fractional part at the right. Bit 0 shows the sign of the number.

ELEMENTS OF MACRO

For example, ^F123.45B8 is formed in two registers as

```
000000 000173 (integer part, right justified)
346314 631462 (fractional part, left justified)
```

Since the Bn operator sets the assumed point after bit 8, the integer part is placed in bits 1 to 8, and the fractional part in bits 9 to 35. (The sign bit 0 is 0, showing a positive number.) Truncation is on the left and right, respectively, giving

```
173 346 314631
  ↑
assumed point
```

You can show a fixed-point decimal number as negative by placing a minus sign before the ^F . The absolute value of the negative number is formed in two registers as a positive number, then two's complemented. This complementing sets bit 0 to 1, showing that the number is negative.

NOTE

The binary number resulting from ^F does not show where the assumed point should be. You must keep track of this through your own programming conventions.

Examples:

```
000000 000173    ^F123.45
000173  346314    ^F123.45B17
346314  631462    ^F123.45B-1
777777  777604    -^F123.45
777604  431463    -^F123.45B17
431463  146316    -^F123.45B-1
```

2.2.5 Floating-Point Decimal Numbers

In your program, a floating-point decimal number is a string of digits with a leading, trailing, or embedded decimal point and an optional leading sign. MACRO recognizes this as a mixed number in radix 10.

MACRO forms a floating-point decimal number with the sign in bit 0, a binary exponent in bits 1 to 8, and a normalized binary fraction in bits 9 to 35.

The normalized fraction can be viewed as follows: its numerator is the binary number in bits 9 to 35, whose value is less than 2 to the 28th power, but greater than or equal to 2 to the 27th power. Its denominator is 2 to the 28th power, so that the value of the fraction is always less than 1, but greater than or equal to 0. (This value is 0 only if the entire stored number is 0.)

ELEMENTS OF MACRO

The binary exponent is incremented by 128 so that exponents from -128 to 127 are represented as 0 to 255.

For a negative floating-point decimal number, MACRO first forms its absolute value as a positive number, then takes the two's complement of the entire word.

Examples:

The floating-point number 17. generates the binary

```
0 10 000 101 100 010 000 000 000 000 000 000
```

where bit 0 shows the positive sign, bits 1 to 8 show the binary exponent, and bits 9 to 35 show the proper binary fraction. The binary exponent is 133 (decimal), which after subtracting the added 128 gives 5. The fraction is equal to 0.53125 decimal. And 0.53125 times 2 to the 5th power is 17, which is the number given.

Similarly, 153. generates

```
0 10 001 000 100 110 010 000 000 000 000 000
```

while -153. generates

```
1 01 110 111 011 001 110 000 000 000 000 000
```

These two examples show that a negative number is two's complemented. Notice that since the binary fraction for a negative number always has some nonzero bits, the exponent field (taken by itself) appears to be one's complemented.

As in FORTRAN, you can write a floating-point decimal number with a suffixed $E\pm n$, and the number will be multiplied by 10 to the $\pm n$ th power. If the sign is missing, n is assumed positive.

Examples:

2840000.	can be written	284.E+4
2840000.	can be written	.284E7
.0000284	can be written	.284E-4
.0000284	can be written	284.E-7

Using this E notation with an integer (no decimal point) is not allowed, and causes an error. Therefore you can use 284.E4, but 284E4 is illegal.

NOTE

MACRO's algorithm for handling numbers given with the E notation is not identical to FORTRAN's. The binary values generated by the two translators may differ in the lowest order bits.

ELEMENTS OF MACRO

2.2.6 Binary Shifting

Binary shifting of a number with B_n sets the location of the rightmost bit at bit n in the storage word, where n is a decimal integer. The shift takes place after the binary number is formed. Any bits shifted outside the range (bits 0 to 35) of the storage word are lost.

For example, here are some numbers with their binary representations given in octal:

300000	000000	^D3B2
000000	042000	^D17E25
000001	000000	1B17
400000	000000	1B0
777777	777777	-1B35
000000	000001	1B35
000000	777777	-1B35

2.2.7 Underscore Shifting

You can also shift a number by using the underscore operator. (On some terminals this is a left-arrow.) If V is an expression with value n , suffixing $_V$ to a number shifts it n bits to the left. (If n is negative, the shift is to the right.)

In an expression of the form W_V , W and V can be any expressions including symbols. The binary value of W is formed in a register, V is evaluated, and the binary of W is shifted V bits when placed in storage.

NOTE

An expression such as $-3.75E4_D18$ is legal, but the shift occurs after conversion to floating-point decimal storage format. Therefore the sign, exponent, and fraction fields are all shifted away from their usual locations. This is true also for other storage formats.

2.2.8 Querying the Position of a Bit Pattern

You can query the position of a bit pattern by prefixing ^L (up-arrow L) to an expression. This generates the number of leading zeros in the binary value of the expression. (^L0 generates 36 decimal.)

ELEMENTS OF MACRO

For example, suppose the current radix is 10. Then

`^L153` generates 35 (29 decimal)

`^L153.` generates 1

`^L-153` generates 0

`^L-153.` generates 0

In the first example, `^L153` generates 29 (decimal) because the binary representation of 153 decimal has its leftmost 1 in bit 28:

```
000 000 000 000 000 000 000 000 000 010 011 001
```

But in the second example, the binary form of 153. is in floating-point format (see Section 2.2.5),

```
010 001 000 100 110 010 000 000 000 000 000 000
```

and its leftmost 1 is in bit 1.

In both of the last two examples, `^L-153` and `^L-153.` generate 0. This is because a negative number in any format sets bit 0 to 1.

2.3 LITERALS

A literal is a character string within square brackets inserted in your source code. MACRO stores the code generated by the enclosed string in a literal pool beginning with the first available literal storage location, and places the address of this location in place of the literal. The literal pool is normally at the end of the binary program. (See the pseudo-op LIT in Chapter 3.)

The statements

```
135 01 0 00 002016'          LDB T1,[POINT 6,JBVER,17]
                                LIT
22 06 0 00 000137
```

are equivalent to

```
135 01 0 00 002020'          LDB T1,PLACE
. . .
22 06 0 00 000137          PLACE: POINT 6,JBVER,17
```

A literal can also be used to generate a constant:

```
PUSH 17,[0]                  ;Generate zero fullword
MOVE L,[3,,1]                ;Generate a word with 3 in
                                ; lefthalf and 14 in righthalf
```

ELEMENTS OF MACRO

Multiline literals are also allowed:

```
GETCHR: ILDB T2,T1          ;Get a character
        CAIN T2,0          ;Is it a null?
        JRST [MOVE T1,XTPTR ;Yes, retrieve pointer
            ILDB T2,T1     ;Get a new character
            CAIN T2,"?"    ;Is it a question mark?
            JRST [MOVE T1,XTPT1 ;Yes, set alternate pointer
                ILDB T2,T1     ;Get the message character
                JRST GETHELP] ;Go to help routine
        POPJ P,]          ;Not question mark, return
        POPJ P,          ;Not a null, return
```

The text of a literal continues until a matching closing square bracket is found (unquoted and not in comment field).

A literal can include any term, symbol, expression, or statement, but it must generate at least one but no more than 99 words of data. A statement that does not generate data (such as a direct-assignment statement or a RADIX pseudo-op) can be included in a literal, but the literal must not consist entirely of such statements.

You can nest literals up to 18 levels. You can include any number of labels in a literal, but a forward reference to a label in a literal is illegal.

If you use a dot (.) in a literal to retrieve the location counter, remember that the counter is pointing at the statement containing the literal, not at the literal itself.

In nested literals, a dot location counter references a statement outside the outermost literal.

In the sequence

```
        JRST [HRRZ AC1,0
            CAIE AC1,0P
            JRST .+1
            JRST EVTSTS]
        SKIPE C
```

the expression `+.1` generates the address of `SKIPE C`, not `JRST EVTSTS`.

Literals having the same value are collapsed in MACRO's literal pool. Thus for the statements:

```
        PUSH P,[0]
        PUSH P,[0]
        MOVEI AC1,[ASCIZ /TEST1/]
```

the same address is shared by the two literals `[0]`, and by the null word generated at the end of `[ASCIZ /TEST1/]`. Literal collapsing is suppressed for those literals that contain errors, undefined expressions, or EXTERNAL symbols.

ELEMENTS OF MACRO

2.4 SYMBOLS

MACRO symbols include:

1. MACRO-defined pseudo-ops (discussed in Chapter 3)
2. MACRO-defined mnemonics (discussed in Section 2.6)
3. User-defined macros (discussed in Chapter 5)
4. User-defined opdefs (discussed at OPDEF in Chapter 3)
5. User-defined labels (discussed in this section)
6. Direct-assignment symbols (discussed in Section 2.4.2.2)
7. Dummy-arguments for macros (discussed in Chapter 5)

MACRO stores symbols in three symbol tables:

1. Op-code table: machine instruction mnemonics and pseudo-ops
2. Macro table: macros, user-defined OPDEFs, and synonyms (See the SYN pseudo-op in Chapter 3.)
3. User symbol table: labels and direct-assignment symbols

An entry in one of these tables shows the symbol, its type, and its value.

Symbols are helpful in your programs because:

1. Defining a symbol as a label gives a name to an address. You can use the label in debugging or as a target for program control statements.
2. In revising a program, you can change a value throughout your program by changing a symbol definition.
3. You can give names to values to make computations clearer.
4. You can make values available to other programs.

2.4.1 Selecting Valid Symbols

Follow these rules in selecting symbols:

1. Use only letters, numerals, dots (.), dollar signs (\$), and percent signs (%). MACRO will consider any other character (including a blank) as a delimiter.
2. Do not begin a symbol with a numeral.
3. If you use a dot for the first character, do not use a numeral for the second. Do not use dots for the first two characters; doing so can interfere with MACRO's created symbols. (See Section 5.5.2.)
4. Make the first six characters unique among your symbols. You can use more than six characters, but MACRO will use only the first six.

ELEMENTS OF MACRO

Examples:

VELOCITY (legal, only VELOCI is meaningful to MACRO)
CHG.VEL (legal, only CHG.VE is meaningful to MACRO)
CHG VEL (illegal, looks like two symbols to MACRO)
1STNUM (illegal, begins with a numeral)
NUM1 (legal)
.1111 (illegal, begins with dot-numeral)
..1111 (unwise, could interfere with created symbols)

2.4.2 Defining Symbols

You can define a symbol by making it a label or by giving its value in a direct-assignment statement. Labels cannot be redefined, but direct-assignment symbols can be redefined anywhere in your program.

You can also define special-purpose symbols called OPDEFs and macros using the pseudo-op OPDEF and the pseudo-op DEFINE. (See Chapter 3.)

2.4.2.1 Defining Labels - A label is always a symbol with a suffixed colon. A label is in the first (leftmost) field of a MACRO statement and is one of the forms:

ERRFOUND:	(MACRO uses only ERRFOU)
CASE1:	(legal label)
OK:CONTIN:	(legal; you can use more than one label at a location)
CASE2::	(double colon declares label INTERNAL; see Section 2.4.5.2)
CASE3:!	(colon and exclamation point suppresses output by debugger)
CASE4::!	(double colon and exclamation point declares label INTERNAL and suppresses output by debugger)

ELEMENTS OF MACRO

When MACRO processes the label, the symbol and the current value of the location counter are entered in the user symbol table. A reference to the symbol addresses the code at the label.

You cannot redefine a label to have a value different from its original value. A label is relocatable if the address it represents is relocatable; otherwise it is absolute.

2.4.2.2 Direct Assignments - You define a direct-assignment symbol by associating it with an expression. (See Section 2.5 for a discussion of expressions.) A direct assignment is in one of the forms:

<code>symbol=expression</code>	(symbol and value of expression are entered in user symbol table)
<code>symbol==expression</code>	(symbol and value of expression are entered in user symbol table, output by debugger is suppressed)
<code>symbol=:expression</code>	(symbol and value of expression are entered in user symbol table, symbol is declared INTERNAL; see Section 2.4.5.2)
<code>symbol==:expression</code>	(symbol and value of expression are entered in user symbol table, symbol is declared INTERNAL, output by debugger is suppressed)

You can redefine a direct-assignment symbol at any time; the new direct assignment simply replaces the old definition.

NOTE

If you assign a multiword value using direct assignment, only the first word of the value is assigned to the symbol. For example, `A=ASCIZ /ABCDEFGH/` is equivalent to `A=ASCIZ /ABCDE/`, since only the first five characters in the string correspond to code in the first word.

2.4.3 Variable Symbols

You can specify a symbol as a variable by suffixing it with a number sign (#). A variable symbol needs no explicit storage allocation. On finding your END statement, MACRO assembles variables into locations following the literal pool.

You can assemble variables anywhere in your program by using the VAR pseudo-op. This pseudo-op causes all variables found so far to be assembled immediately. (Variables found after the VAR statement are assembled at the end of the program or at the next VAR statement.)

ELEMENTS OF MACRO

2.4.4 Using Symbols

When you use a symbol in your program, MACRO looks it up in the symbol tables. Normally MACRO searches the macro table first, then the op-code table, and finally the user symbol table. However, if MACRO has already found an operator in the current statement and is expecting operands, then it searches the user symbol table first.

You can control the order of search for symbol tables by using the pseudo-op `.DIRECTIVE MACPRF`.

2.4.5 Symbol Attributes

The value of a symbol is either relocatable or absolute. The relocatability of a label is determined by the relocatability of the address assigned to it. You can define either an absolute or a relocatable value for a direct-assignment symbol.

In addition, each symbol in your program has one of the following attributes: local, INTERNAL global, or EXTERNAL global. This attribute is determined when the symbol is defined.

2.4.5.1 Local Symbols - A local symbol is defined for the use of the current program only. You can define the same symbol to have different values in separately assembled programs. A symbol is local unless you indicate otherwise.

2.4.5.2 Global Symbols - A global symbol is defined in one program, but is also available for use in other programs. Its table entry is visible to all programs in which the symbol is declared global.

A global symbol must be declared INTERNAL in the program where it is defined; it can be defined in only one program. In other programs sharing the global symbol, it must be declared EXTERNAL; it can be EXTERNAL in any number of programs.

To declare a symbol as INTERNAL global, you can:

1. Use the INTERN pseudo-op.

```
INTERN FLAG1
```

2. Insert a colon after = in a direct-assignment statement.

```
FLAG2=:200
```

```
FLAG3==:200
```

3. Use an extra colon with a label.

```
FLAG4::
```

4. For subroutine entry points, use the ENTRY pseudo-op. (This pseudo-op does more than declare the symbol INTERNAL. See Chapter 3.)

```
ENTRY FLAG5
```

ELEMENTS OF MACRO

To declare a symbol as an EXTERNAL global, you can:

1. Use the EXTERN pseudo-op.

```
EXTERN FLAG6
```

2. Suffix ## to the symbol at any of its uses. (Doing this once is sufficient, but you can use ## with all references to the symbol.)

```
FLAG7##
```

2.5 EXPRESSIONS

You can combine numbers and defined symbols with arithmetic and logical operators to form expressions. You can nest expressions by using angle brackets. MACRO evaluates each expression (innermost nesting levels first), and either resolves it to a fullword value, or generates a Polish expression to pass to LINK. (See Sections 2.5.3 and 2.5.4.)

2.5.1 Arithmetic Expressions

An arithmetic expression can include any number or defined symbol, and any of the following operators:

```
+ addition
- subtraction
* multiplication
/ division
```

These examples assume that WORDS, X, Y, and Z have been defined elsewhere:

```
MOVEI 3,WORDS/5
ADDI 12,<X+Y-Z>
ADDI 12,<<WORDS/5>+1>*5
```

2.5.2 Logical Expressions

A logical expression can include any number or defined symbol whose value is absolute, and any of the following operators:

```
& AND
! OR (inclusive OR)
^! XOR (exclusive OR)
^- NOT
```

ELEMENTS OF MACRO

The unary operation \sim A generates the fullword one's complement of the value of A.

Each of the binary operations $\&$, $!$, and \wedge generates a fullword by performing the indicated operation over corresponding bits of the two operands. For example, A $\&$ B generates a fullword whose bit 0 is the result of A's bit 0 ANDed with B's bit 0, and so forth for all 36 bits.

2.5.3 Polish (Complex) Expressions

MACRO cannot evaluate certain expressions containing relocatable values or EXTERNAL symbols. Instead MACRO generates special expressions called Polish expressions, which tell LINK how to resolve the values at load time. MACRO also generates Polish expressions to resolve inter-PSECT references.

For example, assume that A and B are externally defined symbols. Then MACRO cannot perform the operations A+B-3, but instead generates a special Polish block containing an expression to pass to LINK; the expression is equivalent to \sim +AB3. (See REL Block Type 11 in the LINK Reference Manual.) At load time, the values of A and B are available to LINK, and the expression is resolved.

NOTE

If you have used reverse Polish notation with a calculator, you should notice that although MACRO's Polish expressions are similar, they are not reversed. (These notations are called Polish because they were invented by the Polish logician Jan Lukasiewicz.)

2.5.4 Evaluating Expressions

2.5.4.1 Hierarchy of Operations - MACRO has a hierarchy of operations in evaluating expressions. In an expression without nests (angle brackets), or within a nested expression, MACRO performs its operations in this effective order:

1. All unary operations and shifts: $+$, $-$, \sim , \wedge D, \wedge O, \wedge B, B (binary shift), $_$ (underscore shift), \wedge F, \wedge L, E, K, M, G. Zeros are added for K, M, and G before any other operation is performed.
2. Logical binary operations (from left to right): $!$ (OR), \wedge ! (XOR), $\&$ (AND).
3. Multiplication and division (from left to right): $*$, $/$.
4. Addition and subtraction (binary operations): $+$, $-$.

ELEMENTS OF MACRO

You can override this hierarchy by using angle brackets to show what you want done first. For example, suppose you want to calculate the sum of A and B, divided by C. You cannot do this with $A+B/C$ because MACRO will perform the division B/C first, then add the result to A. With angle brackets you can write the expression $\langle A+B \rangle / C$, telling MACRO to add A and B first, then divide the result by C.

Expressions can be nested to any level. The innermost nest is evaluated first; the outermost, last. Some examples of legal expressions (assuming that A1, B1, and C are defined symbols) are:

```
A1+B1/5
<A1+B1>/5
~A1&B1~!C
~B101M~D98+6
```

NOTE

An expression given in halfword notation (that is, lefthalf,,righthalf) has each half evaluated separately in a 36-bit register. Then the 18 low-order bits of each half are joined to form a fullword. For example, the expression $\langle 4,,6 \rangle / 2$ generates the value 000002 000003.

2.5.4.2 Evaluating Expressions with Relocatable Values - The value of an expression is usually either absolute or relocatable. Recall that relocatable values in your binary code will have the relocation constant added at load time by LINK.

Assume that A and B are relocatable symbols, and that X and Y are absolute symbols, and that the relocation constant is k. Let $a+k$ and $b+k$ be the values of A and B after relocation. Then $A+X$ makes sense (to LINK) because it means $\langle a+k \rangle + X$, which is the same as $\langle a+X \rangle + k$, clearly relocatable.

Since X and Y are both absolute, any operation combining them gives an absolute result.

Now look at the expression $A+B$. This means $\langle a+k \rangle + \langle b+k \rangle$, which is the same as $\langle a+b \rangle + 2k$, neither absolute nor relocatable. Similarly, $A*B$ means $\langle a+k \rangle * \langle b+k \rangle$, or $\langle a*b \rangle + \langle a+b \rangle * k + k*k$, again neither absolute nor relocatable. Such expressions cannot be evaluated by MACRO and are passed as Polish expressions to LINK.

More generally, you can see if an expression is absolute or relocatable by substituting relocated forms as above (for example, $a+k$), and separating it (if possible) into the form

absolute+n*k

where absolute is an absolute expression. If $n=0$, the expression is absolute; if $n=1$, it is relocatable. If n is neither 0 nor 1, or if the expression cannot be put into the form above, then the expression is neither absolute nor relocatable. (Nevertheless, LINK will correctly evaluate the expression at load time.)

ELEMENTS OF MACRO

2.6 MACRO-DEFINED MNEMONICS

MACRO-defined mnemonics are words that MACRO recognizes and can translate to binary code. These mnemonics include:

1. Machine instruction mnemonics
2. I/O instruction mnemonics
3. I/O device code mnemonics
4. KL10 EXTEND instruction mnemonics
5. JRST and JFCL mnemonics

Each type of mnemonic is discussed and tabulated in Appendix C. These mnemonics, together with MACRO's pseudo-ops and special characters, form the MACRO language.

CHAPTER 3

PSEUDO-OPS

A pseudo-op is a statement that directs the assembler to generate code or set switches to control assembly and listing of your program. For example, the pseudo-op RADIX does not generate code, but it tells MACRO how to interpret numbers in your program. The pseudo-op EXP generates one word of code for each argument given with it.

To use a pseudo-op in your program, follow it with a space or tab, and any required or optional arguments or parameters. The program examples in Appendix D show pseudo-ops used in context.

This chapter describes the use and functions of each pseudo-op (alphabetically). The headings included for each description, if applicable, are:

1. FORMAT
2. FUNCTION
3. EXAMPLES
4. OPTIONAL NOTATIONS
5. RELATED PSEUDO-OPS
6. COMMON ERRORS

Some entries under COMMON ERRORS cite single-character error codes (for example, M error). These codes are discussed in Section 8.2.

Many of the examples show some parts of the code assembled. The format and meaning of assembled code is discussed in Section 6.1.

PSEUDO-OPS

ARRAY

FORMAT ARRAY sym[expression]

expression = an integer value in the current radix, indicating the number of words to be allocated; the expression cannot be EXTERNAL, relocatable, or a floating-point decimal number, and its value must not be negative.

FUNCTION Reserves a block of storage whose length is the value of the expression, and whose location is identified by the symbol. Storage is allocated along with other variable symbols in the program.

If the pseudo-op TWOSEG is used, ARRAY storage must be in the low segment. (See the VAR pseudo-op.)

The allocated storage is not necessarily zeroed.

If you use ARRAY in a PSECT, storage is allocated within that PSECT.

NOTE

Though the expression portion of an OPDEF must be in square brackets, this use of the brackets is completely unrelated to literals or literal handling.

EXAMPLES ARRAY START[200]
 ARRAY PLACE[1000]
 ARRAY ERRS[2000]

OPTIONAL NOTATIONS ARRAY sym1,sym2 [expression]

Both sym1 and sym2 have a length equal to the value of the expression.

RELATED PSEUDO-OPS BLOCK, .COMMON, INTEGER, VAR

COMMON ERRORS Using an EXTERNAL symbol for name or size of the array (E error).

PSEUDO-OPS

ASCII

FORMAT ASCII dtextd
d = delimiter; first nonblank character, whose second appearance terminates the text.
text = string of text characters to be entered.

FUNCTION Enters ASCII text in the binary code. Each character uses seven bits. Characters are left justified in storage, five per word, with bit 35 in each word set to 0, and any unused bits in the last word set to 0.

EXAMPLES 105 122 122 117 122 ASCII /ERROR MESSAGE/
040 115 105 123 123
101 107 105 000 000

123 124 101 122 124 ASCII !STARTING AGAIN!
111 116 107 040 101
107 101 111 116 000

105 116 104 123 040 ASCII ?ENDS WITH ZEROS?
127 111 124 110 040
132 105 122 117 123

OPTIONAL NOTATIONS Omit the space or tab after ASCII. This is not allowed if the delimiter is a letter, number, dot, dollar sign, or percent sign (that is, a possible symbol constituent), or if the ASCII value of the delimiter character is less than 040 or greater than 172.

Right justified ASCII can be entered by using double quotes to surround up to five characters; for example,
201 01 0 00 000101 MOVEI AC1,"A"

RELATED PSEUDO-OPS ASCIIZ, .DIRECTIVE FLBLST, RADIX50, SIXBIT

COMMON ERRORS Using the delimiter character in the text string.

Missing the end delimiter (that is, attempting to use a carriage return as a delimiter).

Using more than 5 characters in a right-justified ASCII string, or more than 2 characters if in the address field (Q error).

Giving direct assignment of a long ASCII string value to a symbol (for example A=ASCII /ABCDEFGH/). Only the first word (five characters, left justified) is assigned.

Using ASCII when ASCIIZ is required.

PSEUDO-OPS

ASCIZ

FORMAT ASCIZ dtextd

d = delimiter; first nonblank character, whose second appearance terminates the text.

text = string of text characters to be entered.

FUNCTION Enters ASCII text exactly as in the pseudo-op ASCII, except that a trailing null character is guaranteed. That is, if the number of characters in text is a multiple of five, a fullword of zeros is generated.

EXAMPLES 105 122 122 117 122 ASCIZ /ERROR MESSAGE/
 040 115 105 123 123
 101 107 105 000 000

 123 124 101 122 124 ASCIZ !STARTING AGAIN!
 111 116 107 040 101
 107 101 111 116 000

 105 116 104 123 040 ASCIZ ?ENDS WITH ZEROS?
 127 111 124 110 040
 132 105 122 117 123
 000 000 000 000 000

OPTIONAL NOTATIONS Omit the space or tab after ASCIZ. This is not allowed if the delimiter is a letter, number, dot, dollar sign, or percent sign (that is, a possible symbol constituent), or if the ASCII value of the delimiter character is less than 040 or greater than 172.

RELATED PSEUDO-OPS ASCII, .DIRECTIVE FLBLST, RADIX50, SIXBIT

COMMON ERRORS Using the delimiter character in the text string.

 Missing the end delimiter (that is, attempting to use a carriage return as a delimiter).

 Giving direct assignment of a long ASCII string value to a symbol (for example A=ASCII /ABCDEFGH/). Only the first word (five characters, left justified) is assigned.

 In a macro, using a delimiter character that interferes with recognition of a dummy-argument. For example, in the macro

 DEFINE FOO(X)<
 ASCIZ .X.
 >

 X is not seen as a dummy-argument because .X. is itself a valid symbol.

(Continued on next page)

PSEUDO-OPS

ASCIZ (Cont.)

In the macro

```
DEFINE FOO(X)<  
ASCIZ /X/  
>
```

X is seen as a dummy-argument because the slash (/) is not valid in a symbol.

The macro

```
DEFINE FOO(X)<  
ASCIZ .'X'.  
>
```

uses the concatenation operator (') to assure recognition of X as a dummy-argument. (See Section 5.4 for a discussion on concatenating arguments.)

PSEUDO-OPS

ASUPPRESS

FORMAT ASUPPRESS

FUNCTION Causes all local or INTERNAL symbols that are not referenced after the ASUPPRESS to be deleted from MACRO's symbol table at the end of Pass 2. These symbols will not be output to LINK, will not be available to the debugger, and will not appear in the symbol table in the program listing file.

If you use ASUPPRESS at the end of Pass 1, only those symbols defined or referenced in Pass 2 remain in MACRO's symbol table. This is useful for parameter files that define many more symbols than are actually used, since the unused symbols can be automatically deleted if they are defined in IF1 conditionals.

RELATED PURGE, SUPPRESS
PSEUDO-OPS

PSEUDO-OPS

BLOCK

FORMAT BLOCK expression

expression = an integer value in the current radix, indicating the number of words to be allocated; the expression cannot be EXTERNAL, relocatable, or a floating-point decimal number, and its value must not be negative.

FUNCTION

Reserves a block of locations whose length is the value of the expression. The location counter is incremented by this value. The allocated locations are not necessarily zeroed.

Note that the BLOCK pseudo-op does not generate or store code. Therefore it should not be used in a literal, since this will result in overwriting the reserved space during literal pooling.

If you use the BLOCK pseudo-op to reserve words meant for data storage, these words should be reserved in the low segment of a two-segment program.

EXAMPLES

```

002101' 200 02 0 00 400033'           MOVE 2,[XWD FRM,TO]
002102' 251 02 0 00 003010'           BLT 2,TOEND
.....
002611'                               FRM:   BLOCK 100
002711'                               TO:    BLOCK 100
                                      003010'       TOEND=-1

```

OPTIONAL NOTATIONS Use the pseudo-op Z inside literals.

RELATED PSEUDO-OPS ARRAY, .COMMON, INTEGER, VAR

COMMON ERRORS

Relocatable expression (R error).

Floating-point or negative expression (A error).

Value of expression larger than 777777.

Expression contains EXTERNAL symbol (E error).

Expression contains nonexistent symbol (V error).

BLOCK used in literal (L error).

PSEUDO-OPS

BYTE

FORMAT `BYTE bytedef ... bytedef`
`bytedef=(n)expression,...,expression`
`n = byte size in bits; n is a decimal expression in the range 1 to 36.`
`expression = value to be stored.`

FUNCTION Stores values of expressions in n-bit bytes, starting at bit 0 of the storage word. The first value is stored in bits 0 to n-1; the second in bits n to 2n-1; and so forth for each given value.

 If a byte will not fit in the remaining bits of a word, the bits are zeroed and the byte begins in bit 0 of the next word. If a value is too large for the byte, it is truncated on the left.

 If the byte size is 0 or is missing (empty parentheses), a zero word is generated.

EXAMPLES `000002 VELOCITY=2`
`05 00 00 01 05 02 BYTE (6)5,0,,101,5,VELOCITY`

 generates the storage value 050000 010502. The two commas indicate a null argument; the 101 (octal) is too large for the byte size and is left truncated.

`07 00 01 007 000 BYTE (6)7,0,1(9)7,0,1,"A"`
`001 101 000000`

 Notice that the code for "A" (101) is right justified in its 9-bit byte.

COMMON ERRORS `Byte size too big (A error).`
`Missing left or right parenthesis (A error).`
`Extraneous comma before left parenthesis; the comma generates a null byte.`
`Using an EXTERNAL symbol or EXTERNAL complex expression for n or expression.`

PSEUDO-OPS

COMMENT

FORMAT COMMENT dtextd
d = delimiter; the first nonblank character, whose second appearance terminates the text.
text = text to be entered as a comment.

FUNCTION Treats the text between the delimiters as a comment. The text can include a CR-LF to facilitate multiline comments, as shown below.

EXAMPLES COMMENT /THIS IS A COMMENT
THAT IS MORE THAN 1 LINE LONG/

OPTIONAL NOTATIONS Omit the space or tab after COMMENT. This is not allowed if the delimiter is a letter, number, dot, dollar sign, or percent sign (that is, a possible symbol constituent), or if the ASCII value of the delimiter character is less than 040 or greater than 172.
Use a semicolon (;) to make the rest of the line into a comment.

RELATED PSEUDO-OPS REMARK

COMMON ERRORS Using the delimiter character in the text string.
Missing the end delimiter (that is, attempting to use a carriage return as a delimiter).

PSEUDO-OPS

.COMMON

FORMAT .COMMON symbol[expression]

symbol = name of a FORTRAN COMMON block.

expression = an expression having a positive integer value; this value defines the length of the COMMON block.

FUNCTION Defines a FORTRAN or FORTRAN-compatible COMMON block. Causes the equivalent action of a FORTRAN labeled COMMON. (See the FORTRAN Reference Manual.)

You can use .COMMON to define blank COMMON; to do this, use the symbol .COMM. as the name of the COMMON block. (Both FORTRAN and LINK recognize this as the name of blank COMMON.)

To define a COMMON block, MACRO generates a REL Block Type 20. (See the LINK Reference Manual.)

If used, the .COMMON pseudo-op must precede any MACRO statement that generates binary code, and must precede any other reference to the symbol name.

EXAMPLES .COMMON DATA1[50]

OPTIONAL NOTATIONS .COMMON symbol,...,symbol[expression]

defines a COMMON array for each symbol given. Each array has a length equal to the value of the expression.

RELATED PSEUDO-OPS ARRAY, BLOCK, EXTERN, INTEGER

COMMON ERRORS Missing left or right square bracket (A error).

Using a relocatable value or EXTERNAL symbol in expression.

PSEUDO-OPS

.CREF

FORMAT	.CREF
FUNCTION	Resumes output of cross-referencing that was suspended by the .XCREF pseudo-op.
OPTIONAL NOTATIONS	Can apply to specific symbols to cancel a previous .XCREF on those symbols, as in .CREF symbol,...,symbol
RELATED PSEUDO-OPS	.XCREF
COMMON ERRORS	Specifying a nonexistent symbol (A error).

PSEUDO-OPS

DEC

FORMAT DEC expression,...,expression

FUNCTION Defines the local radix for the line as decimal; the value of each expression is entered in a fullword of code. The location counter is incremented by 1 for each expression.

EXAMPLES

```
                                RADIX 8
000000 000012 DEC 10,4.5,3.1416,6.03E-26,3
203440 000000
202622 077714
055452 456522
000000 000003
```

OPTIONAL NOTATIONS

Use the EXP pseudo-op and prefix ^D to each expression that must be evaluated in radix 10. In the example above, only the first expression, "10," has different evaluations in radix 8 and radix 10. Therefore an equivalent notation is

```
000000 000012 EXP ^D10,4.5,3.1416,6.03E-26,3
203440 000000
202622 077714
055452 456522
000000 000003
```

RELATED PSEUDO-OPS

EXP, RADIX, OCT

PSEUDO-OPS

DEFINE

FORMAT DEFINE macroname(darglist)<macrobody>

macroname = a symbolic name for the macro defined.
This name must be unique among all macro, OPDEF,
and SYN symbols.

darglist = a list of dummy-arguments.

macrobody = source code to be assembled when the macro
is called.

FUNCTION Defines a macro. (See Chapter 5.)

EXAMPLES See Chapter 5.

**RELATED
PSEUDO-OPS** .DIRECTIVE (with .ITABM, .XTABM, or MACMPD arguments),
IRP, IRPC, OPDEF, STOPI, SYN

**COMMON
ERRORS** Mismatched parentheses.
Mismatched angle brackets.
Using identical names for a macro and an OPDEF or SYN
symbol (X error).

PSEUDO-OPS

.DIRECTIVE

FORMAT .DIRECTIVE directive, ..., directive

FUNCTION Sets switches to enable or disable MACRO features. If a directive has a logical opposite, you can use NO as a prefix to reverse the directive. The directives are:

- .ITABM - include spaces and tabs as part of passed arguments in macro call.
- .XTABM - strip leading and trailing spaces and tabs from passed arguments in macro call. .XTABM is the default setting.
- MACMPD - match paired delimiters in macro call. MACMPD is the default for assembly. It implies .XTABM and disables .ITABM. Using .DIRECTIVE NO MACMPD disables all quoting characters except angle brackets in macro arguments, and offers you a choice of .ITABM or .XTABM.
- LITLST - list all binary code for literals in-line.
- FLBLST - list only first line of binary code for multiline text. NO FLBLST is the default.
- .OKOVL - allow overflow for arithmetic and for the pseudo-ops DEC, EXP, and OCT.
- .EROVL - give an N error for arithmetic overflow. .EROVL is the default.
- MACPRF - prefer macro definition of symbol over other definitions of the same symbol. This does not affect the searching of .UNV files.
- SFCOND - suppress source listing for failing conditional assembly. The lines containing the opening and closing angle brackets are not suppressed.
- .NOBIN - do not generate binary (.REL) file.
- KA10 - enter KA10 as CPU type in header block of binary file.
- KI10 - enter KI10 as CPU type in header block of binary file.
- KL10 - enter KL10 as CPU type in header block of binary file.

EXAMPLES .DIRECTIVE MACMPD, .NOBIN

COMMON ERRORS Using NO with a directive that does not have a logical opposite.

PSEUDO-OPS

END

FORMAT **END** expression

expression = an optional operand that specifies the address of the first instruction to be executed; can be EXTERNAL.

FUNCTION Must be the last statement in a MACRO program. Statements after END are ignored. The starting address is optional and normally is given only in the main program. (Since subprograms are called from the main program, they need not specify a starting address.)

When the assembler first encounters an END statement, it terminates Pass 1 and begins Pass 2. The END terminates Pass 2 on the second encounter, after which the assembler simulates XLISTed LIT and VAR statements beginning at the current location. (In a PSECTed program, the LIT and VAR statements are simulated for each PSECT.)

EXAMPLES **END START**

START is a label at the starting address.

OPTIONAL NOTATIONS Use the END statement to specify a transfer word in some output file formats. (See pseudo-ops RIM, RIM10, and RIM10B in Appendix E.)

RELATED PSEUDO-OPS PRGEND

COMMON ERRORS Failing to end a text string or literal with a closing delimiter; MACRO cannot see the END statement.

Including an END statement in a source file when it is not the last file in a group of files you want assembled as a single program.

Closing the input file immediately after the characters "END" with no following carriage return.

PSEUDO-OPS

.ENDPS

FORMAT .ENDPS

FUNCTION Suspends use of the relocation counter associated with the current PSECT. If the current PSECT is nested in other PSECTS, the relocation counter for the next outer PSECT is activated. Otherwise, the relocation counter for the blank PSECT is activated.

MACRO generates a REL Block Type 22. (See the LINK Reference Manual.)

For a complete discussion of PSECTS and their handling, see Section 9.1.3.

OPTIONAL NOTATIONS Give the name of the current PSECT with the .ENDPS pseudo-op. For example,

.ENDPS A

causes MACRO to verify that A is the name of the current PSECT; if not, an error message is issued.

RELATED PSEUDO-OPS LOC, .ORG, .PSECT, RELOC, TWOSEG

PSEUDO-OPS

ENTRY

FORMAT ENTRY symbol,...,symbol

symbol = name of an entry point in a library subroutine.

FUNCTION Defines each symbol in the list following the ENTRY pseudo-op as an INTERNAL symbol and places them in a REL Block Type 4 at the beginning of the .REL output file. If this .REL file is later included in an indexed library of subroutines, then the symbol will also be included in a REL Block Type 14 at the beginning of the library. (Except for this, ENTRY is equivalent to INTERN.)

If LINK is in library search mode, a subroutine will be loaded if the program to be executed contains an undefined global symbol that matches a name in the library entry list for that program.

Since library subroutines are external to programs using them, the calling program must list them in EXTERN statements.

EXAMPLES If the MATRIX subroutine is a library subroutine, it must contain the statement

 ENTRY MATRIX

 in order to make the symbol MATRIX available to other programs. In addition, it must define the symbol MATRIX as a label at the address where execution of the call is to begin:

 MATRIX:

RELATED INTERN, EXTERN

PSEUDO-OPS

COMMON Not defining the symbol in the program.

ERRORS Purging an ENTRY symbol in Pass 2 only. The ENTRY symbol is normally output at the beginning of Pass 2; a PURGE of an ENTRY symbol must occur in Pass 1 to be effective.

PSEUDO-OPS

EXP

FORMAT EXP expression,...,expression

FUNCTION Enters the value of each expression (in the current radix) in a fullword of code.

EXAMPLES

	000003	X=3
	000101	HALF=101
	000004	B=4
	000002	A=2
000000	000003	EXP X,4,"D65,HALF,B+362-A
000000	000004	
000000	000101	
000000	000101	
000000	000364	

RELATED DEC, OCT
PSEUDO-OPS

PSEUDO-OPS

EXTERN

FORMAT EXTERN symbol,...,symbol

FUNCTION Identifies symbols as being defined in other programs. EXTERNAL symbols cannot be defined within the current program.

 At load time, the value of an EXTERNAL symbol is resolved by LINK if you load a module that defines the symbol as an INTERNAL symbol. (If you do not load such a module, LINK gives an error message for the undefined EXTERNAL symbol.)

 An EXTERNAL symbol cannot be used for any program values affecting address assignment (such as arguments to LOC or RELOC).

 For a discussion of global symbols and their resolution by LINK, see Section 2.4.5.2.

EXAMPLES EXTERN SQRT,CUBE,TYPE

OPTIONAL NOTATIONS Suffix ## to the symbol. This declares the symbol EXTERNAL, and eliminates the need for the EXTERN pseudo-op. Most programmers who use the ## notation do so at all occurrences of the symbol to show at each site that the symbol is EXTERNAL.

 For example, the two statements

 EXTERN A
 ATWO=A*2

 can be simplified to

 ATWO=A##*2

RELATED PSEUDO-OPS INTERN, ENTRY, UNIVERSAL

COMMON ERRORS Attempting to declare a symbol as EXTERNAL after its first use has made it local (by default) or INTERNAL (by declaration).

 Declaring a symbol as EXTERNAL in a program that searches a UNIVERSAL file that gives a conflicting definition.

PSEUDO-OPS

.HWFRMT

FORMAT .HWFRMT

FUNCTION Causes binary code to be listed in halfword format.

EXAMPLES 200 01 0 02 000002 MOVE 1,2(2)
 200042 000002 .HWFRMT
 MOVE 1,2(2)

OPTIONAL NOTATIONS Use the /G switch described in Table 7-1.

RELATED .MFRMT
PSEUDO-OPS

PSEUDO-OPS

.IF

FORMAT .**IF** expression,qualifier,<code>

FUNCTION Gives criterion and code for conditional assembly. The code is assembled if:

 qualifier is **AND** expression is

ABSOLUTE	absolute
ASSIGNMENT	a direct-assignment symbol
ENTRY	a symbol given in ENTRY pseudo-op
EXTERNAL	an EXTERNAL symbol
INTERNAL	an INTERNAL or ENTRY symbol
GLOBAL	a global symbol
LABEL	a label
LOCAL	a local symbol
LRELOCATABLE	a lefthalf relocatable symbol
MACRO	a macro name
NEEDED	an undefined but referenced symbol
NUMERIC	numeric
OPCODE	an opcode
OPDEF	a symbol defined by OPDEF pseudo-op
REFERENCED	a symbol already in the symbol table
RELOCATABLE	a relocatable symbol
RRELOCATABLE	a righthalf relocatable symbol
SYMBOL	a symbol (instead of a number)
SYNONYM	a symbol defined by SYN pseudo-op

NOTE

If the expression has different properties in Pass 1 and Pass 2, the number of words of code generated may be different for each pass.

EXAMPLES .**IF** FOO,MACRO,<FOO>

OPTIONAL NOTATIONS Abbreviate qualifier up to unique initial letters. For example, you can abbreviate OPCODE to OPC, but not to OP, since OPDEF has the same first two letters.

 Omit the comma preceding the left angle bracket.

RELATED PSEUDO-OPS .**DIRECTIVE** SFCOND, .IFN, IFx group

COMMON ERRORS Omitting the comma between expression and qualifier.

 Mismatching angle brackets.

 Misplacing the .IF statement in such a way that the property given by the qualifier is different in Pass 1 and Pass 2. For example, the following code generates phase errors in Pass 2:

```

        .IF FOO,OPDEF,<JFCL>
        OPDEF FOO[JRST]
NEXTLAB: END
    
```

PSEUDO-OPS

.IFN

FORMAT .**IFN** expression,qualifier,<code>

FUNCTION Gives criterion and code for conditional assembly. The code is assembled if:

 qualifier is **AND** expression **IS NOT**

ABSOLUTE	absolute
ASSIGNMENT	a direct-assignment symbol
ENTRY	a symbol given in ENTRY pseudo-op
EXTERNAL	an EXTERNAL symbol
INTERNAL	an INTERNAL or ENTRY symbol
GLOBAL	a global symbol
LABEL	a label
LOCAL	a local symbol
LRELOCATABLE	a lefthalf relocatable symbol
MACRO	a macro name
NEEDED	an undefined but referenced symbol
NUMERIC	numeric
OPCODE	an opcode
OPDEF	a symbol defined by OPDEF pseudo-op
REFERENCED	a symbol already in the symbol table
RELOCATABLE	a relocatable symbol
RRELOCATABLE	a righthalf relocatable symbol
SYMBOL	a symbol (instead of a number)
SYNONYM	a symbol defined by SYN pseudo-op

NOTE

If the expression has different properties in Pass 1 and Pass 2, the number of words of code generated may be different for each pass.

EXAMPLES .**IFN** **FOO,OPDEF,<OPDEF FOO[270B8]>**

OPTIONAL NOTATIONS

Abbreviate qualifier up to unique initial letters. For example, **OPCODE** can be abbreviated to **OPC**, but not to **OP**, since **OPDEF** has the same first two letters.

Omit the comma preceding the left angle bracket.

RELATED PSEUDO-OPS .**DIRECTIVE** **SFCOND, .IF, IFx** group

COMMON ERRORS

Omitting the comma between expression and qualifier.

Mismatching angle brackets.

Misplacing the **.IFN** statement in such a way that the property given by the qualifier is different in Pass 1 and Pass 2. For example, the following code generates phase errors in Pass 2:

```
                  .IFN FOO,OPDEF,<JFCL>  
                  OPDEF FOO[JRST]  
NXTLAB: END
```

PSEUDO-OPS

IFx group

FUNCTION

Gives criterion and code for conditional assembly. A symbol or expression used to define the conditions for assembly must be defined before MACRO reaches the conditional statement. If the value of such a symbol or expression is not the same on both assembly passes, a different number of words of code may be generated, and a phase error can occur.

The forms of the IF pseudo-op are listed below; in the first six forms, n is the value of the given expression.

IFE expression,<code> - assemble code if $n=0$.

IFN expression,<code> - assemble code if $n\neq 0$.

IFG expression,<code> - assemble code if $n>0$.

IFGE expression,<code> - assemble code if $n\geq 0$.

IFL expression,<code> - assemble code if $n<0$.

IFLE expression,<code> - assemble code if $n\leq 0$.

IF1 <code> - assemble code on Pass 1.

IF2 <code> - assemble code on Pass 2.

IFDEF symbol,<code> - assemble code if the symbol is defined as user-defined, an opcode, or a pseudo-op.

IFNDEF symbol,<code> - assemble code if the symbol is not defined as user-defined, an opcode, or a pseudo-op. Code is also assembled if the symbol has been referenced, but is not yet defined. This can occur during Pass 1.

IFIDN <string1><string2>,<code> - assemble code if the strings are identical.

IFDIF <string1><string2>,<code> - assemble code if the strings are different.

NOTES

1. For IFIDN and IFDIF, the assembler compares the two strings (interpreted as ASCII) character by character.
2. The IFIDN and IFDIF pseudo-ops usually appear in macro definitions, where one or both strings are dummy-arguments.

(Continued on next page)

PSEUDO-OPS

IFx group (Cont.)

IFB <string>,<code> - assemble code if the string contains only blanks and tabs.

IFNB <string>,<code> - assemble code if the string does not contain only blanks and tabs.

EXAMPLES

```
%%CC==%%CC+1      ;Increment character count
IFG %%CC-5,<%%CC==0 ;Word overflowed?
%%WC==%%WC+1>     ;Yes, to next word
```

OPTIONAL NOTATIONS

Omit angle brackets enclosing code for single-line conditionals.

Omit the comma preceding the code if the code is enclosed in angle brackets.

For IFIDN, IFDIF, IFB, and IFNB only: use a nonblank, nontab character other than < as the initial and terminal delimiters for a string (as in pseudo-ops ASCII and ASCIZ). You can then include angle brackets in the string.

RELATED PSEUDO-OPS

.DIRECTIVE SFCOND, .IF, .IFN

COMMON ERRORS

Comparison string too large (A error).

Mismatched angle brackets.

EXTERNAL symbol used for comparison (E error).

String not properly delimited.

Missing comma with single-line conditional.

PSEUDO-OPS

INTEGER

FORMAT INTEGER symbol,...,symbol
symbol = the name of a location to be reserved.

FUNCTION Reserves storage locations at the end of the program on a one-per-given-symbol basis. The symbols are equivalent to variable symbols.
For a two-segment program, INTEGER storage must be in the low segment.

EXAMPLES INTEGER A,B,C

OPTIONAL NOTATIONS Reserve a single storage location by suffixing a number sign (#) to a symbol in the operand field. For example,

ADD 3,TEMP#

is equivalent to

INTEGER TEMP
ADD 3,TEMP

RELATED PSEUDO-OPS ARRAY, BLOCK, .COMMON, VAR

PSEUDO-OPS

IOWD

FORMAT IOWD expl,exp2

expl, exp2 = expressions.

FUNCTION Generates one I/O transfer word in a special format for use in BLKI and BLKO and all five pushdown instructions (ADJSP, PUSH, POP, PUSHJ, POPJ). The left half of the assembled word contains the 2's complement of the value of expl, and the right half contains the value exp2-1.

EXAMPLES The following line shows how IOWD 6,^D256 places -6 (octal 77772) in the left halfword and 256 (octal 377) in the right halfword:

```
77772 000377          IOWD 6,^D256
```

The following lines show IOWD STL,STK used in a literal. The LIT pseudo-op then shows the code generated in the literal pool.

```

          000017          P==17
          000001          AC1==1
          000100          STL==100
          STK: BLOCK STL
200 17 0 00 001053'      MOVE P,[IOWD STL,STK]
261 17 0 00 000001      PUSH P,AC1
254 00 0 00 001054'      JRST END
          * * *
          * * *
          LIT
777700 000001
104 00 0 00 000170      END: HALTF
```

OPTIONAL NOTATIONS XWD -expl,exp2-1
-expl,,exp2-1

COMMON ERRORS Using a relocatable expression for expl (R error).

PSEUDO-OPS

IRP

FORMAT IRP darg,<code>

darg = one of the dummy-arguments of the enclosing macro definition. (You can use IRP only in the body of a macro definition.)

FUNCTION

Generates one expansion of code for each subargument of the string that replaces darg. Each occurrence of darg within the expansion is replaced by the subargument currently controlling the expansion. (See Section 5.6.)

Concatenation and line continuation are not allowed across end-of-IRP, since a carriage return and linefeed are appended to each expansion. See the example below.

EXAMPLES

```

                                LALL
                                Z=0
                                ANSWER=1
                                Q=2
                                X=3
                                Y=4
                                DEFINE SUM(A,B)<
                                    MOVEI Q,0
                                    IRP A,<ADD Q,A>
                                    MOVEM Q,B
                                >
                                SUM (<X,Y,Z>,ANSWER)~
                                MOVEI Q,0
                                IRP
201 02 0 00 000000          ADD Q,X
140 02 0 00 000003          ADD Q,Y
140 02 0 00 000004          ADD Q,Z
202 02 0 00 000001          MOVEM Q,ANSWER

```

RELATED PSEUDO-OPS

IRPC, STOPI

COMMON ERRORS

- IRP NOT IN A MACRO (A ERROR).
- Argument is not a dummy symbol (A error).
- Argument is a created symbol (A error).
- Mismatched angle brackets.

PSEUDO-OPS

IRPC

FORMAT IRPC darg,<code>

darg = one of the dummy-arguments of the enclosing macro definition. (IRPC can only be used in the body of a macro definition.)

FUNCTION Generates one expansion of code for each character of the string that replaces darg. Each occurrence of darg within the expansion is replaced by the character currently controlling the expansion. (See Section 5.6.)

Concatenation and line continuation are not allowed across end-of-IRPC, since a carriage return and linefeed are appended to each expansion. See the example below.

EXAMPLES	DEFINE A(B)<IRPC B,<ASCIZ \B\>>
	A(String)^IRPC
123 000 000 000 000	ASCIZ \S\
124 000 000 000 000	ASCIZ \T\
122 000 000 000 000	ASCIZ \R\
111 000 000 000 000	ASCIZ \I\
116 000 000 000 000	ASCIZ \N\
107 000 000 000 000	ASCIZ \G\

RELATED IRP, STOPI
PSEUD-OPS

COMMON ERRORS IRPC NOT IN A MACRO (A ERROR).
Argument is not a dummy symbol (A error).
Argument is a created symbol (A error).
Mismatched angle brackets.

PSEUDO-OPS

LALL

FORMAT LALL

FUNCTION Causes the assembler to print in the program listing file everything that is processed, including all text and macro expansions. Since XALL is the default, you must use LALL if you want full macro expansions listed. This can be helpful in debugging a program.

LALL does not produce comments in a macro expansion if the comments are preceded by double semicolons (;;). This is because such comments are not stored.

OPTIONAL NOTATIONS Use the /E switch described in Table 7-1.

RELATED PSEUDO-OPS LIST, SALL, XALL, XLIST

PSEUDO-OPS

.LINK

FORMAT .LINK chain-number,store-address,chain-address

 chain-number = a positive integer expression that
 associates the link with others having the same
 number.

 store-address = a symbol giving the store address for
 this entry in the chain.

 chain-address = an optional integer expression giving
 the address of this entry in the chain. If you
 omit the chain-address, MACRO generates a 0 and
 LINK uses the store-address as the chain-address.

FUNCTION Generates static chains at load time. MACRO generates
 a REL Block Type 12. (See the LINK Reference Manual
 for a full discussion of LINK's handling of these
 chains.)

EXAMPLES See the LINK Reference Manual (REL Block Type 12) for
 extensive examples of using .LINK and .LNKEND.

RELATED
PSEUDO-OPS .LNKEND

COMMON
ERRORS Chain-number not absolute (A error).

 EXTERNAL expression for store-address or chain-address
 (E error).

PSEUDO-OPS

LIST

FORMAT	LIST
FUNCTION	Resumes listing following an XLIST statement. The LIST function is implicitly contained in the END statement.
OPTIONAL NOTATIONS	Use the /L switch described in Table 7-1.
RELATED PSEUDO-OPS	LALL, SALL, XALL, XLIST

PSEUDO-OPS

LIT

FORMAT

LIT

FUNCTION

Assembles literals beginning at the current address. The literals assembled are those found since the previous LIT, or since the beginning of the program, whichever is later. The location counter is incremented by 1 for each word assembled.

In a PSECTed program, LIT assembles only literals in the current PSECT.

A literal found after the LIT is not affected. It will be assembled at the next following LIT, or at the END statement, whichever is earlier.

At the END statement, unassembled literals are placed in open-ended storage after the end-of-program. If data is also to be entered in open-ended storage, literals stored there may be overwritten. (See Appendix F for a discussion of storage allocation.) This possibility is avoided by using LIT before the END statement.

Assembling literals with LIT also produces a listing of their binary code. Literals unassembled at the END are XLISTed.

Literals having the same value are collapsed in MACRO's literal pool. Thus for the statements:

```
PUSH P,[0]
PUSH P,[0]
MOVEI AC1,[ASCIZ /TEST1/]
```

the same address is shared by the two literals [0], and by the null word generated at the end of [ASCIZ /TEST1/]. Literal collapsing is suppressed for those literals that contain errors, undefined expressions, or EXTERNAL symbols.

NOTES

1. If the code immediately preceding a LIT does not cause a transfer of execution control to some other location, execution will "fall into" the literal pool, producing unpredictable results.
2. In a file containing PRGEND pseudo-ops, only one LIT is permitted in each module before the last one. The last module (containing the END statement), or any file without PRGENDS, can contain multiple LITs.

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PSEUDO-OPS

LIT (Cont.)

EXAMPLES	400046' 200 00 0 00 400050'	MOVE 0,[XWD 1,3]
	400047' 047 00 0 00 000041	GETTAB 0,
	400050'	LIT
	400050' 000001 000003	

RELATED PSEUDO-OPS .DIRECTIVE LITLST, END, PRGEND, VAR

COMMON ERRORS Assembling literals so that some are collapsed on Pass 1, but not on Pass 2. For example, in the following lines, the literals [A] and [B] are collapsed on Pass 1 since they have the same value; but on Pass 2 their values are different and they are not collapsed. This produces a phase error for the label FOO.

```

IF1,<A=5
      B=5>
IF2,<A=5
      B=4>
MOVE AC,[A]
MOVE AC,[B]
LIT
FOO:

```

However, literals that have different values in Pass 1 but the same value in Pass 2 do not produce a phase error. For example, the following code generates two words of literal storage in Pass 1. During Pass 2 the values of [A] and [B] are collapsed, but nevertheless MACRO generates two words of literal storage to avoid a phase error at the label FOO.

```

MOVE AC1,[A]
MOVE AC1,[B]
LIT
A=5
B=5
FOO:

```

PSEUDO-OPS

.LNKEND

FORMAT .LNKEND chain-number,store-address

FUNCTION Ends a static chain generated at load time. See the LINK Reference Manual (REL Block Type 12) for extensive examples of using .LINK and .LNKEND.)

RELATED PSEUDO-OPS .LINK

COMMON ERRORS Chain-number not absolute (A error).
EXTERNAL expression for store-address (E error).

PSEUDO-OPS

.MFRMT

FORMAT .MFRMT

FUNCTION Causes multiformat listing of binary code. The type of instruction assembled determines this format. (See Section 6.1.) .MFRMT is the default setting.

OPTIONAL NOTATIONS Use the /F switch described in Table 7-1.

RELATED .HFRMT
PSEUDO-OPS

PSEUDO-OPS

MLOFF

FORMAT MLOFF

FUNCTION Terminates each literal at end-of-line even if no closing square bracket is found. This pseudo-op is intended only to maintain compatibility of programs written for very old versions of MACRO.

EXAMPLES This example shows how MLOFF can be used to interpret [1234 as [1234].

```
                                MLOFF
000000 402001'                 [1234
000000 402001'                 [1234]
```

OPTIONAL NOTATIONS Use the /O switch described in Table 7-1.

RELATED PSEUDO-OPS MLON

PSEUDO-OPS

MLON

FORMAT MLON

FUNCTION Suspends the effect of an earlier MLOFF pseudo-op, thereby enabling the use of multiline literals. MLON is the default setting.

RELATED MLOFF
PSEUDO-OPS

PSEUDO-OPS

.NODDT

FORMAT .NODDT symbol,...,symbol

FUNCTION Suppresses debugger output of each given symbol. Each symbol must have been previously defined. Symbols suppressed with .NODDT can include OPDEF symbols.

EXAMPLES .NODDT CALL,PJRST,P

OPTIONAL NOTATIONS Use == for direct-assignment symbols. (See Section 2.4.2.2.)

 Use :! for label symbols. (See Section 2.4.2.1.)

RELATED PSEUDO-OPS PURGE

COMMON ERRORS Using .NODDT with an undefined symbol argument.

PSEUDO-OPS

NOSYM

FORMAT NOSYM

FUNCTION Suppresses listing of the symbol table in the program listing file.

Suppressing the listing of symbol tables is useful for a library file containing many PRGENDS.

PSEUDO-OPS

OCT

FORMAT OCT expression,...,expression

FUNCTION Defines the local radix for the line as octal; the value of each expression is entered in a fullword of code. The location counter is incremented by 1 for each expression.

EXAMPLES 000000 000001 OCT 1,2,20,100
000000 000002
000000 000020
000000 000100

OPTIONAL NOTATIONS Use the EXP pseudo-op and prefix ^0 to each expression that must be evaluated in radix 8. In the example above, only the third and fourth expressions, "20,100," could have different evaluations in different radices. Therefore an equivalent notation is:

000000 000001 EXP 1,2,^020,^0100
000000 000002
000000 000020
000000 000100

RELATED PSEUDO-OPS DEC, EXP, RADIX

PSEUDO-OPS

OPDEF

FORMAT OPDEF symbol[expression]

FUNCTION Defines the symbol as an operator equivalent to expression, giving the symbol a fullword value. When the operator is later used with operands, the accumulator fields are added, the indirect bits are ORed, the memory addresses are added, and the index register addresses are added.

An OPDEF can be declared INTERNAL, using the INTERN pseudo-op. However, if a symbol of the same name exists, the INTERNAL declaration will apply only to that symbol, and not to the OPDEF.

NOTES

1. If you use a relocatable symbol in defining an OPDEF, the value of the symbol may not be the same for all references to the OPDEF.
2. Though the expression portion of an OPDEF must be in square brackets, this use of the brackets is completely unrelated to literals or literal handling.

EXAMPLES 200062 000010 OPDEF CAL [MOVE 1,@SYM(2)]
 200 02 1 04 000014 CAL 1,BOL(2)

The CAL statement is equivalent to:

200 02 1 04 000014 MOVE 2,@SYM+BOL(4)

RELATED DEFINE, SYN
PSEUDO-OPS

COMMON OPDEF of macroname or SYN symbol (A error).
ERRORS

No code generated by statement in square brackets (A error).

Missing square brackets (A error).

PSEUDO-OPS

.ORG

FORMAT .ORG address

FUNCTION Sets the location counter to the address and causes the assembler to assign absolute or relocatable addresses depending on the mode of the argument. If A is relocatable, then .ORG A is equivalent to RELOC A; if A is absolute, then .ORG A is equivalent to LOC A.

.ORG with no address sets the location counter to the value it had immediately before the last LOC, RELOC, or .ORG.

EXAMPLES

```

400000'                RELOC 400000   ;Set up some labels
400000'   RELAD1:
000000'                RELOC 0
000000'   RELAD2:
000100                LOC 100
000100   ABSAD1:
400100                LOC 400100
400100   ABSAD2:
000100                LOC ABSAD1     ;Set counter to ABSAD1
                                     ; and begin absolute
                                     ; address assignment.
400000'                RELOC RELAD1   ;Set counter to RELAD1
                                     ; and begin relative
                                     ; address assignment.
400100                .ORG ABSAD2     ;Set counter to ABSAD2
                                     ; and begin absolute
                                     ; address assignment.
400000'                .ORG           ;Set counter to value
                                     ; immediately before
                                     ; last LOC, RELOC, or
                                     ; .ORG, and begin
                                     ; address assignment
                                     ; in appropriate mode.
000000'                .ORG RELAD2   ;Set counter to RELAD2
                                     ; and begin absolute
                                     ; address assignment.
400000'                .ORG           ;Set counter to value
                                     ; immediately before
                                     ; last LOC, RELOC, or
                                     ; .ORG, and begin
                                     ; address assignment
                                     ; in appropriate mode.
000000'                .ORG           ;Set counter to value
                                     ; immediately before
                                     ; last LOC, RELOC, or
                                     ; .ORG, and begin
                                     ; address assignment
                                     ; in appropriate mode.

```

RELATED PSEUDO-OPS LOC, RELOC, TWOSEG

COMMON ERRORS Using an EXTERNAL symbol or complex EXTERNAL expression for the address expression.

PSEUDO-OPS

PAGE

FORMAT	PAGE
FUNCTION	Causes the assembler to list the current line and then skip to the top of the next listing page. The subpage number is incremented, but the page number is not.
OPTIONAL NOTATIONS	A formfeed character (CTRL/L) in the input text has a similar effect, but increments the page number and resets the subpage number.

PSEUDO-OPS

PASS2

FORMAT **PASS2**

FUNCTION Switches the assembler to Pass 2 processing for the remaining code. All code preceding this statement will have been processed by Pass 1 only; all following code by Pass 2 only.

 You can use **PASS2** to reduce assembly time during debugging; you can also use **PASS2** to omit the second pass for a **UNIVERSAL** file containing only symbol definitions (**OPDEFs**, macros, and direct assignments).

EXAMPLES Testing a macro defined in the Pass 1 portion:

```
          IF NON,<
                  PRINTX ?HORRIBLE ERROR
                  PASS2
                  END
          >
```

 stops assembly if **NON** = 0.

PSEUDO-OPS

PHASE

FORMAT PHASE address
 address = an integer expression; cannot be an EXTERNAL symbol.

FUNCTION Assembles part of a program so that it can be moved to other locations for execution. To use this feature, the subroutine is assembled at sequential relocatable or absolute addresses along with the rest of the program, but the first statement before the subroutine is PHASE, followed by the address of the first location of the block into which the subroutine is to be moved prior to execution. All address assignments in the subroutine are in relation to the address argument. The subroutine is terminated by DEPHASE, which restores the location counter.

EXAMPLES In the following example, which is the central loop in a matrix inversion, a block transfer instruction moves the subroutine LOOP into accumulators 11 to 15 for execution. (This results in faster execution on KA10 and KI10 processors.)

```
002000' 200 00 0 00 402002' MAIN: MOVE [XWD LOOPX, LOOP]
002001' 251 00 0 00 000015      BLT LOOP+4
002002' 254 00 0 00 000011      JRST LOOP
000011      LOOPX: PHASE 11
000011 210 02 0 03 000002 LOOP: MOVN AC, A(X)
000012 160 02 0 00 000100      FMP AC, MPYR
000013 142 02 0 04 000002      FADM AC, A(Y)
000014 365 03 0 00 000011      SOJGE X, .-3
000015 254 00 0 00 002000'      JRST MAIN
002010'      DEPHASE
```

The label LOOP represents accumulator 11, and the .-3 in the SOJGE instruction represents accumulator 11.

Note that the code inside the PHASE-to-DEPHASE program segment is loaded into the address following the previous relocatable code; all labels inside the segment, however, have the address corresponding to the phase address. Thus the phased code, if it contains control transfers other than skips, cannot be executed until it has been moved (for example, by a BLT instruction) to the address for which it was assembled.

RELATED DEPHASE
 PSEUDO-OPS

COMMON Using an EXTERNAL symbol or complex EXTERNAL expression
 ERRORS as the address (E error).

PSEUDO-OPS

POINT

FORMAT POINT bytesize,address,bitplace

FUNCTION Generates a byte pointer word for use with the machine language mnemonics ADJBP, LDB, IBP, ILDB, and IDBP.

Bytesize gives the decimal number of bits in the byte, and is assembled in bits 6 to 11 of the storage word. Address gives the location of the byte word, and is assembled in bits 13 to 35. Bitplace gives the position (in decimal) of the rightmost bit of the byte. MACRO places the value 35 minus bitplace in bits 0 to 5 of the storage word.

If the address is indirect, bit 13 is set. If the address is indexed, the index is placed in bits 14 to 17. The default bytesize is 0. The default bitplace is -1, so that the byte increment instructions IBP, ILDB, and IDBP will begin at the left of the address word.

EXAMPLES 36 06 0 00 000000 POINT 6,0,5
 44 06 0 00 000100 POINT 6,100

COMMON ERRORS Bytesize or bitplace not given in decimal.
 Bytesize or bitplace not absolute.
 Bytesize or bitplace EXTERNAL.

PSEUDO-OPS

PRGEND

FORMAT PRGEND

FUNCTION Replaces the END statement for all except the last program of a multiprogram assembly. PRGEND closes the local symbol table for the current module.

You can use PRGEND to place several small programs into one file to save space and disk accesses. The resulting binary file can be loaded in search mode. (See the LINK Reference Manual.)

Using PRGEND requires extra memory for assembly, since the tables for each program must be saved for Pass 2. Functionally, however, PRGEND is identical to END, except that PRGEND does not end the current assembly pass.

NOTE

1. PRGEND is not allowed in macros or PSECTS.
2. PRGEND clears the TWOSEG pseudo-op.
3. Like END, PRGEND causes assembly of all unassembled literals and variable symbols.
4. In a file containing PRGENDS, using more than one LIT pseudo-op in any but the last program produces unpredictable results.

OPTIONAL NOTATIONS Give an argument with PRGEND, specifying the start address for the program. See the END pseudo-op for a discussion of this argument and its meaning.

RELATED PSEUDO-OPS END, LIT, VAR

COMMON ERRORS Failing to end a text string, REPEAT, conditional code, DEFINE, or literal with a closing delimiter; MACRO cannot see any following PRGEND or END.

Confusing multiprogram and multifile assemblies. A multiprogram assembly involves multiple programs separated by PRGENDS. A multifile assembly always involves multiple files separated by end-of-file. The two types of assemblies are not mutually exclusive.

PSEUDO-OPS

PRINTX

FORMAT PRINTX text

FUNCTION Causes text to be output during assembly. On Pass 1 the text is output to the terminal and the listing device. On Pass 2 the text is output to the terminal, but only if the terminal is not the listing device.

PRINTX is frequently used to output conditional information and, in very long assemblies, to report progress of the assembler through Pass 1.

EXAMPLES PRINTX ASSEMBLER HAS REACHED POINT NOWGO
IFGE .-1000,<PRINTX CODE MORE THAN 1P>

PSEUDO-OPS

<h3>.PSECT</h3>

FORMAT .PSECT name/attribute,origin

name = a valid symbol giving the name of the PSECT.

attribute = either CONCATENATE or OVERLAID.

origin = an expression giving an address for the PSECT origin.

FUNCTION Specifies the relocation counter to be used for the code following. MACRO generates a REL Block Type 23. (See the LINK Reference Manual.)

Do not use PRGEND and .PSECT in the same file. MACRO will treat the first PRGEND as an END statement and ignore any following source code.

For a complete discussion of PSECTS and their handling, see Section 9.1.3.

EXAMPLES .PSECT A/CONCATENATE,0

 .PSECT FIRST/OVERLAID,1000

OPTIONAL NOTATIONS Omit attribute (defaults to CONCATENATE).

RELATED PSEUDO-OPS .ENDPS, LOC, .ORG, RELOC, TWOSEG

COMMON Using TWOSEG and .PSECT in the same module.

 Using HISEG and .PSECT in the same module.

PSEUDO-OPS

PURGE

FORMAT PURGE symbol,...,symbol

symbol = an assigned symbol, a label, an operator, or a macro name.

FUNCTION Deletes symbols from the symbol tables. Normally used at the end of a program to conserve storage and to delete symbols for the debugger. Purged symbol table space is reused by the assembler.

If you use the same symbol for both a macro name or OPDEF and a label, a PURGE statement deletes the macro name or OPDEF. Repeating the instruction then purges the label.

Purging a symbol that is EXTERNAL or undefined suppresses any error messages associated with it.

EXAMPLES 000040 000001 LABEL: 1,1
PURGE LABEL

RELATED .NODDT, XPUNGE
PSEUDO-OPS

PSEUDO-OPS

RADIX50

FORMAT RADIX50 code,symbol

FUNCTION Packs the symbol into bits 4 to 35 of the storage word,
with the code in bits 0 to 3.

The "50" in RADIX50 is octal, so that the radix in decimal is 40. The 40 characters permitted in symbols are the "digits" of the RADIX50 symbol expression. Thus a symbol is seen by RADIX50 as a "6-digit" number in base 40, converted to binary, and placed in bits 4 to 35 in storage.

The code expression for RADIX50 is a number in the range 0 to 74 octal. Its binary equivalent should end with two zeros (that is, the octal should end with 0 or 4), since the two low-order bits will not be stored. The four high-order bits are placed in bits 0 to 3 in storage.

See Appendix A for the octal values of RADIX50 characters.

EXAMPLES 126633 472376 RADIX50 10,SYMBOL
466633 472376 RADIX50 44,SYMBOL

OPTIONAL NOTATIONS The mnemonic SQUOZE can be used in place of RADIX50.

 RADIX50 ,symbol (code is taken as zero).

RELATED PSEUDO-OPS SQUOZE

COMMON ERRORS RADIX50 code not absolute (A error).
 RADIX50 code does not end with 0 or 4 (Q error).

PSEUDO-OPS

RELOC

FORMAT RELOC expression

expression = an optional operand that specifies the address at which sequential address assignment is to continue.

FUNCTION Sets the location counter to the value of expression, and begins assigning relocatable addresses to the instructions and data that follow.

In a PSECTed program, RELOC sets the location counter for the current PSECT.

If no address is specified, the location counter is restored to its value before the last RELOC, or before the last LOC-LOC sequence, whichever is later. (See the first example below.) If no previous RELOC or LOC-LOC sequence was encountered, the location counter is set to 0.

An implicit RELOC 0 begins every MACRO program. To switch to absolute address mode, use the pseudo-op LOC.

Note that RELOC-RELOC sequences (typically used to switch between segments in a two-segment program) can be interrupted and then resumed. This is demonstrated in the first example below.

EXAMPLES	<pre> 400000' 000000' 000000' 000000 000001 000001' 000000 000002 400000' 400000' 255 00 0 00 000000 000137 000137 000100 000001 400001' 400001' 254 00 0 00 400000' 000002' </pre>	<pre> TWOSEG 400000 ;Set up hises RELOC ;Back to lowsas DEC 1,2 RELOC ;Back to hises JFCL LOC 137 ;Deposit version ; in absolute 137 XWD 100,1 RELOC ;Back to hises ; where left off JRST ,-1 RELOC ;Back to lowsas </pre>
-----------------	---	--

RELATED PSEUDO-OPS LOC, .ORG, TWOSEG

(Continued on next page)

PSEUDO-OPS

RELOC (Cont.)

COMMON
ERRORS

Using an EXTERNAL symbol or complex EXTERNAL expression as the address.

Returning to the wrong segment when using RELOC with TWOSEG. The last four lines of the following example show how this can occur:

```

400000'                                TWOSEG
400000'                                RELOC 400000 ;Sets first RELOC
                                           ; counter to
                                           ; 400000'
000000'                                RELOC 0      ;Saves 400000',
                                           ; sets to 000000'
400000'                                RELOC        ;Swaps counters
400000' 000000 000001                 EXP 1,2      ;Enter values here
400001' 000000 000002
000000'                                RELOC        ;Swaps again
000000' 000000 000003                 EXP 3,4      ;More values here
000001' 000000 000004
400002'                                RELOC        ;Swaps again
400000'                                RELOC 400000 ;Lost counter
                                           ; to 000002'
400002'                                RELOC        ;Swaps again
400000'                                RELOC        ;Swaps again
400000' 000000 000001                 EXP 1        ;Overwrites 400000'

```

PSEUDO-OPS

REMARK

FORMAT	REMARK text
FUNCTION	Text is a comment.
EXAMPLES	REMARK I CAN SAY ANYTHING HERE.
OPTIONAL NOTATIONS	A comment line can also begin with a semicolon.
RELATED PSEUDO-OPS	COMMENT
COMMON ERRORS	Continuing REMARK text to next line without using the continuation character (CTRL/underscore).

PSEUDO-OPS

REPEAT

FORMAT REPEAT expression,<code>

expression = the repeat index, which gives the number of times to repeat assembly of the code given; the repeat index can be any expression having a nonnegative integer value.

FUNCTION Generates the code given in angle brackets n times. REPEAT statements can be nested to any level.

Line continuation is not allowed across end-of-REPEAT, since a carriage return and linefeed are appended to each expansion of the code.

Note that REPEAT 0,<code> is logically equivalent to a false conditional, and REPEAT 1,<code> is logically equivalent to a true conditional.

EXAMPLES

```
000000 COUNT=0
TABLE: REPEAT 4,<COUNT
COUNT=COUNT+1>
002020' 000000 000000 COUNT
000001 COUNT=COUNT+1
002021' 000000 000001 COUNT
000002 COUNT=COUNT+1
002022' 000000 000002 COUNT
000003 COUNT=COUNT+1
002023' 000000 000003 COUNT
000004 COUNT=COUNT+1

REPEAT 3,<. >
002024' 000000 002024' .
002025' 000000 002025' .
002026' 000000 002026' .
```

RELATED PSEUDO-OPS

DEFINE, IRP, IPRC

COMMON ERRORS

No comma after n (A error).

Using an EXTERNAL symbol or complex EXTERNAL expression as the repeat index.

Mismatching angle brackets.

PSEUDO-OPS

.REQUEST

FORMAT .REQUEST filespec

FUNCTION Causes the specified file to be loaded only to satisfy a global request; that is, the file is loaded in library search mode. (See Chapter 7 for a discussion of files.)

The filespec must not include a file type. If you specify a directory, the specification must be a project-programmer number, not a directory name.

MACRO generates a REL Block Type 17. (See the LINK Reference Manual.)

EXAMPLES .REQUEST DSK;MACROS
.REQUEST MACROS

OPTIONAL NOTATIONS DSK: is the default device.

Your connected directory at load time is the default directory.

RELATED PSEUDO-OPS .REQUIRE, .TEXT

PSEUDO-OPS

.REQUIRE

FORMAT .REQUIRE filespec

FUNCTION Causes the specified file to be loaded automatically, independent of any global requests. (See Chapter 7 for discussion of files.)

The filespec must not include a file type. If you specify a directory, the specification must be a project-programmer number, not a directory name.

MACRO generates a REL Block Type 16. (See the LINK Reference Manual.)

EXAMPLES .REQUIRE DSK:MACROS
.REQUIRE MACROS
.REQUIRE SYS:MACREL

OPTIONAL NOTATIONS DSK: is the default device.

Your connected directory at load time is the default directory.

RELATED .REQUEST, .TEXT
PSEUDO-OPS

PSEUDO-OPS

SALL

FORMAT	SALL
FUNCTION	Causes suppression of all macro and repeat expansions and their text; only the input file and the binary generated will be listed. SALL can be nullified by either XALL or LALL. Using SALL generally produces the tidiest listing file.
OPTIONAL NOTATIONS	Use the /M switch described in Table 7-1.
RELATED PSEUDO-OPS	LALL, LIST, XALL, XLIST

PSEUDO-OPS

SEARCH

FORMAT `SEARCH tablename(filename),...,tablename(filename)`

FUNCTION Defines a list of symbol tables for MACRO to search if a symbol is not found in the current symbol table. A maximum of ten tables can be specified. Tables are searched in the order specified.

When the SEARCH pseudo-op is seen, MACRO checks its internal UNIVERSAL table for a memory-resident UNIVERSAL of the specified name. (See the UNIVERSAL pseudo-op for further discussion of memory-resident UNIVERSAL tables and use of the /U switch.)

If no such entry is found in the UNIVERSAL table, MACRO reads in the symbol table using the given file specification. If no file specification is given, MACRO reads tablename.UNV from the connected directory. If no such file is found, MACRO then tries UNV:tablename.UNV and SYS:tablename.UNV, in that order.

When all the specified files are found, MACRO builds a table for the search sequence. If MACRO cannot find a given symbol in the current symbol table, the UNIVERSAL tables are searched in the order specified. When the symbol is found, it is moved into the current symbol table. This procedure saves time (at the expense of core) on future references to the same symbol.

A UNIVERSAL file can search other UNIVERSAL files, provided all names in the search list have been assembled.

The internal table of UNIVERSAL names is cleared on each run (@MACRO) or START command, but is not cleared when MACRO responds with an asterisk.

In a PSECTed program, all UNIVERSAL symbols belong to the blank PSECT.

EXAMPLES `SEARCH MONSYM,MACSYM`

OPTIONAL NOTATIONS Omit the filename and its enclosing parentheses. MACRO then looks on DSK:, UNV:, and SYS: (in that order) for tablename.UNV.

RELATED PSEUDO-OPS UNIVERSAL

COMMON ERRORS Not purging a macro that redefines itself (P error). If a macro is found in a universal file, the definition is copied into the current macro table and the auxiliary table is not searched on Pass 2. Thus, a macro that redefines itself can cause P errors similar to enclosing the macro by IF1. Such macros should be purged before Pass 2.

PSEUDO-OPS

SIXBIT

FORMAT SIXBIT dtextd

 d = delimiter; first nonblank character, whose second appearance terminates the text.

FUNCTION Enters strings of text characters in 6-bit format. Six characters per word are left justified in sequential storage words. Any unused bits are set to zero.

 Lowercase letters in SIXBIT text strings are treated as uppercase. Otherwise, only the SIXBIT character set is allowed. (See Appendix A for SIXBIT characters and their octal codes.)

EXAMPLES 64 45 70 64 00 63 SIXBIT \TEXT STRING\
 64 62 51 56 47 00

 644570 640000 EXP SIXBIT /TEXT/

OPTIONAL NOTATIONS Omit the space or tab after SIXBIT. This is not allowed if the delimiter is a letter, number, dot, dollar sign, or percent sign (that is, a possible symbol constituent), or if the ASCII value of the delimiter character is less than 040 or greater than 172.

 Right-justified SIXBIT can be entered by using single quotes to surround up to six characters; for example,

 006251 475064 'RIGHT'

RELATED PSEUDO-OPS ASCII, ASCIZ, .DIRECTIVE FLBLST

COMMON ERRORS Using the delimiter character in the text string.

 Missing the end delimiter (that is, attempting to use a carriage return as a delimiter).

 Using more than six characters in a right-justified SIXBIT string, or more than three characters if in the address field (Q error).

 Using non-SIXBIT characters in the text string.

PSEUDO-OPS

SQUOZE

FORMAT SQUOZE code,symbol

FUNCTION SQUOZE is a mnemonic for RADIX50.

EXAMPLES 126633 472376 RADIX50 10,SYMBOL
 126633 472376 SQUOZE 10,SYMBOL

OPTIONAL
NOTATIONS RADIX50 code,symbol
 SQUOZE ,symbol (code is taken as 0).

RELATED
PSEUDO-OPS RADIX50

COMMON
Errors Code not absolute (A error).
 Code does not end with 0 or 4 (Q error).

PSEUDO-OPS

STOPI

FORMAT STOPI

FUNCTION Ends an IRP or IRPC before all subarguments or characters are used. The current expansion is completed, but no new expansions are started. STOPI can be used with conditionals inside IRP or IRPC to end the repeat if the given condition is met.

EXAMPLES

```

LALL
DEFINE ONETWO(A)<
    IRP A,<IFIDN<A><ONE>,<STOPI
        EXP 1>>
    IRP A,<IFIDN<A><TWO>,<STOPI
        EXP 2>>
>
ONETWO <A,B,D>~
    IRP
    IFIDN<A><ONE>,<STOPI
        EXP 1>
    IFIDN<B><ONE>,<STOPI
        EXP 1>
    IFIDN<D><ONE>,<STOPI
        EXP 1>

    IRP
    IFIDN<A><TWO>,<STOPI
        EXP 2>
    IFIDN<B><TWO>,<STOPI
        EXP 2>
    IFIDN<D><TWO>,<STOPI
        EXP 2>

~
ONETWO <A,ONE,B,ONE,TWO>~
    IRP
    IFIDN<A><ONE>,<STOPI
        EXP 1>
000000 000001 IFIDN<ONE><ONE>,<STOPI
        EXP 1>

    IRP
    IFIDN<A><TWO>,<STOPI
        EXP 2>
    IFIDN<ONE><TWO>,<STOPI
        EXP 2>
    IFIDN<B><TWO>,<STOPI
        EXP 2>
    IFIDN<ONE><TWO>,<STOPI
        EXP 2>
000000 000002 IFIDN<TWO><TWO>,<STOPI
        EXP 2>
    
```

RELATED IRP, IRPC
PSEUDO-OPS

COMMON STOPI not inside IRP or IRPC.
ERRORS

PSEUDO-OPS

SUBTTL

FORMAT SUBTTL subtitle

FUNCTION Defines a subtitle (of up to 80 characters) to be printed at the top of each page of the listing file until the end-of-listing or until another SUBTTL statement is found.

The initial SUBTTL usually appears on the second line of the first page of the input file, immediately following the TITLE statement.

For subsequent SUBTTL statements, the following rule applies: if the new SUBTTL is on the first line of a new page, then the new subtitle appears on that page; if not, the new subtitle appears on the next page.

NOTE

The statements

```
  . . .
  PRGEND
  TITLE FOO
  SUBTTL BAR
```

do not cause BAR to appear as the subtitle on the first page of the listing of FOO.

SUBTTL affects only the listing file, and subtitles can be changed as often as desired.

EXAMPLES SUBTTL THIS SECTION CONTAINS DEVICE-DEPENDENT ROUTINES

RELATED **TITLE**

PSEUDO-OPS

PSEUDO-OPS

SUPPRESS

FORMAT SUPPRESS symbol,...,symbol

FUNCTION Turns on a suppress bit in the symbol table for the specified symbols. The suppress bit will be turned off for any symbol later referenced in the program. Symbols whose suppress bits are on at the end of assembly are not listed in the symbol table, but will be listed in any tables built by CREF unless they are XCREFed.

When an appended parameter file (as opposed to a UNIVERSAL file) is used in an assembly, many symbols may be defined but never used. These take up space in the binary file and complicate listing of the file.

Unused and unwanted symbols can be removed from tables by SUPPRESS or ASUPPRESS. These pseudo-ops control the suppress bit in each entry of the symbol table; if the bit is on, the symbol in that location is not output.

RELATED PSEUDO-OPS ASUPPRESS

COMMON ERRORS Attempting to suppress an undefined symbol.

PSEUDO-OPS

SYN

FORMAT SYN sym1,sym2

 sym1 = a defined symbol.

 sym2 = a symbol to be defined as synonymous with sym1.

FUNCTION Defines sym2 as synonymous with sym1.

 If sym1 is defined as both a label and an operator,
 sym2 assumes the label definition.

EXAMPLES The following are legal SYN statements:

 SYN X,K
 SYN FAD,ADD
 SYN END,XEND

 To turn XLIST into a null operator,

 DEFINE .XL < >
 SYN .XL,XLIST

 To restore its operation,

 PURGE XLIST

RELATED DEFINE, OPDEF
PSEUDO-OPS

COMMON Missing symbol (A error).
ERRORS Unknown symbol - first operand not defined (A error).
 Missing comma (A error).
 Using a variable as one of the symbol arguments (A
 error).

PSEUDO-OPS

TAPE

FORMAT TAPE

FUNCTION Causes the assembler to begin assembling the program contained in the next source file in the MACRO command string.

EXAMPLES (Interactive)

```
@MACRO
*DSK:BINAME,LPT:=TTY:,DSK:MORE
PARAM=6
TAPE
;THIS COMMENT WILL BE IGNORED
^Z
```

This sets PARAM to 6 and assembles the remainder of the program from the source file DSK:MORE. Since MACRO is a two-pass assembler, the TTY: file must be repeated for Pass 2.

```
[MCREP1 END OF PASS 1]
PARAM=6
TAPE
^Z
```

Note that all text after the TAPE pseudo-op is ignored.

PSEUDO-OPS

.TEXT

FORMAT .TEXT dtextd

d = delimiter; first nonblank character, whose second appearance terminates the text.

FUNCTION Generates an ASCIIZ REL Block Type for LINK and inserts the text string directly into the .REL file output as a separate block. (See the LINK Reference Manual.)

The text inserted in the .REL file is interpreted as a command string for LINK. Therefore a MACRO program loaded by user commands to LINK can contain additional LINK commands, carried out when the MACRO program is loaded.

EXAMPLES .TEXT '/SET!.HIGH.:500000'

OPTIONAL NOTATIONS Omit the space or tab after .TEXT. This is not allowed if the delimiter is a letter, number, dot, dollar sign, or percent sign (that is, a possible symbol constituent), or if the ASCII value of the delimiter character is less than 040 or greater than 172.

RELATED PSEUDO-OPS .REQUEST, .REQUIRE

COMMON ERRORS Using the delimiter character in the text string.

Missing the end delimiter (that is, attempting to use a carriage return as a delimiter).

PSEUDO-OPS

TITLE

FORMAT TITLE title

FUNCTION Gives the program name and a title to be printed at the top of each page of the program listing.

The first characters (up to six characters, or up to the first non-RADIX50 character) are the program name. This name is used when debugging with DDT to gain access to the program's symbol table.

The entire text of the title is printed on each page of the program listing.

Only one TITLE statement is allowed in a module; programs with PRGEND statements can use one TITLE statement for each module.

A TITLE statement can appear anywhere in the program; it usually appears as the first line of the program.

If no TITLE statement is used, the assembler inserts the program name ".MAIN".

EXAMPLES TITLE FLOATING-POINT NUMBER PACKAGE

The program name is FLOATI; the words FLOATING-POINT NUMBER PACKAGE will appear at the head of each page and subpage of the listing.

RELATED PSEUDO-OPS SUBTTL, UNIVERSAL

COMMON ERRORS Using more than one TITLE in a program.

Using TITLE and UNIVERSAL in the same module (M error).

PSEUDO-OPS

TWOSEG

FORMAT TWOSEG expression

expression = any expression giving a nonnegative value as the beginning of the program high segment; cannot be EXTERNAL.

FUNCTION Directs MACRO to assemble a two-segment program with the high segment beginning at the given address. MACRO sets the location counter to the given address, and generates a REL Block Type 3, which tells LINK to expect two segments. (The address is reduced to the next lower multiple of 2000 (octal). If this result is 0, the address defaults to 400000.)

Only one TWOSEG pseudo-op is allowed in a program.

High-segment code is controlled by using RELOC with a value at least as large as the TWOSEG address. Low-segment code is controlled by smaller RELOC values.

NOTE

Using TWOSEG without an argument sets the beginning address for the high segment to 400000. However, this does not set the location counter to 400000.

EXAMPLES

```
TWOSEG
RELOC 0
DATA:  BLOCK 10000    #Low segment
      RELOC 400000
START: EXIT 0        #High segment
```

RELATED PSEUDO-OPS

LOC, .ORG, RELOC

COMMON ERRORS

Using an EXTERNAL symbol or complex EXTERNAL expression as the address argument.

Using TWOSEG more than once in a program (Q error).

Generating relocatable code before the TWOSEG pseudo-op (Q error).

Using PSECT and TWOSEG in the same program.

PSEUDO-OPS

UNIVERSAL

FORMAT UNIVERSAL tablename

FUNCTION Declares the symbol table of the current program available to other programs, and stores the given tablename in MACRO's internal UNIVERSAL table. The tablename is also taken as the program name, and appears in the heading of each page of the listing file.

When an END or PRGEND statement is found, the symbol table is placed immediately after the assembler's pushdown stacks and buffers. In addition to this memory-resident copy of the UNIVERSAL symbol table, the file tablename.UNV is generated. (This file can be suppressed by the /U switch described in Table 7-1.)

UNIVERSAL files can be used to generate data, but are more commonly used to generate symbols, macros, and OPDEFs. The symbols and OPDEFs generated in a UNIVERSAL program need not be declared INTERNAL, since its local symbols are available to accessing programs. (See the SEARCH pseudo-op.)

Memory-resident UNIVERSAL symbol tables are cleared on each run (@MACRO) or START, but are not cleared when MACRO responds with an asterisk. This saves redundant lookups when many programs search a common set of UNIVERSALS.

Note that if a sequence of programs (or even one program) searches more than ten UNIVERSAL symbol tables, a SEARCH table overflow occurs. This overflow forces reinitialization of the assembler by a run (@MACRO) or START command.

For a UNIVERSAL program that does not generate data (that is, it has only symbol, macro, and OPDEF definitions), you can save time by using 1-pass assembly. However, such a file must not contain forward references to symbol definitions.

A UNIVERSAL file cannot contain PSECTS.

(Continued on next page)

PSEUDO-OPS

UNIVERSAL (Cont.)

NOTES

1. For COMPILE-class commands, the existence of the file tablename.REL may prevent recompilation of the UNIVERSAL file tablename.MAC. To avoid this, force compilation of the .MAC file by including /COMPIL in the command string.
2. Generally, a UNIVERSAL file need not be reassembled when referencing programs are assembled with newer versions of MACRO. However, if the UNIVERSAL's assembler version is newer than the program's, you may get the MCRUVS message, indicating skewed UNIVERSAL versions. In this case, reassembly or one or both files is required (using the same assembler version).

EXAMPLES

```
UNIVERSAL S1
START=765
AC1=1
F=0
END
```

RELATED PSEUDO-OPS

SEARCH, TITLE

COMMON ERRORS

Using TITLE and UNIVERSAL in the same module (M error).

PSEUDO-OPS

VAR

FORMAT VAR

FUNCTION Causes variable symbols (defined in previous statements by suffixing the number sign (#), or by ARRAY or INTEGER statements) to be assembled as BLOCK statements. This has no effect on subsequent definitions of symbols of the same type.

If the VAR statement does not appear in the program, all variables are stored at the end of the program.

If the pseudo-op TWOSEG is used, the variables reserved by an array statement must be assigned to the low segment; thus a RELOC back to the low segment is required before using the VAR pseudo-op.

EXAMPLES	402003'	201 01 0 01 000000	ADD2:	MOVEI 1,0(1)
	402004'	202 01 0 00 402012'		MOVEM 1,FIRST#
	402005'	201 02 0 02 000000		MOVEI 2,0(2)
	402006'	202 02 0 00 402013'		MOVEM 2,SECOND#
	402007'	140 01 0 00 000002		ADD 1,2
	402010'	200 01 0 00 402014'		MOVE 1,SUM#
	402011'	263 17 0 00 000000		POPJ 17,
	001052'			RELOC
	001052'			VAR
	001055'			BLOCK 2

RELATED ARRAY, BLOCK, INTEGER
PSEUDO-OPS

PSEUDO-OPS

XALL

FORMAT XALL

FUNCTION Resumes standard listing after previous LALL or SALL.
(XALL is the default among these three.)

XALL suppresses all lines of the program listing file that do not generate binary code.

XALL does not suppress REPEAT expansions.

NOTE

Under XALL only one listing line is output for each source line generating binary code in a macro expansion. Occasionally, a single line of a macro definition expands into several lines of listing text. When this occurs, part of a binary-generating source line may not be listed.

You can avoid this by temporarily setting the listing mode to LALL (list all) or SALL (suppress all) around such lines.

RELATED PSEUDO-OPS LALL, LIST, SALL, XLIST

OPTIONAL NOTATIONS Use the /X switch described in Table 7-1.

PSEUDO-OPS

.XCREF

FORMAT .XCREF symbol,...,symbol

FUNCTION Suspends output of cross-referencing for the specified symbols. References to these symbols between this statement and the next .CREF or the end of the program will not appear in the cross-reference listing.

OPTIONAL .XCREF
NOTATIONS

If no symbol names are specified, MACRO suspends cross-referencing for all symbols.

RELATED .CREF
PSEUDO-OPS

COMMON Specifying a nonexistent symbol (A error).
ERRORS

PSEUDO-OPS

XLIST

FORMAT XLIST

FUNCTION Suspends output to the program listing file. This output occurs only in Pass 2; XLIST does not affect Pass 1. To resume output, use the pseudo-op LIST.

EXAMPLES The following sequence of code shows an XLIST pseudo-op suppressing listing of literals:

```
EXIT ;End of program
XLIST ;Don't list literals
LIT
LIST
END
```

This sequence of code lists as:

```
401023' 104 00 0 00 000170 HALTF ;End of program
XLIST ;Don't list literals
LIST
END
```

Note that the high-segment break will be greater than 401023' because the literals are assembled after the HALTF.

RELATED PSEUDO-OPS LALL, LIST, SALL, XALL

OPTIONAL NOTATIONS Use the /S switch described in Table 7-1.

PSEUDO-OPS

XPUNGE

FORMAT XPUNGE

FUNCTION Deletes all local symbols during Pass 2. This reduces the size of the .REL file and speeds up loading. XPUNGE should immediately precede the END statement.

RELATED PURGE
PSEUDO-OPS

PSEUDO-OPS

XWD

FORMAT XWD lefthalf,righthalf

FUNCTION Enters two halfwords in a single storage word. Each half is formed in a 36-bit register, and the low-order 18 bits are placed in the halfword. The high-order bits are ignored.

XWD statements are used to set up pointer words for block transfer instructions. Block transfer pointer words contain two 18-bit addresses; the left half is the starting location of the block to be moved, and the right half is the first location of the destination.

EXAMPLES	402017' 200 02 0 00 403040'	MOVE 2,[XWD FROM1,TO1]
	402020' 251 02 0 00 403035'	BLT 2,TOEND1
	*****	. . .
	402636'	FROM1: BLOCK 100
	402736'	TO1: BLOCK 100
	403035'	TOEND1=-1

OPTIONAL lefthalf,,righthalf

NOTATIONS

BYTE (18)lefthalf,righthalf

COMMON Using halfword with absolute value larger than 18 bits
ERRORS (Q error).

Using two commas between the arguments to XWD. For example, XWD A,3 is correct; XWD A,,3 is incorrect.

PSEUDO-OPS

Z

FORMAT Z accumulator, address

FUNCTION Z is treated as if it were the null machine language mnemonic. An instruction word is formed with zeros in bits 0 to 8. The rest of the word is formed from the accumulator and address. (See Section 4.7.1.)

EXAMPLES 403036' 000 00 0 00 000000 Z
 403037' 000 01 0 04 000002 Z 1,2(4)

CHAPTER 4

MACRO STATEMENTS AND STATEMENT PROCESSING

A MACRO statement has one or more of the following: a label, an operator, one or more operands, and a comment. The general form of a MACRO statement is:

```
label: operator operand,operand ;comment
```

A carriage return ends the statement.

NOTES

1. Direct-assignment statements receive special handling. (See Section 2.4.2.2.)
2. Processing of macros is not discussed here because a macro call produces a text substitution. After substitution, the text is processed as described in this chapter. Macros are discussed in Chapter 5.

4.1 LABELS

A label is always a symbol with a suffixed colon. (See Section 2.4.2.1.) The assembler recognizes a label by finding the colon. If a statement has labels (you can use more than one), they must be the first elements in the statement.

A label can be defined only once; its value is the address of the first word of code generated after it.

Since a label gives an address, the label can be either absolute or relocatable. A label is a local symbol by default. You can declare a label INTERNAL global or EXTERNAL global. (See Section 2.4.5.)

MACRO STATEMENTS AND STATEMENT PROCESSING

4.2 OPERATORS

After processing any labels, the assembler views the following nonblank, nontab characters as a possible operator. An operator is one of the following:

1. A MACRO-defined mnemonic. All mnemonics are listed in Appendix C, and are discussed in the Hardware Reference Manual.
2. A user-defined operator. (See the pseudo-op OPDEF in Chapter 3.)
3. A pseudo-op. (See Chapter 3.)

If the characters found do not form one of the above, then MACRO views them as an expression.

An operator is ended by the first non-RADIX50 character: if it is ended by a blank or tab, operands may follow; if it is ended by a semicolon, there are no operands and the comment field begins; if it is ended by a carriage return, the statement ends and there are no operands or comments.

4.3 OPERANDS

After processing labels and the operator, if any, the assembler views as operands all characters up to the first unquoted semicolon or carriage return. Commas delimit the operands.

The operator in a statement determines the number (none, one, two or more) and kinds of permitted or required operands. Any expected operand not found is interpreted as null. An operand can be any expression or symbol appropriate for the operator.

4.4 COMMENTS

The first unquoted semicolon in a statement begins the comment field. You can use any ASCII characters in a comment; however, angle brackets in a comment may produce unpredictable results. You can continue a comment to the next line by typing CTRL/ , followed by a carriage return.

If the first nonblank, nontab character in a line is a semicolon, the entire line is a comment. You can also enter a full line of comment with the pseudo-op REMARK, or a multiline comment with the pseudo-op COMMENT. (See Chapter 3.)

Comments do not affect binary program output.

MACRO STATEMENTS AND STATEMENT PROCESSING

4.5 STATEMENT PROCESSING

MACRO processes your program as a linear stream of data. During Pass 1, MACRO may find references to symbols not yet defined. These symbols are entered in the user symbol table. Whenever a symbol is defined, it is entered in the table with its value, so that on Pass 2 all definitions can be found in the table. The values then replace the symbols in the binary code generated.

NOTE

Delayed definition is allowed only for labels and direct-assignment symbols. A symbol that contributes to code generation (for example, an OPDEF, a macro, or a REPEAT index) must be defined before any reference to it.

Statement processing proceeds as follows:

1. Labels are found and entered in the user symbol table.
2. The next characters up to the first unquoted semicolon, blank, tab, comma, or equal sign are processed.
 - a. Equal sign: the characters form a symbol, and the following characters form an expression. The symbol and the value of the expression are entered in the user symbol table.
 - b. Other delimiter: the characters form an expression or an operator. If an operator, it is found in a table and assembled. If an expression, its value is assembled.
3. If the operator takes operands, the next characters up to the first unquoted semicolon or carriage return form operands. Unquoted commas delimit operands. For each operand, leading and trailing blanks and tabs are ignored. Operands are evaluated and assembled for the given operator.
4. The first unquoted semicolon ends processing of the line. Any further characters up to the first carriage return are comment.
5. The first unquoted carriage return ends the statement. Any following characters begin a new statement.

4.6 ASSIGNING ADDRESSES

MACRO normally (and by default) assembles statements with relocatable addresses. Assembly begins with the zero storage word and proceeds sequentially. Each time MACRO assembles a word of binary code, it increments its location counter by 1.

MACRO STATEMENTS AND STATEMENT PROCESSING

A mnemonic operator generates one word of binary code. Direct-assignment statements and some pseudo-ops do not generate code. Some pseudo-ops generate more than one word of code.

You can control address assignment by setting the assembler's location counter using the pseudo-ops LOC and RELOC. (See Section 9.1.)

You can also reference addresses relative to the location counter by using the dot symbol (.). For example, the expression `.-1` used as an address refers to the location immediately preceding the current location.

In revising MACRO programs, you can cause an incorrect address to be assembled by adding or removing statements within the range of a `.*n` expression. For example, in the sequence

```
000000' 332 00 0 01 000000      SKIPE 0(AC)
000001' 254 00 0 00 001020'     JRST GOTONE
000002' 344 01 0 00 000000'     ADJA AC,.-2
```

the expression `.-2` gives the address of the SKIPE statement. If you revise this sequence by inserting a statement, you should change the expression to `.-3` so that it still refers to the correct statement.

```
000000' 332 00 0 01 000000      SKIPE 0(AC)
000001' 254 00 0 00 001020'     JRST GOTONE
000002' 350 00 0 00 000014      ADS NULCNT      ;Added line
000003' 344 01 0 00 000000'     ADJA AC,.-3      ;Changed line
```

For this reason, use great care with such expressions other than `.*1` and `.-1`. Using labels avoids this problem entirely.

4.7 MACHINE INSTRUCTION MNEMONICS AND FORMATS

There are two kinds of machine instruction mnemonics: primary and input/output. Primary instructions generate binary code in primary instruction format; input/output instructions generate binary code in input/output instruction format.

4.7.1 Primary Instructions

A primary instruction is in one of the forms

```
mnemonic accumulator,address
mnemonic accumulator,
mnemonic address
```

where mnemonic is a machine instruction mnemonic, accumulator is an accumulator register address, and address is a memory address. The memory address can be modified by indexing, indirect addressing, or both.

MACRO STATEMENTS AND STATEMENT PROCESSING

A complete list of machine instruction mnemonics and their octal codes is given in Appendix C, and these mnemonics are discussed in the Hardware Reference Manual.

The accumulator address gives the address of a register, and can be any expression or symbol whose value is an integer in the range 0 to 17 octal.

The memory address gives a location in memory, and can be any expression or symbol whose value is an integer in the range 0 to octal 777777.

You can modify the memory address by indirect addressing, indexed addressing, or both. For indirect addressing, prefix an at sign (@) to the memory address in your program. For indexed addressing, suffix an index register address in parentheses to the memory address in your program. This address can be any expression or symbol whose value is an integer in the range 1 to octal 17.

NOTE

To assemble the index, MACRO places the index register address in a fullword of storage, swaps its halfwords, and then adds the swapped word to the instruction word.

For an example of a primary instruction (assuming that AC17, TEMP, and XR have the octal values 17, 100, and 3, respectively), the statement

```
ADD AC17,@TEMP(XR)
```

generates the binary code

instruction code	indirect bit	memory address
010 111 000	1 111 1	0 011 000 000 001 000 000
	accumulator	index register

which appears in the program listing as

```
270 17 1 03 000100 ADD AC17,@TEMP(XR)
```

The mnemonic ADD has the octal code 270, and this is assembled into bits 0 to 8. The accumulator goes into bits 9 to 12. Since the @ appears with the memory address, bit 13 is set to 1. The index register goes into bits 14 to 17. Finally, the memory address is assembled into bits 18 to 35.

If any element is missing from a primary instruction, zeros are assembled in its instruction word field.

MACRO STATEMENTS AND STATEMENT PROCESSING

4.7.2 Mnemonics With Implicit Accumulators

A few mnemonics set bits in the accumulator field as well as in the instruction field. Therefore these mnemonics do not take accumulator operands, and are of the form

mnemonic address

These mnemonics and their octal codes are listed in Table C-5 in Appendix C.

For example, the mnemonic JFOV gives the octal code 25504; JFCL gives 255. Therefore both give the opcode 255 in bits 0 to 8, but JFOV also sets the accumulator bits (9 to 12) to binary 0001. This makes JFOV 100 equivalent to JFCL 1,100:

```
255 01 0 00 000100    JFOV 100
255 01 0 00 000100    JFCL 1,100
```

4.7.3 Input/Output Instructions

An input/output statement in your program resembles a primary instruction statement except that the first operand gives a device number instead of an accumulator. The general format is:

mnemonic device,address

In an input/output instruction, the indirect, index, and address fields (bits 13 to 35 inclusive) are assembled exactly as in a primary instruction.

Unlike a primary instruction word, however, an input/output word has a split instruction code in bits 0 to 2 (always set to 111 binary) and 10 to 12, and a device code in bits 3 to 9. The device code can be any expression or symbol giving a valid device code for your system.

(MACRO-defined I/O instruction mnemonics and device code mnemonics are listed in Tables C-2 and C-3 in Appendix C.)

For example (assuming that NVR has the octal value 1037), the statement

```
DATAI CDR,@NVR(4)
```

generates the binary code

	device code	indirect bit		memory address
111	001 001 1	00 1	1 0 100	000 000 001 000 011 111
	instruction code		index register	

which appears in the listing as

```
7 114 04 1 04 001037' DATAI CDR,@NVR(4)
```

MACRO STATEMENTS AND STATEMENT PROCESSING

The octal code for the mnemonic DATAI is 70004, which is written in bits 0 to 14. The octal device code 114 (for card reader) is then overwritten in bits 3 to 9. The @ in the statement sets bit 13 to 1. The index register and memory address are placed in bits 14 to 17 and 18 to 35, as in a primary instruction.

4.7.4 Extended Instructions

The KL10 Extended Instruction Set is a multifunction instruction set that performs character-string editing, decimal-to-binary conversion, string move with left or right justification, string move with offset or translation, and string compare.

The Extended Instruction Set consists of a single KL10 instruction (EXTEND, octal 123) and a set of 16 extended operators. (See the Supplement to the Hardware Reference Manual.)

The KL10 EXTEND instruction mnemonics are listed in Table C-4 in Appendix C.

CHAPTER 5

USING MACROS

A macro is a sequence of statements defined and named in your program. When you call a macro (by invoking its name in your program), the sequence of statements from its definition is generated in line, replacing the call. A macro can have arguments.

By using macros with arguments, you can generate passages of code that are similar, but whose differences are controlled by the passed arguments. This saves repetition in building a source file.

5.1 DEFINING MACROS

Before you can call a macro, you must define it. You can also redefine a macro if you wish; the new definition simply replaces the old one.

To define (or redefine) a macro, use the pseudo-op `DEFINE`:

```
DEFINE macroname (darglist)<macrobody>
```

where `macroname` is the name of the macro, `darglist` is an optional list of dummy-arguments, and `macrobody` is a sequence of statements.

The `macroname` is a symbol; you must follow the rules for valid symbols in selecting a `macroname`. (See Section 2.4.1.)

The optional dummy-argument list can give one or more dummy-argument symbols through which values are passed to the sequence of statements. If a macro definition has dummy-arguments, they must be enclosed in parentheses. Use commas as delimiters between dummy-arguments. For each dummy-argument, leading and trailing spaces and tabs are ignored.

The `macrobody` is the sequence of statements you want to generate when you call the macro. The `macrobody` must be enclosed in angle brackets.

Here is an example of a macro definition:

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```
DEFINE VMAG (WHERE,LENG) <
    ;Vector length routine
    MOVE 0,WHERE      ;Get first
                    ; component
    FMP 0             ;Square it
    MOVE 1,WHERE+1   ;Get second
                    ; component
    FMP 1,1          ;Square it
    FAD 1             ;Add square
                    ; of second
    MOVE1,WHERE+2    ;Get third
                    ; component
    FMP 1,1          ;Square it
    FAD 1             ;Add square
                    ; of third
    PUSHJ 17,FSQRT   ;Floating SQRT
                    ; routine
    MOVEM LENG       ;Store the
                    ; length
>
```

NOTE

Comments in a macro use storage. If you begin a comment with a double semicolon, the comment is listed in the definition but not stored for listing with expansions.

5.2 CALLING MACROS

You can call a macro by putting its name in your program. Recall that you must define the macro before you can call it. You can use the macroname as a label, an operator, or an operand.

If the macro's definition has dummy-arguments, the macro call can have arguments. The arguments passed to the macro are inserted into the defined sequence of statements as it is generated. The first passed argument replaces the first dummy-argument; the second passed argument replaces the second dummy-argument; this treatment continues for each argument passed. Any missing arguments are passed as nulls (zeros) or filled in by default arguments (see Section 5.5).

NOTE

If FOO is a macro with four dummy-arguments, the call FOO A,,C passes A and C as the first and third arguments. The second argument is passed as nulls; it is not considered missing and cannot be replaced by a default argument. The fourth argument is missing and will be replaced by a default argument if one has been defined; otherwise it is passed as nulls. (See Section 5.5.1.)

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After argument substitution, the defined sequence of statements replaces the macroname and argument list in the source text. For example, suppose you have defined VMAG(A,B) as shown in Section 5.1 above, and VMAG appears in your program as

```

LALL
P7=245
VLEN=11
PLACE=15
TAG1:  MOVE 1,P7           ;Get P7
        MOVEM PLACE       ;Put it in PLACE
TAG2:  VMAG PLACE,VLEN
TAG3:  MOVE 1,VLEN        ;Get length
    
```

Then the code to be assembled is:

		LALL
	000245	P7=245
	000011	VLEN=11
	000015	PLACE=15
200 01 0 00 000245		TAG1: MOVE 1,P7 ;Get P7
202 00 0 00 000015		MOVEM PLACE ;Put it in PLACE
		TAG2: VMAG PLACE,VLEN [^]
		;Vector length routine
200 00 0 00 000015		MOVE 0,PLACE ;Get first
		; component
160 00 0 00 000000		FMP 0 ;Square it
200 01 0 00 000016		MOVE 1,PLACE+1 ;Get second
		; component
160 01 0 00 000001		FMP 1,1 ;Square it
140 00 0 00 000001		FAD 1 ;Add square
		; of second
200 01 0 00 000017		MOVE 1,PLACE+2 ;Get third
		; component
160 01 0 00 000001		FMP 1,1 ;Square it
140 00 0 00 000001		FAD 1 ;Add square
		; of third
264 00 0 00 001007 [']		JSR FSQRT ;Floating SQRT
		; routine
202 00 0 00 000011		MOVEM VLEN ;Store
		; length
		~
200 01 0 00 000011		TAG3: MOVE 1,VLEN ;Get length

Notice that the macro definition has the dummy-arguments A and B in the macrobody. The call VMAG PLACE,VLEN causes PLACE to replace each appearance of A, and VLEN to replace each appearance of B.

NOTES

1. Under LALL, when the text of a macrobody is listed at call, it is enclosed in up-arrows (^).
2. Under XALL, the beginning of the text of a macrobody is marked by an up-arrow; the ending is marked by an up-arrow only if the last line of the macrobody generates binary code.

USING MACROS

5.2.1 Macro Call Format

In a macro call, delimit the macroname with one or more blanks or tabs.

If the macro has arguments, the first nonblank, nontab character begins the argument list. Each argument ends with a comma, a carriage return, or a semicolon. These three characters cannot be used within arguments unless enclosed by special quoting characters. (See Section 5.2.2.)

Leading and trailing spaces and tabs are stripped from each argument unless they are within special quoting characters. Embedded spaces and tabs are not stripped.

You can continue an argument to the next line by using CTRL/underscore. Otherwise an unquoted carriage return or semicolon ends the argument and the argument list. An unquoted semicolon also begins the comment field.

5.2.2 Quoting Characters in Arguments

The special quoting characters for macro argument handling are:

< > angle brackets
() parentheses
[] square brackets
" " quote marks

NOTE

Single quote marks (apostrophes) are not special quoting characters.

Any character, including the semicolon (;), enclosed in special quoting characters is treated as a regular character. If one of the special quoting characters is to be passed as a regular character, it must be enclosed by different special quoting characters.

Here are the rules for macro argument handling. In the examples, FOO is assumed to be a defined macro:

1. The special quoting characters are not argument delimiters. They only tell the assembler to treat the enclosed characters as regular characters.

FOO C<A,B> has one argument: C<A,B>.

FOO C,D<A,B> has two arguments: C and D<A,B>.

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2. With the two exceptions explained below, special quoting characters are always included in passed arguments.

FOO A,(B,C) has two arguments: A and (B,C).

FOO [XWD 1,L1]-1(AC) has one argument: [XWD 1,L1]-1(AC).

FOO "(",0 has two arguments: "(" and 0.

Exception 1: If the first character of the argument list is a left parenthesis, then it and its matching right parenthesis delimit the argument list. They are not treated as special quoting characters and are not included in passed arguments. All nested quoting characters except angle brackets are disabled. After stripping the outer parentheses, angle brackets are handled as described in Exception 2 below.

FOO (A,B,C) has three arguments: A, B, and C.

FOO (?LENGTH >132) has one argument: ?LENGTH >132.

FOO ([A,B]) has two arguments: [A and B].

FOO (<A,B>) has one argument: A,B.

Exception 2: If a left angle bracket is the first character of the argument list, or the first character after an unquoted comma, then it and its matching right angle bracket are treated as special quoting characters, but are not included in passed arguments.

FOO <A,B>,C has two arguments: A,B and C.

FOO C,<A,B> has two arguments: C and A,B.

You can alter this argument handling by using the pseudo-op `.DIRECTIVE` with `MACMPD`, `.ITABM`, and `.XTABM`. (See Chapter 3.)

NOTE

To pass special characters in a macro call, we suggest defining the macro so that the delimiters are part of the passed argument. For example, use

```
DEFINE T1 (A) <OUTSTR [ASCIZ A]>
```

rather than

```
DEFINE T2 (A) <OUTSTR [ASCIZ \A\]>
```

The call `T1 ">>"` will work, but `T2 ">>"` will not.

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5.2.3 Listing of Called Macros

You can control the listing of called macros by using the pseudo-ops XALL, SALL, and LALL. LALL causes macro expansions to be listed in full; XALL suppresses part of the listing; LALL suppresses all of the listing. The default among these three is XALL.

The following example shows the action of these pseudo-ops on macro listings:

```

                                DEFINE FOO (N)<
                                IFE N,<2>
                                IFN N,<1>
                                >
                                SALL
000000 000002 FOO(0)
000000 000001 FOO(1)
                                XALL
                                FOO(0)^
000000 000002 IFE 0,<2>
                                FOO(1)^
000000 000001 IFN 1,<1>
                                LALL
                                FOO(0)^
000000 000002 IFE 0,<2>
                                IFN 0,<1>
                                ^
                                FOO(1)^
                                IFE 1,<2>
000000 000001 IFN 1,<1>
                                ^
```

5.3 NESTING MACRO DEFINITIONS

You can nest macro definitions. That is, you can define a macro within the body of another macro definition. Notice, however, that the nested macro is not defined to the assembler until the nesting macro is called.

Here is an example:

```

DEFINE PERSON (A) <
    DEFINE CHILD (B) <
        DEFINE GRANDCHILD (C) <
            EXP A,B,C>
        >
    >
>
```

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Until the DEFINE PERSON statement is assembled, calls to PERSON, CHILD, and GRANDCHILD are illegal. These macros are not yet defined to the assembler.

When the DEFINE PERSON statement is reached and assembled, PERSON can be called, but not CHILD or GRANDCHILD. The call PERSON 1 generates the text

```
PERSON 1^
  DEFINE CHILD (B) <
    DEFINE GRANDCHILD (C) <
      EXP 1,B,C>
    >
  >
```

thus defining CHILD to the assembler. The following call CHILD 2 generates the text

```
CHILD 2^
  DEFINE GRANDCHILD (C) <
    EXP 1,2,C>
  >
```

and GRANDCHILD is defined to the assembler. Finally, a call to GRANDCHILD 3 generates

```
GRANDCHILD 3^
000000 000001          EXP 1,2,3^
000000 000002
000000 000003
```

Notice the result of a subsequent call to CHILD 10. The text

```
CHILD 10^
  DEFINE GRANDCHILD (C) <
    EXP 1,10,C>
  >
```

is generated, and this definition replaces the old definition of GRANDCHILD; the definitions of PERSON and CHILD are not changed. After this, the call GRANDCHILD 3 generates

```
GRANDCHILD 3^
000000 000001          EXP 1,10,3^
000000 000010
000000 000003
```

NOTE

Using multiple angle brackets for a passed argument preserves the argument as one unit. For example passing the argument <<A,B,C>> to nested macros causes the outer macro to pass <A,B,C> as one argument; the first nested macro passes A, B, and C as three arguments.

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5.4 CONCATENATING ARGUMENTS

The apostrophe (') is the concatenation operator for macro calls. If you insert an apostrophe immediately before or after a dummy-argument in the body of a macro, the assembler removes it at call. This removal joins (concatenates) the passed argument to the neighboring character in the generated text.

(One application of this concatenation is shown under COMMON ERRORS for the ASCIZ pseudo-op.)

If the apostrophe precedes the dummy-argument, the passed argument is suffixed to the preceding character; if the apostrophe follows the dummy-argument, the passed argument is prefixed to the following character.

You can use more than one apostrophe with a dummy-argument. In this case only apostrophes next to the dummy-argument will be removed (at most one from each side). Other apostrophes are treated as regular characters in the macrobody. The following example shows the treatment of apostrophes on both sides of the dummy-argument, and of double apostrophes.

```
DEFINE O (PREFIX,MIDFIX) <
    DEFINE OCOMP (SUFFIX) <
        PREFIX'O'MIDFIX''SUFFIX>
    >
```

Now the call O A,J generates

```
DEFINE OCOMP (SUFFIX) <
    AOJ'SUFFIX>
```

because when the assembler replaces PREFIX with A, the apostrophe following is removed to form AO. When J replaces MIDFIX, the preceding apostrophe and first following apostrophe are removed to form AOJ'SUFFIX.

Now the call OCOMP LE generates

```
                                OCOMP LE^
343 00 0 00 000000                AOJLE^
```

since the apostrophe is removed to join AOJ to LE.

5.5 DEFAULT ARGUMENTS AND CREATED SYMBOLS

Ordinarily, an argument missing from a macro call is passed as nulls. For example, the macro defined by

```
DEFINE WORDS (A,B,C) <
    EXP A,B,C>
```

when called by WORDS 1,1 generates three words containing 1, 1, and 0, respectively.

```
                                WORDS 1,1^
000000 000001                EXP 1,1,^
000000 000001
000000 000000
```

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You can, however, alter this handling by specifying default values other than nulls, or by using created symbols.

5.5.1 Specifying Default Values

If you want a missing argument to default to some value other than nulls, you can specify the default value in your DEFINE statement. Do this by inserting the default value in angle brackets immediately after the dummy-argument. For example, the macro defined by

```
DEFINE WORDS (A,B<222>,C<333>)<
  EXP A,B,C>
```

when called by WORDS 1,1 generates three words containing 1, 1, and 333, respectively.

```
                                WORDS 1,1~
000000 000001                    EXP 1,1,333~
000000 000001
000000 000333
```

NOTE

An argument passed as nulls by consecutive commas is not considered missing and cannot invoke a default value. Therefore missing arguments can occur only at the end of the list of passed arguments.

5.5.2 Created Symbols

A symbol used as a label in a macrobody must be different for each call of the macro (since duplicate labels are not allowed). Therefore for each call a different symbol for the label must be passed as an argument.

If you do not refer to such a label from outside the macro, you can simply let the assembler provide a new label for each call. This label is called a created symbol, and is of the form ..nnnn where nnnn is a 4-digit number.

To use a created symbol in place of a passed argument, use the percent sign (%) as the first character of the dummy-argument in your DEFINE statement. The assembler then creates a symbol for use in the macro expansion if that argument is missing from a call to the macro. If you provide an argument in the call, the passed argument overrides the created symbol.

USING MACROS

NOTES

1. A null argument (indicated by two adjacent delimiters) is not treated as missing.
2. Avoid using symbols of the form ..nnnn, since they could interfere with created symbols.

The following example shows a macro defined with a created symbol, the macro called using the created symbol, and the macro called overriding the created symbol:

```
DEFINE COMPAR (TEST,SAVE,INDEX,%HERE) <
%HERE:  MOVE SAVE,TEST
        SETZ INDEX,
        CAME SAVE,TABLE(INDEX)
        JRST %HERE
>
COMPAR T1,T2,T3^
..0001: MOVE T2,T1
        SETZ T3,
        CAME T2,TABLE(T3)
        JRST ..0001
COMPAR T1,T2,T4,HERE1^
HERE1:  MOVE T2,T1
        SETZ T4
        CAME T2,TABLE(T4)
        JRST HERE1
```

5.6 INDEFINITE REPETITION

The pseudo-ops IRP, IRPC, and STOPI give a convenient way to repeat all or part of a macro; you can change arguments on each repetition if you wish, and the number of repetitions can be computed at assembly time. You can use these three pseudo-ops only within the body of a macro definition.

To see how IRP works, assume the macro definition

```
DEFINE DOEACH (A) <
  IRP A,<A>>
```

The call DOEACH <ALPHA,BETA,GAMMA> produces the code

```
000200      ALPHA=200
000300      BETA=300
000400      GAMMA=400
            DOEACH <ALPHA,BETA, GAMMA>^
            IRP
000000 000200      ALPHA
000000 000300      BETA
000000 000400      GAMMA
            ^
```

because each subargument passed to IRP generates one repetition of the code. Notice that the range of IRP must be enclosed in angle brackets.

USING MACROS

NOTE

Using angle brackets in the call to `DOEACH` is critical, since they make the string `ALPHA,BETA,GAMMA` a single argument for `IRP`. `IRP` then sees the commas as delimiting subarguments.

`IRPC` is similar to `IRP`, but an argument passed to `IRPC` generates one repetition for each character of the argument.

`STOPI` ends the action of `IRP` or `IRPC` after assembly of the current expansion. You can use `STOPI` with a conditional assembly to calculate a stopping point during assembly. For example:

```
                ;Enter value of 111 for each radix from 2 to K
DEFINE CONV1 (L) <
    RADIX L ;Set radix
    111    ;Evaluate and enter
    RADIX 8 ;Back to radix 8
>

DEFINE CONVERT (A) <
    IRP A,<IFE K-A,<STOPI> ;Still OK?
        CONV1 A> ;CONV1
>

000004         K=4
                CONVERT <2,3,4,5,6,7,8,9>~
                IRP
                IFE K-2,<STOPI> ;Still OK?
                    CONV1 2~
000000 000007     RADIX 2 ;Set radix
                    111    ;Evaluate and enter
                    RADIX 8 ;Back to radix 8
                ~
                IFE K-3,<STOPI> ;Still OK?
                    CONV1 3~
000000 000015     RADIX 3 ;Set radix
                    111    ;Evaluate and enter
                    RADIX 8 ;Back to radix 8
                ~
                IFE K-4,<STOPI> ;Still OK?
                    CONV1 4~
000000 000025     RADIX 4 ;Set radix
                    111    ;Evaluate and enter
                    RADIX 8 ;Back to radix 8
                ~
                ~
                ~
                ;CONV1
                ~
```

5.7 ALTERNATE INTERPRETATIONS OF CHARACTERS PASSED TO MACROS

The normal argument passed by a macro call is simply the string of characters given with the call. `MACRO` offers three alternate interpretations of the passed argument.

USING MACROS

If you prefix a backslash (\) to an expression argument, the argument passed is the ASCII numeric character string giving the value of the expression.

If you prefix a backslash-apostrophe (\') to an expression argument, the argument passed is the string whose value is the SIXBIT string with the integer value of the expression.

If you prefix a backslash-quotemark (\") to an expression argument, the argument passed is the string whose value is the ASCII string with the integer value of the expression.

To show how these work, the following example defines a macro to print the argument passed. Then four different arguments are passed using the various argument interpretations.

```
LALL
DEFINE LOOKIE (ARG) <
REMARK The passed argument is: ARG >

LOOKIE 60~
REMARK The passed argument is: 60 ~

LOOKIE \60~
REMARK The passed argument is: 60 ~

LOOKIE \'60~
REMARK The passed argument is: P ~

LOOKIE \*60~
REMARK The passed argument is: 0 ~

000060 Z=60

LOOKIE Z~
REMARK The passed argument is: Z ~

LOOKIE \Z~
REMARK The passed argument is: 60 ~

LOOKIE \'Z~
REMARK The passed argument is: P ~

LOOKIE \*Z~
REMARK The passed argument is: 0 ~

635170 425164 ZZ='SIXBIT'

LOOKIE ZZ~
REMARK The passed argument is: ZZ ~

LOOKIE \ZZ~
REMARK The passed argument is: 635170425164 ~

LOOKIE \'ZZ~
REMARK The passed argument is: SIXBIT ~
```

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203234 162311

ZZZ='ASCII'

LOOKIE ZZZ^

REMARK The passed argument is: ZZZ ^

LOOKIE \ZZZ^

REMARK The passed argument is: 203234162311 ^

LOOKIE *ZZZ^

REMARK The passed argument is: ASCII ^

CHAPTER 6
ASSEMBLER OUTPUT

MACRO can generate three kinds of output files:

1. A program listing (.LST) file
2. A binary program (.REL) file
3. A UNIVERSAL (.UNV) file

6.1 THE PROGRAM LISTING FILE

MACRO outputs the program listing file to the device you specify, usually your terminal or a disk file. You can control the form of the program listing by using the pseudo-ops `.DIRECTIVE FLBLST`, `.DIRECTIVE SFCOND`, `LIST`, `XLIST`, `LALL`, `XALL` and `SALL`. (See Chapter 3.) All MACRO programs begin with the implicit pseudo-ops `LIST` and `XALL`.

The listing has a heading at the top of each page and subpage. The first line gives the program name, the assembler version, the time and date of assembly, and the page number. The second line gives the program filename (including file type), the date and time of creation, and an optional program subtitle.

Example:

```
TIMER  MACRO Z53(711)  10:07  27-APR-77      PAGE 2
TIMER  MAC      27-AUG-77    10:06      MACDEF
```

The listing has up to 55 lines per page. You can change this by using the `L` switch; `/nnL` specifies `nn` lines per page. A formfeed (`CTRL/L`) in your program begins a new page and increments the page number. If the linecount exceeds lines-per-page before a formfeed is found, a subpage number is formed. For example, the subpages following page 6 are 6-1, 6-2, and so forth. A formfeed would begin page 7.

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The five columns in the program listing give:

1. The CREF line number (if the program was assembled with the CREF switch on).
2. The line sequence number (if the input file is sequenced).
3. The 6-digit octal address of the storage word, usually a sequential location assignment.

```
400066'  
400067'  
400070'
```

An apostrophe (') after the address shows that it is relocatable.

For a PHASE pseudo-op, the phased address is given.

For a BLOCK pseudo-op, only the address of the first word is given.

For a program with PSECTS, the 2-digit PSECT number of the current PSECT immediately follows the address. For example,

```
000100'02
```

For a LOC or RELOC pseudo-op, only the address to which the location counter is set is given; the next word of code will be assembled at that address.

4. The assembled binary code (if any) in one of eight formats.

Fullword: all zeros with number sign (000000000000#), showing that a fullword Polish fixup is required for the word of code.

Halfword: two 18-bit bytes. Each halfword can be followed by an apostrophe (') to indicate that it is relocatable, or by a pound sign (#) to indicate that a Polish fixup is required for it. When you use the .HWFRMT pseudo-op, all code is listed in halfword format.

Instruction: 9-bit op-code; 4-bit accumulator code; 1-bit indirect code; 4-bit index; 18-bit address.

Input/output: 3-bit I/O code; 7-bit device code; 3-bit operand; 1-bit indirect code; 4-bit index; 18-bit address.

Byte pointer: 6-bit byte position; 6-bit byte size; 1 unused bit; 1-bit indirect code; 4-bit index; 18-bit address.

ASCII: five 7-bit bytes; one unused bit.

SIXBIT: six 6-bit bytes.

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BYTE: binary representation of specified bytes. Bytes appear on the program listing only to the extent that available horizontal space permits. For example, 36 1-bit bytes cannot be represented as individual bytes on the listing. Any halfword byte containing an address can be flagged by an apostrophe (') or by a pound sign (#). See the halfword format above.

OPDEF or assignment: one or two 18-bit bytes, as needed.

These examples show some code in each format:

000056'	000000000000#		B=A+C	
000057'	000001 000017'		1,,TAG1	;Halfword
000060'	000017 000001		AC17,,1	;Halfword
000061'	255 01 0 00 000100		JFOV 100	;Instruction
000062'	255 01 0 00 000100		JFCL 1,100	;Instruction
000063'	7 114 04 1 04 001037'		DATAI CDR,@NVR(4)	;I/O
000064'	7 110 20 1 05 000004		CONO CDP,@4(5)	;I/O
000065'	21 06 0 00 000067'	P1:	POINT 6,B1,18	;Byte pointer
000066'	44 10 0 00 000070'	P2:	POINT 8,B2	;Byte pointer
000067'	07 00 01 000000	B1:	BYTE (6)7,0,1	;Byte
000070'	006 004 002 000 00	B2:	BYTE (8)6,4,2,0	;Byte
	017000 000000		OPDEF Z1[17B8]	;OPDEF
	026000 000000		OPDEF Z2[26B8]	;OPDEF
000071'	061 062 063 064 065		ASCII /12345/	;ASCII
000072'	101 102 103 104 105		ASCII \ABCDE\	;ASCII
000073'	21 22 23 24 25 26		SIXBIT /123456/	;SIXBIT
000074'	41 42 43 44 45 46		SIXBIT \ABCDEF\	;SIXBIT

An apostrophe (') shows the code as relocatable. The examples show relocatable values in the right half of some words. The left half can also be relocatable.

An asterisk (*) shows a symbol to be EXTERNAL or undefined.

A number sign (#) shows that a Polish expression is required to resolve the value.

5. Source statements and comments.

If the assembler finds errors in a line of text, it suffixes one or more letters to the sequence number as error codes. These error codes are discussed in Chapter 8. A code is not repeated for multiple errors of the same type in a line.

ASSEMBLER OUTPUT

At the end of the listing, the assembler gives the total number of errors, followed by break addresses. The program break is the largest relocatable address assembled, plus 1. The absolute break is the largest absolute address assembled. The high-segment break is the largest high-segment address assembled. For a program with PSECTs, the break for each PSECT is also given.

The listing gives CPU time in the form mm:ss.sss where mm is minutes and ss.sss is seconds. Core used is given in P's; one P is 512 words (1000 octal).

In the symbol table at the end of the listing, some symbols may have the following codes:

```
ent result of ENTRY pseudo-op
ext EXTERNAL symbol
int INTERNAL symbol
pol defined in terms of EXTERNAL symbols
sen suppressed result of ENTRY pseudo-op
sex suppressed EXTERNAL symbol
sin suppressed INTERNAL symbol
spd suppressed for debugger
udf undefined symbol
```

If you use the /C switch with MACRO, you can generate three additional tables in the program listing. The /C switch directs MACRO to generate the listing file in a format suitable for input to CREF, the cross-referencing program. This is a .CRF file rather than the usual .LST file.

After assembly, the .CRF file can be used as input to CREF, and the output is the cross-referenced .LST file. This file contains the program listing and symbol table as described above. In addition, it has a cross-referenced symbol table, a table of macros and OPDEFs, and, if you use the /O switch with CREF, a cross-referenced table of opcodes and pseudo-ops.

The cross-referenced symbol table lists each user-defined symbol (except macros, OPDEFs, and SYN symbols), and lists the sequence number of each line containing the symbol.

The table of macros and OPDEFs shows each reference to macros, OPDEFs, and SYN symbols.

The opcode table shows each reference to MACRO-defined opcodes and pseudo-ops, giving the sequence number of each line containing the opcode or pseudo-op.

ASSEMBLER OUTPUT

6.2 THE BINARY PROGRAM FILE

MACRO outputs the binary program file to the device you specify, usually a storage device. The default device is a disk. Most of the file is the binary expansion of your program instructions. These instructions are formatted into groups called REL Blocks; each block is labeled so that LINK can recognize it. Details of this formatting and labeling are discussed in the LINK Reference Manual.

A relocatable binary program file can be stored on any input/output device. The output format is not related to either block types or logical divisions of the device.

6.3 THE UNIVERSAL FILE

THE UNIVERSAL file is output only if the source file contains the UNIVERSAL pseudo-op. (See the discussions at UNIVERSAL in Chapter 3 and in Section 9.2.)

A UNIVERSAL file contains only symbols and definitions. These definitions are available to any program, and can be obtained by using the SEARCH pseudo-op.

CHAPTER 7

USING THE ASSEMBLER

To assemble a MACRO program, use one of the following:

1. The operating system command COMPILE (See the User's Guide for details.)
2. The \$MACRO card for the BATCH program (See the BATCH Reference Manual.)
3. The MACRO command level

To assemble a program in the command level of MACRO, type the word MACRO to the system. The system then runs MACRO, which responds with an asterisk (*):

```
@MACRO
*
```

Then define files for MACRO by typing a command of the form

```
relfile,listfile=sourcefile,...,sourcefile
```

where:

relfile is a filespec for the binary program output file.

listfile is a filespec for the program listing output file.

each sourcefile is a filespec for a source program input file; MACRO assembles source files in the order given.

The default device for each file is DSK:, but you can override this by prefixing devicecode: to any of the files. Default file types are .REL for relfile, .LST for listfile (.CRF if you use the /C switch), and .MAC for each sourcefile. You can override these by suffixing a file type to any of the files.

You can specify a directory for any of these files by suffixing a project-programmer number (PPN) in square brackets. (See Appendix G.) You can set switches by suffixing /char or (char) to a file, where char is a switch code. Switch codes and their meanings are given in Table 7-1.

USING THE ASSEMBLER

You can suppress the binary file by omitting its file specification (but keeping the comma):

```
,listfile=sourcefile,...,sourcefile
```

You can suppress the listing file by omitting its file specification and the comma:

```
relfile=sourcefile,...,sourcefile
```

You can suppress both output files by omitting their file specifications (but keeping the equal sign):

```
=sourcefile,...,sourcefile
```

You can access an indirect file (containing valid asterisk-level MACRO command strings) by typing a command of the form:

```
@indirectfile
```

where indirectfile is the file specification for the file.

Examples:

DATE,DATE=DATE	Assemble source file DATE.MAC from disk into binary program file DATE.REL on disk, and put the listing in file DATE.LST on disk.
DATE=DATE	No listing file.
,DATE=DATE	No binary file.
=DATE	No binary or listing file. Print all error diagnostics on the terminal.
DATE,TTY:=DATE	Send the listing to the terminal.
DATE,DATE=TTY:	Accept source code from the terminal.
DATE,DATE=TTY: ,DSK:DATE	Accept source code from the terminal (usually symbol definitions), followed by more source code from the disk. Notice that DSK must be specified; otherwise, TTY would be assumed.

NOTE

Many programmers use the following commands to check assembly of short code sequences:

```
*,TTY:=TTY:  
PASS2
```

This displays the assembled code line by line as you type it in.

USING THE ASSEMBLER

Table 7-1
MACRO Switch Options

Switch	Meaning
/A	Advance magnetic tape reel by one file. The /A switch must immediately follow the device to which the switch refers.
/B	Backspace magnetic tape reel by one file. The /B switch must immediately follow the device to which the switch refers.
/C	Produce listing file in a format acceptable as input to CREF. Unless the filename is given, CREF.CRF is assumed; if no file type is given, .CRF is assumed; if no listing device is specified, DSK: is assumed. The /C switch can be used only with the file specification for the program listing file; it must appear between the comma and the equal sign.
/E	List macro expansions (same as LALL pseudo-op).
/F	Output binary listing in multiformat (same as .MFRMT pseudo-op).
/G	Output binary listing in halfword format (same as .HWFRMT pseudo-op).
/H	Print HELP text (list of switches and explanations).
/L	Reinstate listing (same as LIST pseudo-op).
/M	List only the call and binary produced in a macro expansion (same as SALL pseudo-op).
/N	Suppress error printouts on the terminal.
/O	End literal with CR-LF or right square bracket (same as MLOFF pseudo-op).
/P	Increase the size of the pushdown list. This switch can appear as many times as desired. The pushdown list is initially set to a size of 80 (decimal) locations; each /P increases the size by 80 (decimal). /P must appear on the left of the =.
/Q	Suppress Q (questionable) warning errors on the listing. /Q must appear on the left of the =.

(Continued on next page)

USING THE ASSEMBLER

Table 7-1 (Cont.)
MACRO Switch Options

Switch	Meaning
/S	Suppress listing (same as XLIST pseudo-op).
/T	Skip to the logical end of the magnetic tape. The /T switch must immediately follow the device to which the switch refers.
/U	Do not generate a .UNV file on DSK. The /U switch must appear immediately after the specification for the binary program file; that is, it must appear between the file specification and the comma.
/W	Rewind the magnetic tape. The /W switch must immediately follow the device to which the switch refers.
/X	Suppress listing of macro expansions (same as XALL).

CHAPTER 8
ERRORS AND MESSAGES

MACRO has three kinds of messages:

1. Informational messages
2. Single-character error codes
3. MCRxxx messages (where xxx is a 3-letter mnemonic code)

8.1 INFORMATIONAL MESSAGES

MACRO's informational messages are printed at the foot of the program listing. These messages and their explanations are given in Table 8-1.

ERRORS AND MESSAGES

Table 8-1
MACRO Informational Messages

Message	Explanation
ABSOLUTE BREAK	The highest absolute address over 137.
CORE USED	The size of the low segment used to assemble the source program.
CPU TIME USED	The CPU time for assembly in minutes and seconds.
ERRORS DETECTED	The number of errors detected by MACRO during assembly (errors marked on the listing by single-character codes other than Q).
HI-SEG. BREAK	The length of the high segment.
PROGRAM BREAK	The length of the low segment.
PSECT n BREAK	The length of PSECT n.
UNASSIGNED DEFINED AS IF EXTERNAL	Undefined symbol; treated as EXTERNAL.
WARNINGS GIVEN	The number of Q errors found. Processing is terminated if under BATCH.

ERRORS AND MESSAGES

8.2 SINGLE-CHARACTER ERROR CODES

Single-character error codes are printed in the program listing near the left margin of the line where the error occurs. If more than one kind of error occurs in the same line, more than one character will be printed; if more than one error of the same kind occurs in the line, the code is printed only once.

Codes for M, P, V, and X errors are typed during Pass 1.

If you use CREF to produce a cross-referenced listing file, all the single-character error codes will appear in the cross-reference table as %....x, where x is the code character.

Table 8-2 gives the single-character error codes and their explanations.

ERRORS AND MESSAGES

Table 8-2
MACRO Single-Character Error Codes

Code	Explanation
A	<p>Argument error in pseudo-op. This is a broad class of errors that can be caused by an improper argument in a pseudo-op. The A errors include:</p> <ol style="list-style-type: none"> 1. Symbol used is improperly formed. 2. IFIDN comparison string is too large. 3. OPDEF of macro or SYN. 4. Invalid SIXBIT character. 5. Byte size in BYTE more than 36. 6. RADIX50 code not absolute. 7. End of line of IF reached before < character seen. 8. Assignment made in an address field; for example, MOVEI A=10. (However, MOVEI <A=10> is valid.) 9. Assignment of a label; for example, TAG: TAG=1. 10. Missing symbol in SYN. 11. Unknown symbol in SYN. 12. Missing right parenthesis in an index. 13. Missing left parenthesis in a BYTE statement. 14. No comma after repeat count. 15. IRP or IRPC not in a macro. 16. Argument for IRP or IRPC is not a dummy symbol; for example, DEFINE GO (A) IRP B. 17. IRP or IRPC argument is a created symbol. 18. STOPI not in IRP or IRPC.
D	<p>Multiply defined symbol. The statement contains a tag that refers to a multiply defined symbol. The first definition is used for assembling the statement.</p>

(Continued on next page)

ERRORS AND MESSAGES

Table 8-2 (Cont.)
MACRO Single-Character Error Codes

Code	Explanation
E	<p>Improper use of an EXTERNAL symbol. The E errors include:</p> <ol style="list-style-type: none"> 1. Symbol both EXTERNAL and internal. 2. EXTERNAL symbol used as accumulator register address. 3. EXTERNAL symbol used with IF. 4. EXTERNAL symbol used as address for LOC, RELOC, PHASE, HISEG, or TWOSEG. 5. EXTERNAL symbol used for array name or size in ARRAY. 6. EXTERNAL symbol used as REPEAT count.
L	<p>Literal generates less than 1 or more than 99 words of data.</p>
M	<p>Symbol defined more than once; retains its first definition. If a symbol is first defined as a variable and later as a label, it retains the label definition. This error can be caused by multiple appearances of TITLE, or TITLE with UNIVERSAL.</p>
N	<p>Number error. The N errors include:</p> <ol style="list-style-type: none"> 1. Number exceeds the permitted range. 2. B shift not absolute. 3. Digits exceed current radix. If radix is 8, the single character 9 is acceptable but the number 19 is not acceptable. 4. Character after up-arrow not B, O, F, L, D, !, or -. 5. Illegal expression after E.
O	<p>Operation code undefined. It is assembled as zeros.</p>
P	<p>Phase error. In general, the assembler generates the same number of program locations in Pass 1 and Pass 2. Any discrepancy causes a phase error.</p> <p>Phase errors can be caused by incorrect literal allocation.</p> <p>If a symbol is used as a macro to generate code in Pass 1, and is used as a label in Pass 2, a phase error can occur.</p> <p>A relocatable label that is defined in a literal and then used in an arbitrary expression; MACRO generates a Polish expression instead of treating the label as EXTERNAL.</p>

(Continued on next page)

ERRORS AND MESSAGES

Table 8-2 (Cont.)
MACRO Single-Character Error Codes

Code	Explanation
Q	<p>Questionable. This is a broad class of warnings in which the assembler finds ambiguous language. Statements causing Q errors may not generate correct code. The Q errors include:</p> <ol style="list-style-type: none"> <li data-bbox="412 491 1349 548">1. Too many ASCII characters in double quotes ("). Only the first five are used. <li data-bbox="412 575 1349 632">2. Too many SIXBIT characters. Only the first six are used. <li data-bbox="412 659 1166 680">3. Value too large; high-order bits are lost. <li data-bbox="412 707 906 728">4. Illegal expression after E. <li data-bbox="412 756 889 777">5. Illegal control character. <li data-bbox="412 804 1349 861">6. Comma detected after all required fields filled; for example, MOVE 1,2,. <li data-bbox="412 888 1349 945">7. HISEG or TWOSEG found after relocatable code assembled. <li data-bbox="412 972 1349 1050">8. Instruction memory address operand does not have either all 0's or all 1's in its left half; for example, 1,,0 or -4,,-1. <li data-bbox="412 1077 1052 1098">9. More than 18-bit values used in XWD.
R	<p>Relocation error. The R errors include:</p> <ol style="list-style-type: none"> <li data-bbox="412 1184 1187 1205">1. Expression neither absolute nor relocatable. <li data-bbox="412 1232 943 1253">2. LOC or RELOC used improperly. <li data-bbox="412 1281 943 1302">3. Relocatable BLOCK size given. <li data-bbox="412 1329 1089 1350">4. Relocatable accumulator address given.
S	<p>PSECT usage error. The S errors include:</p> <ol style="list-style-type: none"> <li data-bbox="412 1457 1105 1478">1. More than 64 distinct PSECT names used. <li data-bbox="412 1505 1154 1526">2. More than 16 levels of PSECT nesting used. <li data-bbox="412 1554 1349 1633">3. PSECT name given with .ENDPS is not the name of the current PSECT.
U	<p>Undefined symbol.</p>
V	<p>Symbol used to control the assembler is undefined. Make the definition precede the reference.</p>
X	<p>Error in defining or calling a macro during Pass 1.</p>

ERRORS AND MESSAGES

8.3 MCRxxx MESSAGES

The MCRxxx messages are issued to the terminal during assembly. (The xxx represents a 3-letter code.)

Any MCRxxx message that is preceded by a question mark is normally fatal under batch processing. A few MCRxxx messages are informational; these are issued within square brackets.

Table 8-3 gives all the MCRxxx messages. Each 3-letter code and its message are printed in boldface type. For some messages, an explanation is printed in lightface type.

ERRORS AND MESSAGES

Table 8-3
MCRxxx Messages

Code	Message and Explanation
ATS	<p>LINES/PAGE ARGUMENT TOO SMALL</p> <p>The argument given must be greater than three to allow space for the page heading.</p>
CAP	<p>CORE ALLOCATION PROBLEM WITH MEMORY-RESIDENT UNIVERSALS</p> <p>UNIVERSAL programs assembled with the /U switch must have the same output specifications as succeeding files. (See the pseudo-op UNIVERSAL in Chapter 3.) However, if none of the memory-resident UNIVERSALS are to be searched by subsequent files in the command sequence, you can clear the UNIVERSALS and force the needed memory allocation by typing CTRL/C, followed by START.</p>
CFU	<p>CANNOT FIND UNIVERSAL</p> <p>Correct the request for the UNIVERSAL file, or assemble the required UNIVERSAL file.</p>
CME	<p>COMMAND ERROR</p> <p>The last command string contains an error.</p>
CTL	<p>COMMAND LINE TOO LONG</p> <p>The last input command string contains more than 200 characters.</p>
DNA	<p>DEVICE NOT AVAILABLE</p> <p>The specified device cannot be initialized because it is in use.</p>
ECF	<p>ERROR READING COMMAND FILE</p> <p>This is a file status error.</p>
EPl	<p>END OF PASS 1</p> <p>Manual input is required to begin Pass 2 because input is from cards or terminal.</p>
EPP	<p>EXPRESSION PARSING PROBLEM</p> <p>An expression was misinterpreted because MACRO interpreted a slash as a division operator, or a hyphen as a subtraction operator.</p>
ERU	<p>UNEXPECTED END-OF-FILE READING UNIVERSAL FILE</p>
EWE	<p>ERROR WHILE EXPANDING</p> <p>MACRO has an internal error in expanding a macro. Rewrite the macro, and submit a Software Performance Report.</p>

(Continued on next page)

ERRORS AND MESSAGES

Table 8-3 (Cont.)
MCRxxx Messages

Code	Message and Explanation
FNF	FILE NOT FOUND
IBL	INPUT BLOCK TOO LARGE DEVICE An input block from the specified device is too large.
ICP	INPUT CHECKSUM OR PARITY ERROR DEVICE This is a hard-data error.
IDE	INPUT DATA ERROR DEVICE This is a hard-data error.
ISC	ILLEGAL SYNTAX IN CONDITIONAL OR REPEAT
ISD	ILLEGAL SYNTAX IN MACRO DEFINITION The macro is improperly defined.
ISI	ILLEGAL SYNTAX IN [IRP or IRPC] INSIDE MACRO
ISR	ILLEGAL SYNTAX IN REPEAT
LFO	LST FILE OPEN ERROR
LNF	LOAD THE NEXT FILE The command string specifies the next file device as card reader or terminal. Input the file through the appropriate device.
LTL	LITERAL TOO LONG
MDE	MONITOR DETECTED SOFTWARE INPUT ERROR DEVICE The input file is not in a valid mode.
MPA	MISSING CLOSE PAREN AROUND ARG LIST
NEC	INSUFFICIENT CORE Not enough memory is available to assemble the program.
NES	NO END STATEMENT ENCOUNTERED ON INPUT FILE
NUF	NOT A REAL UNIVERSAL FILE No such UNIVERSAL file was found.

(Continued on next page)

ERRORS AND MESSAGES

Table 8-3 (Cont.)
MCRxxx Messages

Code	Message and Explanation
OBL	<p>OUTPUT BLOCK TOO LARGE DEVICE</p> <p>This is a file-status error.</p>
OCP	<p>OUTPUT CHECKSUM OR PARITY ERROR DEVICE</p> <p>This is a hard-data error.</p>
ODE	<p>OUTPUT DATA ERROR DEVICE</p> <p>This is a hard data error.</p>
OQE	<p>OUTPUT QUOTA EXCEEDED ON DEVICE</p>
OUF	<p>UNIVERSAL FILE DEFAULT ARGUMENTS LOST, REASSEMBLE</p>
PDL	<p>PDP OVERFLOW, TRY /P</p> <p>See the /P switch in Table 7-1.</p>
PET	<p>INPUT PHYSICAL END OF TAPE DEVICE</p>
PGE	<p>PRGEND ERROR</p> <p>See the PRGEND pseudo-op for proper use of PRGEND.</p>
PTC	<p>POLISH TOO COMPLEX</p> <p>A Polish expression is too complex for MACRO to handle. Restructure or split the expression.</p>
RFO	<p>.REL FILE OPEN ERROR</p>
SOC	<p>STATEMENT OUT OF ORDER .COMMON</p> <p>The .COMMON pseudo-op must precede all statements that generate code, and all references to the COMMON block.</p>
STO	<p>SEARCH TABLE OVERFLOW, CANNOT SEARCH UNIVERSAL</p>
TMU	<p>TOO MANY UNIVERSALS</p> <p>Too many UNIVERSAL files are being searched. The number permitted is an assembly parameter; it can be increased by reassembling MACRO.</p>
UVS	<p>UNIVERSAL VERSION SKEW, REASSEMBLE UNIVERSAL</p> <p>The UNIVERSAL file was assembled with a later version of MACRO than you are using now. Reassemble the UNIVERSAL file.</p>
UWU	<p>UNABLE TO WRITE UNIVERSAL FILE</p>
WLE	<p>OUTPUT WRITE-LOCK ERROR DEVICE</p>

CHAPTER 9

PROGRAMMING CONSIDERATIONS

The previous chapters of this manual define the MACRO language elements. In particular, the pseudo-op definitions in Chapter 3 define many of MACRO's most important features. However, the usefulness of some pseudo-ops can be seen only in the context of a "family" of pseudo-ops.

In this chapter, we discuss three such families of pseudo-ops. The programming features concerned are:

1. Program segmentation
2. UNIVERSAL files
3. Conditional assembly

9.1 PROGRAM SEGMENTATION

MACRO's relocation counters can accommodate three types of programs:

1. A single-segment program uses only one relocation counter.
2. A two-segment program also uses one relocation counter, and is characterized by its use of the TWOSEG pseudo-op.
3. A program with PSECTS can use many relocation counters, and is characterized by its use of the .PSECT and .ENDPS pseudo-ops.

9.1.1 Single-Segment Programs

A single-segment program uses only one relocation counter. This counter can be used to assign any address from 0 to 777777. The initial setting of the counter is 0.

As MACRO assembles your program, it places code and data at the address given by the current value of the relocation counter, incrementing the counter's value for each word assembled.

For example, a statement can require assembly of one word of code, incrementing the relocation counter by 1. Another statement can require assembly of five words of code, incrementing the relocation counter by 5. Still another statement may not generate code, leaving the relocation counter unchanged.

PROGRAMMING CONSIDERATIONS

You can reset the value of the relocation counter by using the pseudo-op RELOC with an argument. For example, using RELOC A sets the value of the relocation counter to the value of A.

In the following example, 100 words are allocated for a table, incrementing the relocation counter by 100. Then the table length is calculated as TABLEN. A RELOC TABLE returns to the top of the table, where the first three words are initialized. Finally a RELOC TABLE+TABLEN sets the relocation to the foot of the table to continue assembly.

```
000000'          TABLE: BLOCK 100          ;Allocate table
                   000100          TABLEN=-TABLE      ;Table length
000000'          RELOC TABLE          ;Top of table
000000' 000000 000001          EXP 1,2,3          ;Init first 3
000001' 000000 000002
000002' 000000 000003
000100'          RELOC TABLE+TABLEN ;Continue
```

9.1.2 Two-Segment Programs

By using the TWOSEG pseudo-op, you can divide your program into a high segment and a low segment. This pseudo-op must precede any statement in your program that generates code.

The TWOSEG pseudo-op tells MACRO that there will be two segments, and MACRO generates a REL Block Type 3, which tells LINK to expect two segments for loading.

You can use TWOSEG either with or without an address argument. There are important differences between the two:

1. TWOSEG without an argument specifies that the high segment begins at the address 400000. The initial value of the relocation counter is at the address 0 in the low segment.
2. TWOSEG with an argument specifies that the high segment begins at the given address, and further specifies that the initial value of the relocation counter is that address. (The given address is reduced to the next lower multiple of 2000 octal; if this result is 0, MACRO treats the TWOSEG as if no argument were given.)

The high-segment starting address divides all code into two segments. MACRO and LINK consider all code at addresses above the high-segment address to be in the high segment, and all other code to be in the low segment.

MACRO always remembers the value the relocation counter had before the last RELOC found. (This stored value is initially 0.)

Therefore in a two-segment program, you can begin in one segment, and then RELOC to the other. From then on, you can switch segments simply by using RELOC with no argument. MACRO will begin assigning addresses at the first unused location in the opposite segment.

PROGRAMMING CONSIDERATIONS

For example,

```

400000'          TWOSEG
000000' 000000 000001  EXP 1,2      ;Lo-ses
000001' 000000 000002
400000'          RELOC 400000  ;Hi-ses
400000' 000000 000003  EXP 3,4
400001' 000000 000004
000002'          RELOC          ;Lo-ses
000002' 000000 000005  EXP 5,6
000003' 000000 000006
400002'          RELOC          ;Hi-ses
400002' 000000 000007  EXP 7,10
400003' 000000 000010
    
```

9.1.3 Programs With PSECTS

You can construct a program having up to 64 segments by using the .PSECT and .ENDPS pseudo-ops. These pseudo-ops control switching among program segments (PSECTS).

Each PSECT has its own relocation counter; each is separately relocated at load time. Therefore a program with two PSECTS is different from a two-segment program in that the PSECTed program has two relocation counters, while the two-segment program has only one.

The pseudo-op .PSECT specifies that code should be assembled for a given PSECT. For example, .PSECT A specifies that code is to be assembled in the program segment (PSECT) called A. The pseudo-op .ENDPS ends assembly in the current PSECT.

PSECTS can be nested up to 16 levels. In a nested PSECT, the .ENDPS pseudo-op begins assembly in the next outer PSECT; in an unnested PSECT, .ENDPS begins assembly in the blank PSECT. (You can think of the blank PSECT as being outside of all your explicitly declared PSECTS.)

Here is an example showing three PSECTS (A, B, and C):

```

000000'00 000000 000001  EXP 1,2      ;Blank PSECT
000001'00 000000 000002
000000'01          .PSECT A          ;1st PSECT
000000'01 000000 000003  EXP 3,4
000001'01 000000 000004
000000'02          .PSECT B          ;2nd PSECT (nested)
000000'02 000000 000005  EXP 5,6
000001'02 000000 000006
000002'01          .ENDPS B          ;1st PSECT
000002'01 000000 000007  EXP 7,10
000003'01 000000 000010
000002'00          .ENDPS A          ;Blank PSECT
000002'00 000000 000011  EXP 11,12
000003'00 000000 000012
000000'03          .PSECT C          ;3rd PSECT
000000'03 000000 000013  EXP 13,14
000001'03 000000 000014
000004'00          .ENDPS C          ;Blank PSECT
000002'02          .PSECT B          ;2nd PSECT
000002'02 000000 000015  EXP 15,16
000003'02 000000 000016
000004'00          .ENDPS B          ;Blank PSECT
    
```

PROGRAMMING CONSIDERATIONS

In the example, the blank PSECT surrounds everything. Embedded in the blank PSECT are:

1. PSECT A (which also nests some of PSECT B)
2. PSECT C
3. Another segment of PSECT B

Each PSECT used in a program generates the PSECT name as a global symbol. At load time, this symbol will take the value of the origin specified for the PSECT.

When LINK loads your program, all the parts of the same PSECT are loaded together. These parts can be in more than one program, or in more than one file. For details of LINK's handling of PSECTS at load time, see the LINK Reference Manual.

9.2 UNIVERSAL FILES

A UNIVERSAL file contains direct-assignment symbol definitions. The symbols defined can have any attributes.

A UNIVERSAL file is convenient because it can contain definitions that you want for many programs. Those programs can then obtain the definitions by your use of the SEARCH pseudo-op. This searching adds to the assembly only those definitions that are needed; other definitions in the UNIVERSAL file are not used.

To build a UNIVERSAL file from a MACRO source file, insert the pseudo-op

UNIVERSAL filespec

where the filespec gives the file for output of the UNIVERSAL file. This file will contain all the symbols and definitions given in the program.

Another program can obtain these definitions if it contains the SEARCH pseudo-op:

SEARCH filespec

where filespec names the UNIVERSAL file. At the end of Pass 1 assembly, MACRO will search the UNIVERSAL file for any undefined symbols. If a definition is found in the UNIVERSAL file, MACRO moves it into the symbol tables of the current program.

For example, a UNIVERSAL file can contain definitions for register mnemonics:

UNIVERSAL REGS

000000	R0=0
000001	R1=1
000002	R2=2
000003	R3=3
000004	T1=4
000005	T2=5
000016	SP=16
000017	P=17
	END

PROGRAMMING CONSIDERATIONS

Then another assembly can obtain these by using the SEARCH REGS pseudo-op:

SEARCH REGS

```
000000' 000 00 0 00 000000      Z R0,  
000001' 000 01 0 00 000000      Z R1,  
000002' 000 02 0 00 000000      Z R2,  
000003' 000 03 0 00 000000      Z R3,  
000004' 000 04 0 00 000000      Z T1,  
000005' 000 05 0 00 000000      Z T2,  
000006' 000 16 0 00 000000      Z SP,  
000007' 000 17 0 00 000000      Z P,
```

A UNIVERSAL file can contain definitions for any user-defined symbols. You may find it convenient to build UNIVERSAL files containing macros, OPDEFs, and direct-assignment symbols that you use often in your programs.

An example of a UNIVERSAL program appears in the program examples in Appendix D.

9.3 CONDITIONAL ASSEMBLY

Using conditional assembly in your programs can make programming easier, and can make your assembled programs shorter. The pseudo-ops used for conditional assembly are IRP, IRPC, STOPI, .IF, .IFN, and the IFx group. IRP, IRPC, and STOPI are discussed fully in Chapter 3 and Section 5.6.

We will confine the discussion here to a few classic uses of the remaining conditional assembly pseudo-ops.

The first of these is the use of IFNDEF to establish default switch settings for a program. The example here is from the MACRO program itself, and concerns assembly of F40-switch-dependent symbols.

Near the beginning of the code, MACRO has the statement:

```
IFNDEF F40 <F40==0>
```

This statement has effect only if the symbol F40 is not defined, in which case the statement F40==0 is assembled. This sets the F40 switch to "off."

But if a file defining F40 is assembled with (and before) the MACRO source file, then the statement F40==0 is not assembled, leaving the "outside" definition in force.

Therefore the statement IFNDEF F40 <F40==0> serves as a default definition for F40, and this default is used only if no other definition overrides it.

Another application of conditional assembly is connected with the symbol F40. In MACRO's program segments on symbol searching, some symbols will be defined (and therefore found in the search) only if the F40 switch is "on."

PROGRAMMING CONSIDERATIONS

Here is how MACRO's code handles these symbols. There is a code sequence as follows:

```
#MACRO TO HANDLE F40 UUOS
  IFE F40,<
DEFINE XF (SB,CD) <>>          #NULL MACRO
  IFN F40,<SYN X,XF>          #USUAL X MACRO
```

The "usual X macro" is merely a macro to set up symbols to be defined and the code to assemble on finding them. The macro XF will be used to handle definitions for F40 UUOs.

Now if the F40 switch is on, the macro XF is made synonymous with the macro X, and the F40 UUOs are defined in the same way as other operators. But if the F40 switch is off, XF is made a null macro so that all the F40 UUOs are ignored during assembly and are not defined to MACRO.

The assembly of the F40 UUOs depends on the value of the F40 switch, and the value of the switch depends on its definition. If MACRO had no IFNDEF F40 statement, an "outside" file would have to define the switch at every assembly of MACRO. But the default definition allows assembly of MACRO alone, and the outside file is needed only to turn the switch on.

Examples of conditional assembly are shown in the program examples in Appendix D.

APPENDIX A

MACRO CHARACTER SETS

Table A-1 gives the 101 ASCII characters allowed in MACRO and their octal ASCII codes; the 64 SIXBIT characters and their octal SIXBIT codes; and the 40 RADIX50 characters and their octal RADIX50 codes.

Table A-1
MACRO Character Sets

Character	ASCII Code	SIXBIT Code	RADIX50 Code
(horizontal tab)	011		
(linefeed)	012		
(vertical tab)	013		
(formfeed)	014		
(carriage-return)	015		
(CTRL/Z)	032		
(CTRL/_)	037		
(blank)	040	00	00
!	041	01	
"	042	02	
#	043	03	
\$	044	04	46
%	045	05	47
&	046	06	
'	047	07	
(050	10	
)	051	11	
*	052	12	
+	053	13	
,	054	14	
-	055	15	
.	056	16	45
/	057	17	

(Continued on next page)

MACRO CHARACTER SETS

Table A-1 (Cont.)
MACRO Character Sets

Character	ASCII Code	SIXBIT Code	RADIX50 Code
0	060	20	01
1	061	21	02
2	062	22	03
3	063	23	04
4	064	24	05
5	065	25	06
6	066	26	07
7	067	27	10
8	070	30	11
9	071	31	12
:	072	32	
;	073	33	
<	074	34	
=	075	35	
>	076	36	
?	077	37	
@	100	40	
A	101	41	13
B	102	42	14
C	103	43	15
D	104	44	16
E	105	45	17
F	106	46	20
G	107	47	21
H	110	50	22
I	111	51	23
J	112	52	24
K	113	53	25
L	114	54	26
M	115	55	27
N	116	56	30
O	117	57	31
P	120	60	32
Q	121	61	33
R	122	62	34
S	123	63	35
T	124	64	36
U	125	65	37
V	126	66	40
W	127	67	41

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MACRO CHARACTER SETS

Table A-1 (Cont.)
MACRO Character Sets

Character	ASCII Code	SIXBIT Code	RADIX50 Code
X	130	70	42
Y	131	71	43
Z	132	72	44
[133	73	
\	134	74	
]	135	75	
^	136	76	
_	137	77	
a	141		
b	142		
c	143		
d	144		
e	145		
f	146		
g	147		
h	150		
i	151		
j	152		
k	153		
l	154		
m	155		
n	156		
o	157		
p	160		
q	161		
r	162		
s	163		
t	164		
u	165		
v	166		
w	167		
x	170		
y	171		
z	172		

APPENDIX B

MACRO SPECIAL CHARACTERS

Characters and combinations having special interpretations in MACRO are given in Table B-1. These interpretations apply only in the contexts described. In particular, they do not apply within text strings or comment fields.

For each usage of special characters, a cross-reference to a text discussion is given in the rightmost column of the table. For references to pseudo-ops, only the pseudo-op name is given; all pseudo-ops are discussed in alphabetical order in Chapter 3.

Table B-1
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
B	between two integer expressions	mBn	causes the binary representation of m to be placed with rightmost bit at bit n (decimal).	2.2.6
^B	before integer expression	^Bn	shows that n is a binary number.	2.2.2
^D	before integer expression	^Dn	shows that n is a decimal number.	2.2.2
E	between floating-point decimal number and signed decimal integer	fE+n	multiplies f by the +nth power of 10.	2.2.5
^F	before integer expression	^Fn	shows that n is a fixed-point decimal number.	2.2.4
G	after integer	nG	suffixes nine zeros to n.	2.2.3
K	after integer	nK	suffixes three zeros to n.	2.2.3
^L	before decimal integer expression	^Ln	generates the number of leading zeros in the binary representation of n.	2.2.8
M	after integer	nM	suffixes six zeros to n.	2.2.3

(Continued on next page)

Table B-1 (Cont.)
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
<code>^0</code>	before integer expression	<code>^On</code>	shows that n is an octal number.	2.2.2
<code>:</code>	after symbol	<code>sym:</code>	shows that sym is a label.	2.4.2.1, 4.1, 4.5
<code>::</code>	after symbol	<code>sym::</code>	shows that sym is a global INTERNAL label.	2.4.2.1, 4.1, 4.5
<code>:! </code>	after symbol	<code>sym:!</code>	shows that sym is a label, but not to be output by debugger.	2.4.2.1, 4.1, 4.5
<code>::!</code>	after symbol	<code>sym::!</code>	shows that sym is a global INTERNAL label, but not to be output by debugger.	2.4.2.1, 4.1, 4.5
<code>;</code>	before end of line	<code>;text</code>	shows that text is a comment.	4.4, 4.5
<code>::</code>	before end of line (usually in a macro)	<code>::text</code>	shows that text is a comment to be printed in the macro definition but not at call.	4.4, 4.5
<code>.</code>	as expression	<code>.</code>	generates current value of the location counter.	2.3, 4.6
<code>.</code>	embedded in numerals	<code>int.fr</code>	shows that int.fr is a floating-point decimal number.	2.2.5

(Continued on next page)

Table B-1 (Cont.)
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
,	among numbers and symbols	,	delimits operands, accumulator, arguments.	4.3, 4.5 5.1, 5.2
,,	among numbers and symbols	,,	delimits a null macro argument.	5.2, 5.5
,,	between two expressions	lhw,,rhw	delimits left halfword (lhw) from right halfword (rhw).	2.5.4.1
!	between two expressions	A!B	generates the logical inclusive OR of A and B.	2.5.2
^!	between two expressions	A^!B	generates the logical exclusive OR of A and B.	2.5.2
&	between two expressions	A&B	generates the logical AND of A and B.	2.5.2
^-	before expression	^-A	generates one's complement of value of A (logical NOT).	2.5.2
*	between two expressions	A*B	generates product of A and B.	2.5.1
/	between two expressions	A/B	generates quotient of A by B.	2.5.1
+	between two expressions	A+B	generates sum of A and B.	2.5.1

(Continued on next page)

Table B-1 (Cont.)
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
-	between two expressions	A-B	generates difference of A and B.	2.5.1
-	before an expression	-A	generates the two's complement of the value of A.	2.2.1, 2.2.4, 2.2.5
"..."	around text	"text"	shows that text is a 7-bit ASCII string, to be right justified in field of five characters.	ASCII, ASCIZ
'...'	around text	'text'	shows that text is a SIXBIT string, to be right justified in field of six characters.	SIXBIT
'	adjoining dummy argument in macro body	text'darg or darg'text	concatenates passed argument to text at call to macro.	5.4
#	after symbol	sym#	shows that sym is a variable symbol, whose address is usually at the end of the binary program.	2.4.3
##	after symbol	sym##	shows that sym is a global EXTERNAL symbol.	2.4.5.2
\	prefixed to expression in macro call	\expr	directs that the argument passed be the string for the ASCII value of expr in the current radix.	5.7.1

(Continued on next page)

Table B-1 (Cont.)
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
\'	prefixed to expression in macro call	\'expr	directs that the argument passed be the string whose SIXBIT code is the value of expr.	5.7.3
\"	prefixed to expression in macro call	\"expr	directs that the argument passed be the string whose ASCII code is the value of expr.	5.7.3
CTRL/_ (CONTROL-underscore)	before CR-LF	CTRL/_	continues argument to next line; does not operate across end-of-macro.	5.2.1
_	between two expressions	A <u>B</u>	shifts the binary representation of A to the left B positions. (If B is negative, shift is to right.)	2.2.6
@	prefixed to address	@address	sets bit 13 of the instruction word, indicating indirect addressing.	4.7.1
%	1st character of dummy argument in macro definition	%darg	directs that %darg be replaced by a created symbol at macro call; MACRO will substitute a different symbol for it on each use of the macro.	5.5.2
()		(...)	encloses index field; encloses dummy arguments in macro definition; quotes characters for macro argument handling; swaps the two halves of enclosed value.	4.7.1, 5.1 5.2.2

(Continued on next page)

Table B-1 (Cont.)
Interpretations of Special Characters

Characters	Context	Form	Interpretation	Discussed in Section
< >		<...>	nests expressions; encloses conditional assembly code; encloses code in REPEAT, IRP, and IRPC pseudo-ops; encloses macrobody in DEFINE pseudo-op; quotes characters for macro argument handling; forces evaluation of symbol.	2.5.4 IFx, .IF, .IFN, REPEAT, IRP, IRPC, DEFINE, 5.1, 5.2.2
[]		[...]	delimits literals; delimits argument in ARRAY, .COMMON, and OPDEF pseudo-ops; quotes characters for macro argument handling.	2.3, ARRAY, .COMMON, OPDEF, 5.2.2
=	between symbol and expression	sym=exp	assigns value of exp to sym.	2.4.2.2, 4.5
==	between symbol and expression	sym==exp	assigns value of exp to sym but sym is not output by debugger.	2.4.2.2, 4.5
:=	between symbol and expression	sym:=exp	assigns value of exp to sym and declares sym as global INTERNAL.	2.4.2.2, 4.5
==:	between symbol and expression	sym==:exp	assigns value of exp to sym and declares sym as global INTERNAL, but sym is not output by debugger.	2.4.2.2, 4.5

APPENDIX C

MACRO-DEFINED MNEMONICS

This appendix contains tables showing all of MACRO's defined mnemonics and the code they generate. These mnemonics, together with the pseudo-ops and the special characters given in Appendix B, make up the entire MACRO language.

NOTE

Throughout this appendix, the following notes apply to the tables:

- * Indicates mnemonic defined only if MACRO is assembled with the KL10 switch on.
- ** Indicates mnemonic defined only if MACRO is assembled with the KI10 switch on.

C.1 MACHINE INSTRUCTION MNEMONICS

Table C-1 shows MACRO's machine instruction mnemonics and the code assembled by each mnemonic. See Section 4.7 for a discussion of machine instructions used in programs.

MACRO-DEFINED MNEMONICS

Table C-1
Machine Instruction Mnemonics

270	00	0	00	000000	ADD	303	00	0	00	000000	CAILE
273	00	0	00	000000	ADDB	306	00	0	00	000000	CAIN
271	00	0	00	000000	ADDI	310	00	0	00	000000	CAM
272	00	0	00	000000	ADDM	314	00	0	00	000000	CAMA
133	00	0	00	000000	*ADJBP	312	00	0	00	000000	CAME
105	00	0	00	000000	*ADJSP	317	00	0	00	000000	CAMG
404	00	0	00	000000	AND	315	00	0	00	000000	CAMGE
407	00	0	00	000000	ANDB	311	00	0	00	000000	CAML
410	00	0	00	000000	ANDCA	313	00	0	00	000000	CAMLE
413	00	0	00	000000	ANDCAB	316	00	0	00	000000	CAMN
411	00	0	00	000000	ANDCAI	400	00	0	00	000000	CLEAR
412	00	0	00	000000	ANDCAM	403	00	0	00	000000	CLEARB
440	00	0	00	000000	ANDCB	401	00	0	00	000000	CLEARI
443	00	0	00	000000	ANDCBB	402	00	0	00	000000	CLEARM
441	00	0	00	000000	ANDCBI	114	00	0	00	000000	*DADD
442	00	0	00	000000	ANDCBM	117	00	0	00	000000	*DDIV
420	00	0	00	000000	ANDCM	110	00	0	00	000000	**DFAD
423	00	0	00	000000	ANDCMB	113	00	0	00	000000	**DFDV
421	00	0	00	000000	ANDCMI	112	00	0	00	000000	**DFMP
422	00	0	00	000000	ANDCMM	131	00	0	00	000000	DFN
405	00	0	00	000000	ANDI	111	00	0	00	000000	**DFSB
406	00	0	00	000000	ANDM	234	00	0	00	000000	DIV
253	00	0	00	000000	AOBJN	237	00	0	00	000000	DIVB
252	00	0	00	000000	AOBJP	235	00	0	00	000000	DIVI
340	00	0	00	000000	AOJ	236	00	0	00	000000	DIVM
344	00	0	00	000000	AOJA	120	00	0	00	000000	**DMOVE
342	00	0	00	000000	AOJE	124	00	0	00	000000	**DMOVEM
347	00	0	00	000000	AOJG	121	00	0	00	000000	**DMOVN
345	00	0	00	000000	AOJGE	125	00	0	00	000000	**DMOVNM
341	00	0	00	000000	AOJL	116	00	0	00	000000	*DMUL
343	00	0	00	000000	AOJLE	137	00	0	00	000000	DPB
346	00	0	00	000000	AOJN	115	00	0	00	000000	*DSUB
350	00	0	00	000000	AOS	444	00	0	00	000000	EQV
354	00	0	00	000000	AOSA	447	00	0	00	000000	EQVB
352	00	0	00	000000	AOSE	445	00	0	00	000000	EQVI
357	00	0	00	000000	AOSG	446	00	0	00	000000	EQVM
355	00	0	00	000000	AOSGE	250	00	0	00	000000	EXCH
351	00	0	00	000000	AOSL	123	00	0	00	000000	*EXTEND
353	00	0	00	000000	AOSLE	140	00	0	00	000000	FAD
356	00	0	00	000000	AOSN	143	00	0	00	000000	FADB
320	00	0	00	000000	ARG	141	00	0	00	000000	FADL
240	00	0	00	000000	ASH	142	00	0	00	000000	FADM
244	00	0	00	000000	ASHC	144	00	0	00	000000	FADR
251	00	0	00	000000	BLT	147	00	0	00	000000	FADRB
300	00	0	00	000000	CAI	145	00	0	00	000000	FADRI
304	00	0	00	000000	CAIA	146	00	0	00	000000	FADRM
302	00	0	00	000000	CAIE	170	00	0	00	000000	FDV
307	00	0	00	000000	CAIG	173	00	0	00	000000	FDVB
305	00	0	00	000000	CAIGE	171	00	0	00	000000	FDVL
301	00	0	00	000000	CAIL	172	00	0	00	000000	FDVM

(Continued on Next Page)

MACRO-DEFINED MNEMONICS

Table C-1 (Cont.)
Machine Instruction Mnemonics

174	00	0	00	000000	FDVR	547	00	0	00	000000	HLRS
177	00	0	00	000000	FDVRB	554	00	0	00	000000	HLRZ
175	00	0	00	000000	FDVRI	555	00	0	00	000000	HLRZI
176	00	0	00	000000	FDVRM	556	00	0	00	000000	HLRZM
126	00	0	00	000000	**FIXR	557	00	0	00	000000	HLRZS
127	00	0	00	000000	**FLTR	504	00	0	00	000000	HRL
160	00	0	00	000000	FMP	534	00	0	00	000000	HRLE
163	00	0	00	000000	FMPB	535	00	0	00	000000	HRLEI
161	00	0	00	000000	FMPL	536	00	0	00	000000	HRLEM
162	00	0	00	000000	FMPM	537	00	0	00	000000	HRLES
164	00	0	00	000000	FMPR	505	00	0	00	000000	HRLI
167	00	0	00	000000	FMPRB	506	00	0	00	000000	HRLM
165	00	0	00	000000	FMPRI	524	00	0	00	000000	HRLO
166	00	0	00	000000	FMPRM	525	00	0	00	000000	HRLOI
150	00	0	00	000000	FSB	526	00	0	00	000000	HRLOM
153	00	0	00	000000	FSBB	527	00	0	00	000000	HRLOS
151	00	0	00	000000	FSBL	507	00	0	00	000000	HRLS
152	00	0	00	000000	FSBM	514	00	0	00	000000	HRLZ
154	00	0	00	000000	FSBR	515	00	0	00	000000	HRLZI
157	00	0	00	000000	FSBRB	516	00	0	00	000000	HRLZM
155	00	0	00	000000	FSBRI	517	00	0	00	000000	HRLZS
156	00	0	00	000000	FSBRM	540	00	0	00	000000	HRR
132	00	0	00	000000	FSC	570	00	0	00	000000	HRRE
500	00	0	00	000000	HLL	571	00	0	00	000000	HRREI
530	00	0	00	000000	HLLE	572	00	0	00	000000	HRREM
531	00	0	00	000000	HLLEI	573	00	0	00	000000	HRRES
532	00	0	00	000000	HLLEM	541	00	0	00	000000	HRRI
533	00	0	00	000000	HLLES	542	00	0	00	000000	HRRM
501	00	0	00	000000	HLLI	560	00	0	00	000000	HRRO
502	00	0	00	000000	HLLM	561	00	0	00	000000	HRROI
520	00	0	00	000000	HLLO	562	00	0	00	000000	HRRM
521	00	0	00	000000	HLLOI	563	00	0	00	000000	HRRS
522	00	0	00	000000	HLLOM	543	00	0	00	000000	HRRZ
523	00	0	00	000000	HLLOS	550	00	0	00	000000	HRRZI
503	00	0	00	000000	HLLS	551	00	0	00	000000	HRRZM
510	00	0	00	000000	HLLZ	552	00	0	00	000000	HRRZS
511	00	0	00	000000	HLLZI	133	00	0	00	000000	IBP
512	00	0	00	000000	HLLZM	230	00	0	00	000000	IDIV
513	00	0	00	000000	HLLZS	233	00	0	00	000000	IDIVB
544	00	0	00	000000	HLR	231	00	0	00	000000	IDIVI
574	00	0	00	000000	HLRE	232	00	0	00	000000	IDIVM
575	00	0	00	000000	HLREI	136	00	0	00	000000	IDPB
576	00	0	00	000000	HLREM	134	00	0	00	000000	ILDB
577	00	0	00	000000	HLRES	220	00	0	00	000000	IMUL
545	00	0	00	000000	HLRI	223	00	0	00	000000	IMULB
546	00	0	00	000000	HLRM	221	00	0	00	000000	IMULI
564	00	0	00	000000	HLRO	222	00	0	00	000000	IMULM
565	00	0	00	000000	HLROI	434	00	0	00	000000	IOR
566	00	0	00	000000	HLROM	437	00	0	00	000000	IORB
567	00	0	00	000000	HLROS						

(Continued on Next Page)

MACRO-DEFINED MNEMONICS

Table C-1 (Cont.)
Machine Instruction Mnemonics

435 00 0 00 000000	IORI	471 00 0 00 000000	ORCBI
436 00 0 00 000000	IORM	472 00 0 00 000000	ORCBM
255 00 0 00 000000	JFCL	464 00 0 00 000000	ORCM
243 00 0 00 000000	JFFO	467 00 0 00 000000	ORCMB
267 00 0 00 000000	JRA	465 00 0 00 000000	ORCMI
254 00 0 00 000000	JRST	466 00 0 00 000000	ORCMM
266 00 0 00 000000	JSA	435 00 0 00 000000	ORI
265 00 0 00 000000	JSP	436 00 0 00 000000	ORM
264 00 0 00 000000	JSR	262 00 0 00 000000	POP
104 00 0 00 000000	JSYS	263 00 0 00 000000	POPJ
320 00 0 00 000000	JUMP	261 00 0 00 000000	PUSH
324 00 0 00 000000	JUMPA	260 00 0 00 000000	PUSHJ
322 00 0 00 000000	JUMPE	241 00 0 00 000000	ROT
327 00 0 00 000000	JUMPG	245 00 0 00 000000	ROTC
325 00 0 00 000000	JUMPGE	424 00 0 00 000000	SETA
321 00 0 00 000000	JUMPL	427 00 0 00 000000	SETAB
323 00 0 00 000000	JUMPLE	425 00 0 00 000000	SETAI
326 00 0 00 000000	JUMPN	426 00 0 00 000000	SETAM
135 00 0 00 000000	LDB	450 00 0 00 000000	SETCA
242 00 0 00 000000	LSH	453 00 0 00 000000	SETCAB
246 00 0 00 000000	LSHC	451 00 0 00 000000	SETCAI
257 00 0 00 000000	**MAP	452 00 0 00 000000	SETCAM
200 00 0 00 000000	MOVE	460 00 0 00 000000	SETCM
201 00 0 00 000000	MOVEI	463 00 0 00 000000	SETCMB
202 00 0 00 000000	MOVEM	461 00 0 00 000000	SETCMI
203 00 0 00 000000	MOVES	462 00 0 00 000000	SETCMM
214 00 0 00 000000	MOVMM	414 00 0 00 000000	SETM
215 00 0 00 000000	MOVMI	417 00 0 00 000000	SETMB
216 00 0 00 000000	MOVMM	415 00 0 00 000000	SETMI
217 00 0 00 000000	MOVMS	416 00 0 00 000000	SETMM
210 00 0 00 000000	MOVN	474 00 0 00 000000	SETO
211 00 0 00 000000	MOVNI	477 00 0 00 000000	SETOB
212 00 0 00 000000	MOVNM	475 00 0 00 000000	SETOI
213 00 0 00 000000	MOVNS	476 00 0 00 000000	SETOM
204 00 0 00 000000	MOVSI	400 00 0 00 000000	SETZ
205 00 0 00 000000	MOVSI	403 00 0 00 000000	SETZB
206 00 0 00 000000	MOVSM	401 00 0 00 000000	SETZI
207 00 0 00 000000	MOVSS	402 00 0 00 000000	SETZM
224 00 0 00 000000	MUL	330 00 0 00 000000	SKIP
227 00 0 00 000000	MULB	334 00 0 00 000000	SKIPA
225 00 0 00 000000	MULI	332 00 0 00 000000	SKIPE
226 00 0 00 000000	MULM	337 00 0 00 000000	SKIPG
434 00 0 00 000000	OR	335 00 0 00 000000	SKIPGE
437 00 0 00 000000	ORB	331 00 0 00 000000	SKIPL
454 00 0 00 000000	ORCA	333 00 0 00 000000	SKIPLE
457 00 0 00 000000	ORCAB	336 00 0 00 000000	SKIPN
455 00 0 00 000000	ORCAI	360 00 0 00 000000	SOJ
456 00 0 00 000000	ORCAM	364 00 0 00 000000	SOJA
470 00 0 00 000000	ORCB	362 00 0 00 000000	SOJE
473 00 0 00 000000	ORCBB	367 00 0 00 000000	SOJG

(Continued on Next Page)

MACRO-DEFINED MNEMONICS

Table C-1 (Cont.)
Machine Instruction Mnemonics

365	00	0	00	000000	SOJGE	667	00	0	00	000000	TLON
361	00	0	00	000000	SOJL	621	00	0	00	000000	TLZ
363	00	0	00	000000	SOJLE	625	00	0	00	000000	TLZA
366	00	0	00	000000	SOJN	623	00	0	00	000000	TLZE
370	00	0	00	000000	SOS	627	00	0	00	000000	TLZN
374	00	0	00	000000	SOSA	640	00	0	00	000000	TRC
372	00	0	00	000000	SOSE	644	00	0	00	000000	TRCA
377	00	0	00	000000	SOSG	642	00	0	00	000000	TRCE
375	00	0	00	000000	SOSGE	646	00	0	00	000000	TRCN
371	00	0	00	000000	SOSL	600	00	0	00	000000	TRN
373	00	0	00	000000	SOSLE	604	00	0	00	000000	TRNA
376	00	0	00	000000	SOSN	602	00	0	00	000000	TRNE
274	00	0	00	000000	SUB	606	00	0	00	000000	TRNN
277	00	0	00	000000	SUBB	660	00	0	00	000000	TRO
275	00	0	00	000000	SUBI	664	00	0	00	000000	TROA
276	00	0	00	000000	SUBM	662	00	0	00	000000	TROE
650	00	0	00	000000	TDC	666	00	0	00	000000	TRON
654	00	0	00	000000	TDCA	620	00	0	00	000000	TRZ
652	00	0	00	000000	TDCE	624	00	0	00	000000	TRZA
656	00	0	00	000000	TDCN	622	00	0	00	000000	TRZE
610	00	0	00	000000	TDN	626	00	0	00	000000	TRZN
614	00	0	00	000000	TDNA	651	00	0	00	000000	TSC
612	00	0	00	000000	TDNE	655	00	0	00	000000	TSCA
616	00	0	00	000000	TDNN	653	00	0	00	000000	TSCE
670	00	0	00	000000	TDO	657	00	0	00	000000	TSCN
674	00	0	00	000000	TDOA	611	00	0	00	000000	TSN
672	00	0	00	000000	TDOE	615	00	0	00	000000	TSNA
676	00	0	00	000000	TDON	613	00	0	00	000000	TSNE
630	00	0	00	000000	TDZ	617	00	0	00	000000	TSNN
634	00	0	00	000000	TDZA	671	00	0	00	000000	TSO
632	00	0	00	000000	TDZE	675	00	0	00	000000	TSOA
636	00	0	00	000000	TDZN	673	00	0	00	000000	TSOE
641	00	0	00	000000	TLC	677	00	0	00	000000	TSON
645	00	0	00	000000	TLCA	631	00	0	00	000000	TSZ
643	00	0	00	000000	TLCE	635	00	0	00	000000	TSZA
647	00	0	00	000000	TLCN	633	00	0	00	000000	TSZE
601	00	0	00	000000	TLN	637	00	0	00	000000	TSZN
605	00	0	00	000000	TLNA	130	00	0	00	000000	UFA
603	00	0	00	000000	TLNE	256	00	0	00	000000	XCT
607	00	0	00	000000	TLNN	430	00	0	00	000000	XOR
661	00	0	00	000000	TLO	433	00	0	00	000000	XORB
665	00	0	00	000000	TLOA	431	00	0	00	000000	XORI
663	00	0	00	000000	TLOE	432	00	0	00	000000	XORM

MACRO-DEFINED MNEMONICS

C.2 I/O INSTRUCTION AND DEVICE CODE MNEMONICS

Table C-2 shows MACRO's I/O instruction mnemonics and the code each assembles. Note that I/O machine instructions are executable only in executive mode.

Table C-2
I/O Instruction Mnemonics

7 000 00 0 00 000000	BLKI	7 000 30 0 00 000000	CONSZ
7 000 10 0 00 000000	BLKO	7 000 04 0 00 000000	DATAI
7 000 24 0 00 000000	CONI	7 000 14 0 00 000000	DATAO
7 000 20 0 00 000000	CONO	7 000 04 0 00 000000	RSW
7 000 34 0 00 000000	CONSO		

Table C-3 shows MACRO's I/O device code mnemonics. Each is assembled with the I/O instruction mnemonic DATAI so that the value of the device code will be in its proper field. In the first table entry, for example, the assembled code is:

7 024 04 0 00 000000

where the 7 and 04 are generated by the DATAI instruction, and the 024 by the ADC device code mnemonic.

NOTE

MACRO leaves these device code mnemonics as undefined symbols during Pass 1. At the end of Pass 1, the mnemonics are found in MACRO's tables only if one or more I/O instructions have been found.

Therefore, if a device code mnemonic is not assembled in Pass 1, or if no I/O instruction mnemonics were found, MACRO will not have defined the device code mnemonic.

MACRO-DEFINED MNEMONICS

Table C-3
I/O Device Code Mnemonics

7 024 04 0 00 000000	DATAI ADC,
7 030 04 0 00 000000	DATAI ADC2,
7 000 04 0 00 000000	DATAI APR,
7 014 04 0 00 000000	DATAI CCI,
7 110 04 0 00 000000	DATAI CDP,
7 114 04 0 00 000000	DATAI CDR,
7 070 04 0 00 000000	DATAI CLK,
7 074 04 0 00 000000	DATAI CLK2,
7 000 04 0 00 000000	DATAI CPA,
7 150 04 0 00 000000	DATAI CR,
7 154 04 0 00 000000	DATAI CR2,
7 200 04 0 00 000000	DATAI DC,
7 204 04 0 00 000000	DATAI DC2,
7 300 04 0 00 000000	DATAI DCSA,
7 304 04 0 00 000000	DATAI DCSB,
7 270 04 0 00 000000	DATAI DDC,
7 274 04 0 00 000000	DATAI DDC2,
7 270 04 0 00 000000	DATAI DF,
7 130 04 0 00 000000	DATAI DIS,
7 134 04 0 00 000000	DATAI DIS2,
7 060 04 0 00 000000	DATAI DLB,
7 160 04 0 00 000000	DATAI DLB2,
7 064 04 0 00 000000	DATAI DLC,
7 164 04 0 00 000000	DATAI DLC2,
7 240 04 0 00 000000	DATAI DLS,
7 244 04 0 00 000000	DATAI DLS2,
7 250 04 0 00 000000	DATAI DPC,
7 254 04 0 00 000000	DATAI DPC2,
7 260 04 0 00 000000	DATAI DPC3,
7 264 04 0 00 000000	DATAI DPC4,
7 464 04 0 00 000000	DATAI DSI,
7 474 04 0 00 000000	DATAI DSI2,
7 170 04 0 00 000000	DATAI DSK,
7 174 04 0 00 000000	DATAI DSK2,
7 460 04 0 00 000000	DATAI DSS,
7 470 04 0 00 000000	DATAI DSS2,
7 320 04 0 00 000000	DATAI DTC,
7 330 04 0 00 000000	DATAI DTC2,
7 324 04 0 00 000000	DATAI DTS,
7 334 04 0 00 000000	DATAI DTS2,
7 124 04 0 00 000000	DATAI LPT,
7 234 04 0 00 000000	DATAI LPT2,
7 260 04 0 00 000000	DATAI MDF,
7 264 04 0 00 000000	DATAI MDF2,
7 220 04 0 00 000000	DATAI MTC,
7 230 04 0 00 000000	DATAI MTM,
7 224 04 0 00 000000	DATAI MTS,
7 010 04 0 00 000000	DATAI PAG,

(Continued on Next Page)

MACRO-DEFINED MNEMONICS

Table C-3 (Cont.)
I/O Device Code Mnemonics

7 004 04 0 00 000000	DATAI PI,
7 140 04 0 00 000000	DATAI PLT,
7 144 04 0 00 000000	DATAI PLT2,
7 100 04 0 00 000000	DATAI PTP,
7 104 04 0 00 000000	DATAI PTR,
7 340 04 0 00 000000	DATAI TMC,
7 350 04 0 00 000000	DATAI TMC2,
7 344 04 0 00 000000	DATAI TMS,
7 354 04 0 00 000000	DATAI TMS2,
7 120 04 0 00 000000	DATAI TTY,
7 210 04 0 00 000000	DATAI UTC,
7 214 04 0 00 000000	DATAI UTS,

MACRO-DEFINED MNEMONICS

C.3 KL10 EXTEND INSTRUCTION MNEMONICS

Table C-4 shows the KL10 EXTEND instruction mnemonics and the code assembled by each. All of these mnemonics are defined only if MACRO is assembled with the KL10 switch on.

See the Supplement to the Hardware Reference Manual for a discussion of these EXTEND instructions.

Table C-4
KL10 EXTEND Instruction Mnemonics

002 00 0 00 000000	*CMPSE	010 00 0 00 000000	*CVTDBO
007 00 0 00 000000	*CMPSG	011 00 0 00 000000	*CVTDBT
005 00 0 00 000000	*CMPSGE	004 00 0 00 000000	*EDIT
001 00 0 00 000000	*CMPSL	016 00 0 00 000000	*MOVSLJ
003 00 0 00 000000	*CMPGLE	014 00 0 00 000000	*MOVSO
006 00 0 00 000000	*CMPST	017 00 0 00 000000	*MOVSRJ
012 00 0 00 000000	*CVTDBO	015 00 0 00 000000	*MOVST
013 00 0 00 000000	*CVTDBT	020 00 0 00 000000	*XBLT

MACRO-DEFINED MNEMONICS

C.4 JRST AND JFCL MNEMONICS

Table C-5 shows mnemonics that assemble both operator and accumulator fields in the machine instruction. The left side of the table shows the mnemonics and the code they generate; the right side shows JRST and JFCL mnemonics with accumulators generating the equivalent code.

Table C-5
JRST and JFCL Mnemonics

Code and Mnemonic	Equivalent Code and Mnemonic
254 04 0 00 000000 HALT	254 04 0 00 000000 JRST 4,
255 06 0 00 000000 JCRY	255 06 0 00 000000 JFCL 6,
255 04 0 00 000000 JCRY0	255 04 0 00 000000 JFCL 4,
255 02 0 00 000000 JCRY1	255 02 0 00 000000 JFCL 2,
254 12 0 00 000000 JEN	254 12 0 00 000000 JRST 12,
255 01 0 00 000000 JFOV	255 01 0 00 000000 JFCL 1,
255 10 0 00 000000 JOV	255 10 0 00 000000 JFCL 10,
254 02 0 00 000000 JRSTF	254 02 0 00 000000 JRST 2,
254 01 0 00 000000 PORTAL	254 01 0 00 000000 JRST 1,
254 06 0 00 000000 *XJEN	254 06 0 00 000000 JRST 6,
254 05 0 00 000000 *XJRSTF	254 05 0 00 000000 JRST 5,
254 07 0 00 000000 *XPCW	254 07 0 00 000000 JRST 7,
254 14 0 00 000000 *XSFM	254 14 0 00 000000 JRST 14,

APPENDIX D

PROGRAM EXAMPLES

The following pages contain examples of MACRO programs. Each program has been assembled with the /C (CREF) switch on; this produces a .CRF file for the program listing (instead of the usual .LST file). The /O switch has been used with the CREF program to produce a .LST file that includes all operators in an operator symbol table.

MACROS MACRO Z53(1017) 16:17 2-Mar-78 Page 1
EXAM20 MAC 2-Mar-78 16:17 Example One

```
1          SUBTTL Example One
2          UNIVERSAL MACROS
3
4          ;This UNIVERSAL program contains the macro QUIT, which uses
5          ; conditional assembly to generate a program exit monitor
6          ; call. If the TOPS10 switch is on when QUIT is called (or if
7          ; it is undefined), QUIT generates "EXIT"; if the switch
8          ; is off, QUIT generates "HALTF".
9
10         DEFINE QUIT <
11             IFNDEF TOPS10,<
12                 TOPS10==1             ;;Default is TOPS10
13         >
14             IFE TOPS10,<
15                 HALTF
16         >
17             IFN TOPS10,<
18                 EXIT
19         >
20         >
21         PRGEND
```

NO ERRORS DETECTED

PROGRAM BREAK IS 000000
CPU TIME USED 00:00.570

34F CORE USED

D-2

PROGRAM EXAMPLES

```
22          SUBTTL Example Two
23          TITLE Second Example of MACRO Program
24
25          ;This program contains the macros CLEAR, CONCAT, and EXPAND.
26          ; These can be used to append arbitrary text into a buffer,
27          ; and to recall the text later. Two sequences of calls
28          ; to the macros show possible uses.
29          ;
30          ;The following points are of interest:
31          ;
32          ; 1. The buffer is cleared by calling CLEAR. Text is added
33          ; (on the right side of the buffer) by calling CONCAT.
34          ; EXPAND, when used in a context allowed for macro calls,
35          ; expands the contents of the buffer into source code.
36          ;
37          ; 2. A call to CLEAR defines the text buffer, EXPAND, to
38          ; contain no text. It also defines the macro CONCAT in
39          ; such a way that the first call to CONCAT redefines
40          ; EXPAND to contain the first piece of text, and CONCAT
41          ; redefines itself so that further calls to CONCAT will
42          ; call the internal macro CON1. Following the second
43          ; call to CONCAT, each further call merely appends new
44          ; text to the old.
45          ;
46          ; 3. A key feature of EXPAND is that it contains no carriage
47          ; returns. If it did, then each concatenation of new
48          ; text would also insert a carriage return into the text.
49          ;
50          ; 4. The first use of these macros shows that EXPAND can be
51          ; placed in contexts where more than one argument will
52          ; result (as in the BYTE pseudo-op). Note that because
53          ; angle brackets are used internally (inside the macros)
54          ; to delimit text, all concatenated text must contain
55          ; matched angle brackets.
56          ;
57          ; 5. Note that carriage returns, if desired, can be easily
58          ; concatenated to the buffer; this is done in the second
59          ; use of the macros.
60
61          ; . . .
```

```
62 ; . . .
63
64 DEFINE CLEAR <
65     DEFINE CONCAT (FTXT) <
66         DEFINE CONCAT (TEXT) <
67             CON1 <TEXT>,<FTXT>
68         >
69     DEFINE EXPAND <FTXT>
70 >
71 DEFINE EXPAND <>
72 >
73
74 DEFINE CON1 (NTXT,OTXT) <
75     DEFINE CONCAT (TEXT) <
76         CON1 <TEXT>,<OTXT'NTXT>
77     >
78     DEFINE EXPAND <OTXT'NTXT>
79 >
80
81 SALL
82
83 CLEAR
84
85 CONCAT <10>
86 CONCAT <,>
87 CONCAT <"A">
88 CONCAT <,<<-1,,6>&177>>
89
90 LALL
91 000000' 010 101 006 00000 BYTE (7)EXPAND~10,"A",<<-1,,6>&177>~
92
93 SALL
94 CLEAR
95
96 CONCAT <DEF>
97 CONCAT <INE FOO (>
98 CONCAT <(N)>
99 CONCAT <<2*N>
100 DEFINE>
101 CONCAT < BAR (N) <3*N>
102 >
103
104 ; . . .
```

Second Example of MACRO Program MACRO %53(1017) 16:17 2-Mar-78 Page 4
EXAM20 MAC 2-Mar-78 16:17 Example Two

```
105 ; . . .
106
107 LALL
108 EXPAND^DEFINE FOO (N) <2*N>
109 DEFINE BAR (N) <3*N>
110 ^
111
112 000001' 000000 000004 FOO 2^2*2^
113 000002' 000000 000006 FOO 3^2*3^
114 000003' 000000 000006 BAR 2^3*2^
115 000004' 000000 000011 BAR 3^3*3^
116
117 PRGEND
```

NO ERRORS DETECTED

PROGRAM BREAK IS 000005
CPU TIME USED 00:00.166

34P CORE USED

```
118          SUBTTL Example Three
119          TITLE Third Example of MACRO Program
120
121          ;This program uses the macros NUMLST and X to generate parallel
122          ; tables.
123          ;
124          ;This example generates a table that contains keywords suitable
125          ; for comparison to user input; the second table generated
126          ; contains addresses of routines that handle those keywords;
127          ; the third table contains useful values.
128          ;
129          ;The keyword table is arranged alphabetically to speed searching;
130          ; the other two tables correspond entry-for-entry to the
131          ; keyword table.
132          ;
133          ;Key features of this program include:
134          ;
135          ; 1. Changing the size of the tables is easy. For example,
136          ;    if a new entry, FIFTH, is needed, adding the word and
137          ;    a dummy label to the definition of NUMLST will update
138          ;    both tables; no separate update is required.
139          ;
140          ; 2. The macro NUMLST calls the macro X. Before each call
141          ;    to NUMLST, X is redefined so that the proper kind of
142          ;    table is built. Note that a definition of X need not
143          ;    use both arguments in the macrobody. (However, X should
144          ;    define both arguments.)
145          ;
146          ; 3. The second definition of X uses concatenation to build
147          ;    mnemonic labels for the table LBLTBL.
148          ;
149          ; 4. The program uses the macro QUIT so that it can be used
150          ;    for either TOPS-10 or TOPS-20. The SEARCH MACROS statement
151          ;    makes the definition of QUIT available; since the default
152          ;    for QUIT is TOPS-10, the program will run on TOPS-10 if
153          ;    either it defines TOPS10=-1 or does not define TOPS10;
154          ;    the program will run on TOPS-20 only if it defines
155          ;    TOPS10=0.
156          ;
157          ; . . .
```

```

158                                     ; . . .
159
160 SEARCH MACROS,MONSYM
161                                000000
162                                TOPS10==0
163                                .DIRECTIVE SFCOND
164
164 DEFINE NUMLST <
165     X (FIRST,1)
166     X (FOURTH,4)
167     X (SECOND,2)
168     X (THIRD,3)
169 >
170
171 DEFINE X (TEXT,JUNK) <EXP SIXBIT /TEXT/>
172
173 000000' NAMTBL: NUMLST^
174 000000' 465162 636400     X (FIRST,1)^EXP SIXBIT /FIRST/^
175 000001' 465765 626450     X (FOURTH,4)^EXP SIXBIT /FOURTH/^
176 000002' 634543 575644     X (SECOND,2)^EXP SIXBIT /SECOND/^
177 000003' 645051 624400     X (THIRD,3)^EXP SIXBIT /THIRD/^
178                                000004
179                                TBLLEN==.-NAMTBL
180
180 DEFINE X (JUNK,LABL) <$/LABL>
181
182 000004' LBLTBL: NUMLST^
183 000004' 000000 000014'     X (FIRST,1)^$1^
184 000005' 000000 000017'     X (FOURTH,4)^$4^
185 000006' 000000 000015'     X (SECOND,2)^$2^
186 000007' 000000 000016'     X (THIRD,3)^$3^
187
188
188 DEFINE X (JUNK,VALU) <DEC VALU>
189
190 000010' VALTBL: NUMLST^
191 000010' 000000 000001     X (FIRST,1)^DEC 1^
192 000011' 000000 000004     X (FOURTH,4)^DEC 4^
193 000012' 000000 000002     X (SECOND,2)^DEC 2^
194 000013' 000000 000003     X (THIRD,3)^DEC 3^
195
196                                     ; . . .

```

```
197 ; . . .
198
199 XALL
200 000014' $1: QUIT^
201 000014' 104 00 0 00 000170 HALYF
202 000015' $2: QUIT^
203 000015' 104 00 0 00 000170 HALTF
204 000016' $3: QUIT^
205 000016' 104 00 0 00 000170 HALTF
206 000017' $4: QUIT^
207 000017' 104 00 0 00 000170 HALTF
208
209 PRGEND
```

NO ERRORS DETECTED

PROGRAM BREAK IS 000020
CPU TIME USED 00:00.152

34P CORE USED

Third Example of MACRO Program MACRO %53(1017) 16:17 2-Mar-78 Page S-1
EXAM20 MAC 2-Mar-78 16:17 SYMBOL TABLE

HALTF	104000	000170	int
LBLTBL		000004'	
NAMTBL		000000'	
TBLLEN		000004	spd
TOPS10		000000	spd
VALTBL		000010'	
\$1		000014'	
\$2		000015'	
\$3		000016'	
\$4		000017'	

```
210          SUBTTL Example Four
211          TITLE Fourth Example of MACRO Program
212
213          ;This program contains a complex and useful macro, COMMON.
214          ; The macro allows declaration of variable names for a
215          ; FORTRAN-compatible COMMON block. Note that the pseudo-op
216          ; .COMMON allows declaration of a COMMON block, but not of
217          ; variable names within the block.
218          ;
219          ;The COMMON macro uses two arguments:
220          ;
221          ; 1. The name of the COMMON block.
222          ;
223          ; 2. An IRP-style list of the variable names for the block.
224          ; The list can contain either variable names only (with
225          ; an assumed length of one word for each variable), or
226          ; can contain an angle-bracketed pair giving the name and
227          ; the length in decimal.
228          ;
229          ;Key features of the program include:
230          ;
231          ; 1. Lengths for variables are given in decimal numbers,
232          ; so that the definitions look much like those in the
233          ; FORTRAN language. This is accomplished by storing
234          ; the current radix in a created symbol, and restoring
235          ; it at the end of the macro.
236          ;
237          ; 2. The macro uses the technique of IRPins more than once
238          ; on the IRP list. The first IRP counts the length of
239          ; the entire COMMON block, so that the .COMMON pseudo-op
240          ; can be used; the second IRP declares variable names
241          ; for each entry in the block.
242          ;
243          ; 3. The pseudo-ops .XCREF and PURGE are used often
244          ; in the macro; this is to remove references to created
245          ; symbols from the CREF listings and the symbol table.
246          ;
247          ; 4. Created symbols are used in the macro for symbols that
248          ; are used only within the macro itself. This minimizes
249          ; the chance that other definitions will conflict with
250          ; these symbols.
251          ;
252          ; 5. Once the COMMON macro has been called, symbols in the
253          ; COMMON block may be used much as any other symbols;
254          ; this is shown in the IFIX and ZERO routines.
255          ;
256          ; . . .
```

```

257             ; . . .
258
259             DEFINE COMMON (COM, VARS, %RAD, %LEN, %VAL, %COM, %PAS) <
260             .XCREF %RAD, %LEN, %VAL, %COM, %PAS
261
262             ;;Temp macro to strip one pair of angle brackets from
263             ;; a macro argument and pass it to another macro
264
265             DEFINE %PAS (A,B) <A B>
266
267             ;;Temp macro to compute length of COMMON
268
269             DEFINE %COM (VAR, LEN<1>) <%LEN==%LEN+LEN>
270
271             %RAD==10             ;;Save current radix, use 10
272             RADIX 10             ;; so defs read like FORTRAN
273             %LEN==0             ;;Set to count length of COMMON
274             IRP VARS<%PAS %COM, VARS> ;;Get length of this COMMON
275             .COMMON COM%LEN]     ;;Allocate the whole COMMON
276
277             DEFINE %COM (VAR, LEN<1>) <             ;;Set up another temp macro
278             VAR=%VAL             ;;Define COMMON block entry
279             %VAL==%VAL+LEN       ;;Increment to next entry
280             >
281
282             %LEN==0             ;;Reinitialize length
283             %VAL==COM           ;;Start to define entries in block
284             IRP VARS<%PAS %COM, VARS> ;;Define next COMMON entry
285             RADIX %RAD           ;;Restore current radix
286
287             IF2, <PURGE %LEN, %RAD, %VAL, %COM, %PAS> ;;Keep symbol table clean
288             >
289
290             ; . . .

```

```

291 ; . . .
292
293 ; INTEGER SINGLE,ARRAY,MULTI
294 ; REAL REAL
295 ; DOUBLE PRECISION DOUBLE
296 ; COMMON /AREA/SNGLE,REAL,DOUBLE,ARRAY(10),MULTI(5,10)
297
298 COMMON AREA,<SNGLE,REAL,<DOUBLE,2>,<ARRAY,10>,<MULTI,5*10>>
299
300 ;Sample routine to do SNGLE=IFIX(REAL)
301
302 000000' 122 01 0 00 000000# IFIX: FIX 1,REAL
303 000001' 202 01 0 00 000000# MOVEM 1,SNGLE
304 000002' 263 17 0 00 000000 POPJ 17,
305
306 ;Sample routine to set all elements in ARRAY to 0
307
308 000003' 200 01 0 00 000007' ZERO: MOVE 1,[XWD ARRAY,ARRAY+1]
309 000004' 402 00 0 00 000000# SETZM ARRAY
310 000005' 251 01 0 00 000000# BLT 1,ARRAY+^D9
311 000006' 263 17 0 00 000000 POPJ 17,
312
313 000007' LIT
314 000007' 000000# 000000#
315
316 END

```

NO ERRORS DETECTED

PROGRAM BREAK IS 000010

CPU TIME USED 00:00.232

36P CORE USED

Fourth Example of MACRO Program MACRO %53(1017) 16:17 2-Mar-78 Page S-2
EXAM20 MAC 2-Mar-78 16:17 SYMBOL TABLE

AREA	000001'	ext
ARRAY	000000000000#	Pol
DOUBLE	000000000000#	Pol
IFIX	000000'	
MULTI	000000000000#	Pol
REAL	000000000000#	Pol
SNGLE	000000*	
ZERO	000003'	

AREA	299#	299							
ARRAY	299#	308	309	310					
DOUBLE	299#								
IFIX	302#								
LBLTBL	182#								
MULTI	299#								
NAMTBL	173#	178							
REAL	299#	302							
SNGLE	299#	303							
TBLLEN	178#								
TOPS10	161#	201	202	203	204	205	206	207	208
VALTBL	190#								
ZERO	308#								
\$1	183	200#							
\$2	185	202#							
\$3	186	204#							
\$4	184	206#							

BAR	109#	114	115											
CLEAR	64#	83	94											
COMMON	259#	298												
CON1	74#	86	87	88	97	98	100	102						
CONCAT	83#	85	85#	86	86#	87	87#	88	88#	94#	96	96#	97	97#
	98	98#	99	100#	101	102#								
EXPAND	83#	85#	86#	87#	88#	91	94#	96#	97#	98#	100#	102#	108	
FOO	108#	112	113											
HALTF	201	203	205	207										
NUMLST	164#	173	182	190										
QUIT	10#	200	202	204	206									
X	171#	174	175	176	177	180#	183	184	185	186	188#	191	192	193
	194													
..0004	299	299#												
..0005	299													

BLT	310													
BYTE	91													
DEC	191	192	193	194										
DEFINE	10	64	74	83	85	86	87	88	94	96	97	98	100	102
	108	109	164	171	180	188	259	299						
END	316													
EXP	174	175	176	177										
FIX	302													
IF2	299													
IFE	201	203	205	207										
IFN	202	204	206	208										
IFNDEF	201	203	205	207										
IRP	299													
LALL	90	107												
LIT	313													
MOVE	308													
MOVEM	303													
POPJ	304	311												
PRGEND	21	117	209											
PURGE	299													
RADIX	299													
SALL	81	93												
SEARCH	160													
SETZM	309													
SIXBIT	174	175	176	177										
SUBTTL	1	22	118	210										
TITLE	23	119	211											
UNIVER	2													
XALL	199													
XWD	308													
.COMMO	299													
.DIREC	162													

APPENDIX E

PSEUDO-OPS FOR SYSTEM COMPATIBILITY

The pseudo-ops in this appendix are included for system compatibility; they are to be used only to assemble TOPS-10 programs while running TOPS-20.

PSEUDO-OPS FOR SYSTEM COMPATIBILITY

HISEG

FORMAT HISEG address

address = program high-segment origin address. Must be equal to or greater than 400000 and must be a multiple of 1000.

FUNCTION

Directs the loader to load the current program into the high segment if the program has reentrant (two-segment) capability. HISEG should appear at the beginning of the source program.

HISEG does not affect assembler operation. The code produced by HISEG will execute at either relocatable 0 or relocatable 400000, depending on the loading instructions given.

The code following HISEG looks as if it was assembled to start at relocatable 0.

This pseudo-op has been replaced by TWOSEG.

PSEUDO-OPS FOR SYSTEM COMPATIBILITY

RIM

FORMAT RIM

FUNCTION Specifies a format for absolute binary programs (useful only for PDP-6 systems), and consists of a series of paired words.

The first word of each pair is a paper-tape read instruction giving the memory address of the second word. The last pair of words is a transfer block; the first is an instruction obtained from the END statement and executed when the transfer block is read, and the second is a dummy word to stop the reader.

PSEUDO-OPS FOR SYSTEM COMPATIBILITY

RIM10

FORMAT RIM10

FUNCTION Causes a program format in which programs are absolute, unblocked, and not checksummed. When the RIM10 statement follows a LOC statement in a program, the assembler punches out each storage word in the object program, starting at the absolute address specified in the LOC statement. RIM10 writes an arbitrary "paper tape"; if it is in the format given below, it can be read by the DECSYSTEM-10 Read-In Mode hardware.

IOWD n,first

where n is the length of the program including the ending word transfer, and first is the first memory location to be occupied. The last location must contain a transfer instruction to begin the program, such as

JRST 4,GO

For example, if a program with RIM10 output has its first location at START and its last location at FINISH, you can write

IOWD FINISH-START+1,START

NOTE

If the location counter is increased but no binary output occurs (for example, BLOCK, LOC, and VAR pseudo-ops), MACRO inserts a zero word into the binary output file for each location skipped by the location counter.

PSEUDO-OPS FOR SYSTEM COMPATIBILITY

RIM10B

FORMAT RIM10B

FUNCTION If a program is assembled into absolute locations (not relocatable), a RIM10B statement following the LOC statement at the beginning of the source program causes the assembler to write out the object program in RIM10B format. This format is designed for use with the DECsystem-10 Read-In Mode hardware.

The program is punched during Pass 2, starting at the location specified in the LOC statement. If the first two statements in the program are

```
LOC 1000
RIM10B
```

MACRO assembles the program with absolute addresses starting at 1000 and punches the program in RIM10B format, also starting at location 1000. You can reset the location counter during assembly, but only one RIM10B statement is needed to punch the entire program.

In RIM10B format, the assembler punches the RIM10B Loader, followed by the program in 17-word (or less) data blocks, each block separated by blank tape. The assembler inserts an I/O transfer word (IOWD) preceding each data block, and also inserts a 36-bit checksum following each data block. The word count in the IOWD counts only the data words in the block, and the checksum is the 36-bit added checksum of the IOWD and the data words.

Data blocks can contain less than 17 words. If the assembler assigns a nonconsecutive location, the current data block is terminated, and an IOWD containing the next location is inserted, starting a new data block.

The transfer block consists of two words. The first word of the transfer block is an instruction obtained from the END statement. This first word is executed when the transfer block is read. The second word is a dummy word to stop the reader.

APPENDIX F
STORAGE ALLOCATION

MACRO allocates storage in two directions:

1. User symbols and macronames are entered in the symbol tables.
2. Macros and literals are entered in free space.

A symbol table entry is two words long. The first word is the symbol name in SIXBIT. The second word has flags in the left half, and either the value or a pointer in the right half. The flags indicate symbol type and attributes.

The following list shows how symbols and values are stored.

Type	How Stored
18-bit symbol	Value in right half of second word.
36-bit symbol (includes OPDEFs and negative numbers)	Value in free storage with a pointer in symbol table.
EXTERNAL symbol	Pointer in symbol table to a 2-word block in free storage. The first word is the value that is the last reference in a chain of references to the symbol; the second word is the symbol name in SIXBIT.
Polish symbol	The symbol table entry points to a 2-word block: word 1: 0 word 2: negative number,,address Word 1 is the relocation word and is always zero. Word 2 gives the address of a Polish stack in free storage. The Polish stack is of the form: word 1: 0 word 2: opcode word 3: relocation constant word 4: value word 5: relocation constant word 6: value

STORAGE ALLOCATION

Words 3 and 4 designate an operand. If the operator is binary, words 5 and 6 designate the second operand; if the operator is unary, the stack contains only four words.

If an operand is EXTERNAL, its two words (3 and 4, or 5 and 6) are:

word i: pointer to EXTERNAL symbol
word i+1: 0

If an operand is itself a Polish symbol, its two words are:

word i: Polish pointer
word i+1: 0

Inter-PSECT reference

Polish stack containing:

word 1: 0
word 2: 15
word 3: -2
word 4: referenced PSECT index
word 5: relocation constant
word 6: address

Synonym operator
(SYN argument)

SIXBIT operator name in free storage with a pointer in the symbol table.

Macroname

Value in free storage with a pointer to the text string in symbol table.

The text string is stored in a 4-word block of the form:

word 1: link to next block (0 if last),,two characters
word 2: five characters
word 3: five characters
word 4: five characters

However, the first such block is special:

word 1: link to next block,,link to last block
word 2: pointer to default arg.,,number of args expected + reference count
word 3: five characters
word 4: five characters

The number of args expected is the number of dummy-arguments in the macro definition.

The reference count is incremented when the macro is called and decremented when the macro is exited. When this count goes to zero, the macro is removed from free space.

STORAGE ALLOCATION

Macro arguments

Stored in the same linked block, but not in the symbol table. Repeats (two or more times) are also stored in the same way. The text blocks are removed when the macro exits or the repeat exits, since the reference count has gone to zero.

The addresses of the actual argument blocks are stored in a pushdown stack in order of generation.

Default arguments are stored in the same way, except that the list is in free core. The pointer to the default arg list is stored in the left half of the second word of the first block of the macro definition.

Macros

The macrobody is stored as is, except that dummy-arguments are replaced by special symbols.

ASCII 177 (RUBOUT) signals that the next character is a special character, as follows:

```
001 ;end of macro
002 ;end of dummy symbol
003 ;end of REPEAT
004 ;end of IRP or IRPC
005 ;RUBOUT
```

If the character is more than 5 and less than 100, it is illegal.

If the character is greater than or equal to 100, it is a dummy symbol; the value of the character is ANDed with 37 to get the dummy symbol number, and the corresponding pointer retrieved from the stack of actual arguments.

If the symbol was not specified (that is, has no pointer), and if the 40 bit is on, this symbol requires a created symbol, and one is created; otherwise the argument is ignored.

NOTE

Verbose macros can use too much storage space.

STORAGE ALLOCATION

Literals

Four-word block for each word generated

word 1: form word
word 2: relocation bits
word 3: code
word 4: pointer to next block

Form word is the word used for listing. This word is not checked when comparing literals, so that different forms producing the same code are classed as equal.

Relocation bits are 0, 1, or EXTERNAL pointers.

Pointer is the address of the zero word of the next block.

NOTE

Long literals slow assembly and use storage; they should be written as subroutines or inline code.

APPENDIX G

ACCESSING ANOTHER USER'S FILE

MACRO allows you to access another user's file in two ways. The first is to give a logical name in place of the device name; the second is to give a project-programmer number instead of a directory name. You can give either of these in your program or in a MACRO command line.

For more information about referencing other users' files, refer to the DECSYSTEM-20 User's Guide.

G.1 USING LOGICAL NAMES

To use a logical name in accessing another user's file, you must:

1. Give the DEFINE command to define a logical name (of no more than six characters) as the other user's directory name.
2. Use the logical name as the device name whenever giving the file specification.

G.1.1 Giving the DEFINE Command

To give the DEFINE command:

1. Type DEF and press the ESCAPE key; the system prints INE (LOGICAL NAME).

```
@DEFINE (LOGICAL NAME)
```

2. Type the logical name, ending it with a colon; then type the directory name in angle brackets and RETURN:

```
@DEFINE (LOGICAL NAME) BAK:<BAKER>  
@
```

To check the logical name, give the INFORMATION (ABOUT) LOGICAL-NAMES command.

```
@INFORMATION (ABOUT) LOGICAL-NAMES  
BAK: => <BAKER>  
@
```

ACCESSING ANOTHER USER'S FILE

G.1.2 Using the Logical Name

You can include the logical name in a command line or in your program.

G.1.2.1 Command Lines - To include the logical name in a command line, type the logical name in place of a device name.

The following example shows how to compile the file <BAKER>SPEC.MAC. You must have already defined the logical name BAK: as <BAKER>.)

```
@MACRO
*SPEC.REL=BAK:SPEC.MAC
```

G.1.2.2 User Programs - After giving the DEFINE command, include the logical name within the program to reference the file.

The following example shows how to reference the file <BAKER>MACROS.MAC with a .REQUEST pseudo-op.

```
.REQUEST BAK:MACROS.MAC
```

This command causes LINK to load the file MACROS.MAC from the directory that has been assigned the logical name BAK.

G.2 USING PROJECT-PROGRAMMER NUMBERS

To use a project-programmer number in accessing another user's file, you must:

1. Run the TRANSL program to find the corresponding project-programmer number for the given directory name.
2. Include the project-programmer number after the filename.

You do not have to define a logical name if you use a project-programmer number. Project-programmer numbers, however, sometimes change; therefore, use logical names wherever possible.

G.2.1 Running the TRANSL Program

To run the TRANSL program, you must:

1. Type TRANSL and press the ESCAPE key. The system completes the line as TRANSLATE (DIRECTORY).

```
@TRANSLATE (DIRECTORY)
```

2. Type the directory name and press the RETURN key. The system prints the appropriate project-programmer number.

```
TRANSLATE (DIRECTORY)<BAKER>
PS:<BAKER> IS PS:[4,204]
```

ACCESSING ANOTHER USER'S FILE

You can also use the TRANSL program to make sure a project-programmer number is correct. Simply replace the directory name with the project-programmer number.

```
@TRANSLATE (DIRECTORY)[4,204]
PS:[4,204] IS PS:<BAKER>
```

G.2.2 Using the Project-Programmer Number

You can include the project-programmer number in a command line or in your program. Because project-programmer numbers can change, you should use a logical name.

G.2.2.1 Command Lines - To include a project-programmer number in a command line, type the project-programmer number after the file specification.

The following example shows how to compile the file <BAKER>SPEC.MAC by using a project-programmer number.

```
@MACRO
*SPEC.REL=SPEC.MAC[4,204]
```

G.2.2.2 User Programs - After obtaining the project-programmer number, you can use it within the program to reference the file.

The following example shows how to reference the file <BAKER>MACROS.MAC from your program.

```
.REQUEST MACROS.MAC[4,204]
```

This command causes LINK to load the file MACROS.MAC from the directory associated with [4,204].

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