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**IBM 7090/7094 Programming Systems:
Macro Assembly Program (MAP) Language**

This publication provides detailed information for writing source programs in the 7090/7094 Macro Assembly Program (MAP) Language.

Users of the MAP symbolic programming language are provided with an extensive set of pseudo-operations, as well as all 7090/7094 machine operations.

The Macro Assembly Program, IBMAP, is a component of the 7090/7094 IBJOB Processor and operates under the IBJOB Monitor.

Preface

The MAP language and its use in writing 7090/7094 programs are described in this publication. This symbolic language encompasses all 7090/7094 machine operations, extended machine operations, and special operation. In addition, MAP provides more than sixty pseudo-operations, including the powerful macro-facility, all of which are described in this publication.

MAP language programs are processed by the 7090/7094 assembly program, IBM MAP, which is a component of the 7090/7094 IJOB Processor and which operates under the IJOB Monitor. The facilities of IOCS, FORTRAN, and COBOL are accessible to the MAP user.

To assist the user in making the most effective use of this flexible programming tool, basic information about the MAP language is provided in Part I of this publication. Its main features and capabilities are outlined, and the constituents of MAP symbolic instructions are explained.

The pseudo-operations provided by MAP have been divided into classes according to function. Most of the pseudo-operations are described in Part II, where their formats are shown and their use in programs is explained and demonstrated.

The macro-facility is described separately in Part III. Five appendixes following Part III provide supplementary information related to the MAP language.

It has been assumed that the reader is familiar with the contents of one of the following publications:
IBM 7090 Data Processing System, Form A22-6528
IBM 7094 Data Processing System, Form A22-6703

The following related publications may also be useful, depending on individual interests and requirements:

IBM 7090/7094 IBSYS Operating System: System Monitor (IBSYS), Form C28-6248

IBM 7090/7094 IBSYS Operating System: IJOB Processor, Form C28-6275

IBM 7090/7094 IBSYS Operating System: Input/Output Control System, Form C28-6345

IBM 7090/7094 Programming Systems: FORTRAN IV Language, Form C28-6274

IBM 7090/7094 Programming Systems: COBOL Language, Form J28-6260

Machine requirements for MAP language programs are given in the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form C28-6275

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Part I. Symbolic Programming Using MAP

Programmers can communicate instructions to computers at three general language levels. The language of the computer itself is the most basic. At the highest level are scientific and commercial programming languages, such as FORTRAN and COBOL, respectively. Assembly-program languages like the MAP (Macro Assembly Program) language are at the intermediate level.

Because the computer executes instructions at the machine-language level, a source program written at either of the other two levels must be reduced to a machine-language object program before it can be executed. Machine-language programming is theoretically the most efficient, since no translation from source program to object program is required. For the programmer, however, programming in machine language is tedious and time consuming, and programming errors are more likely.

A source program written in the FORTRAN language closely resembles the mathematical notation used to state a problem to be solved by traditional methods. The COBOL language is based on English statements much like those that would be used to explain a procedure. These languages are relatively easy to learn and to use because of their similarity to the ordinary languages of business and science.

Source programs written in these languages are translated into machine-language programs within the computer by a compiler program. By using a compiler, the computer can produce an efficient machine-language program from a FORTRAN or COBOL source program faster and more accurately than a programmer can. Such compiler languages thus offer marked advantages over machine-language programming. However, compiler languages are somewhat restrictive. Some programming features that are available when using machine language cannot be included in any present-day compiler.

An assembly-program language is similar in structure to machine language. However, mnemonic symbols are substituted for each binary instruction code, and symbols provided by the programmer are substituted for the other fields of an instruction. An assembly-program language can also provide additional advantages beyond machine-language programming. For example, pseudo-operations can be provided, which often permit the coding of one instruction instead of many instructions. Thus, an assembly program provides the programmer with all the flexibility and versatility of

machine language but with greatly reduced programming effort. In addition, error checking can be included to facilitate source program debugging.

7090/7094 MAP Language Features

Operations

The 7090/7094 MAP (Macro Assembly Program) language can be used for all of the 7090/7094 machine operations, the extended machine operations, and the special machine operations. (All such operations recognized by MAP are listed in Appendix A with supplementary information about them.) In addition, the MAP language provides an extensive set of pseudo-operations that supplement machine instructions.

A pseudo-operation is any operation included in the MAP language that is not an actual machine operation, extended machine operation, or special machine operation. Pseudo-operations are used by the programmer in much the same way as machine operations. MAP provides more than sixty such pseudo-operations to meet a variety of programming needs. These pseudo-operations, which are described in detail in Parts II and III, have been divided into classes according to function.

Location-Counter Pseudo-Operations enable the programmer to establish symbolic location counters and control their operation.

Storage-Allocation Pseudo-Operations reserve areas of core storage.

Data-Generating Pseudo-Operations introduce data into a program in any of a variety of formats. They are also used in combination to generate tables of data.

Symbol-Defining Pseudo-Operations are used to assign specific values to symbols.

Boolean Pseudo-Operations define symbols as Boolean quantities.

Conditional-Assembly Pseudo-Operations base assembly of an instruction on programmer established criteria.

Symbol-Qualifying Pseudo-Operations qualify symbols within sections of a program.

Control-Section Pseudo-Operations delimit sections of a program, facilitating cross-referencing among programs and among program segments.

File-Description Pseudo-Operations define the requirements of input/output files used by the program.

Operation-Defining Pseudo-Operations define or re-define symbols as operation codes.

Miscellaneous Pseudo-Operations indicate the end of a program, extend the variable field of an operation, and permit remarks to be entered into the assembly listing.

Absolute-Assembly Pseudo-Operations specify the punched output format of an absolute assembly.

List-Control Pseudo-Operations specify the contents and format of an assembly listing.

Special Systems Pseudo-Operations generate subroutine calling sequences. They may also be used to save and restore the index registers and indicators.

Macro-Defining Pseudo-Operations are used to define programmer macro-operations. They are used in conjunction with the *macro-related pseudo-operations*, which extend the facilities of macro-operations.

Macro-Operations

The programmer macro-operation facility is a very flexible and powerful programming tool. Many programming applications involve a repetition of a pattern of instructions, often with parts of the instructions varied at each iteration. Using the macro-defining pseudo-operations, a programmer can define the pattern as a macro-operation.

In defining the pattern, the programmer gives it a name that becomes the operation code used to generate the pattern of instructions. Thus, the coding of a single instruction can cause the pattern of instructions to be repeated as often as desired. Moreover, parts of the instruction can be varied each time the sequence is repeated. The contents of any field of any instruction within the pattern may be varied, and even entire instructions can be inserted in the sequence. The macro-operation facility is described in Part III.

Location Counters

During assembly, a location counter registers the next location to be assigned to an instruction. For most machine instructions processed by the assembly program, the contents of the location counter in effect at that time (the "current" location counter) is increased by 1. Some pseudo-operations may result in no increase, an increase of 1, or an increase of more than 1.

MAP enables a programmer to create and control as many symbolic location counters as he needs by using the location-counter pseudo-operations. Control can be transferred back and forth among them as often as desired.

This feature permits instructions coded in one sequence to be loaded in another, the establishment of constant tables, etc.

Absolute and Relocatable Assemblies

The control routines of the operating system occupy lower core storage. Therefore, a program may not be

loaded into this area but must be loaded into the first unused machine location. However, the programmer need not know the address of this location, since the loader (IBLDR) can automatically relocate each program segment to be loaded.

The first address of a program segment to be executed is called the load address, and each succeeding instruction is loaded relative to that address. Thus, the address of an instruction at load time is the address assigned to it during assembly plus the load address of the program segment in which the instruction appears.

In a relocatable assembly, the assembly program produces an object deck that is automatically relocated at execution time by IBLDR. However, it may sometimes be desirable to load a program beginning at a certain fixed location in core storage. A program loaded in this way is said to have an absolute origin. The programmer specifies a certain location as the load address for that deck. (An absolute origin may also be specified within a relocatable assembly. See the section "Relocation Properties of Symbols.")

In absolute assemblies, output is in the standard 22-word-per-card format, which is specified on the `§BMAP` control card and by the `ABS` pseudo-operation. Output in this format cannot be handled by IBLDR. Whether the assembly is absolute or relocatable is specified by the programmer on the `§BMAP` card (see the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form C28-6275.)

Error Checking

Source programs written in the MAP language are checked for a variety of errors, including format errors, table overflow errors, input/output errors, improper references, and incorrectly coded operations. In addition, the severity of the error is indicated.

In a normal assembly, messages are printed just after the assembly listing. All messages for a given card are printed together, and the card groups are printed in ascending sequence. Correlation with the listing is accomplished by printing the line number, which is assigned by the assembly program, in the left margin of the listing for each card that requires a message.

A list of MAP error messages and an explanation of the severity code used are included in the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form C28-6275.

Forming Symbolic Instructions

Instruction Fields

In the MAP language, each symbolic instruction is punched on a separate standard IBM card. A single

instruction may have as many as five parts, occupying five fields on the card.

THE NAME FIELD

An instruction may be given a symbolic name by the programmer, so that references may be made in other instructions to the named instruction. (Other methods are also available for referring from one instruction to another. For example, see the section "Relative Addressing.")

The use of a name is generally optional. However, some pseudo-operations do require a symbol in the name field. Name-field and other requirements of each of the pseudo-operations are explained in Parts II and III. Also, the specifications for symbols used in the name field are given in the section "Symbols."

The name given to a symbolic instruction is from 1 to 6 characters long, and it occupies columns 1 through 6 on the card.

THE OPERATION FIELD

The machine operation code, pseudo-operation code, programmer macro-operation code, or an operation code previously defined by one of the operation-defining pseudo-operations appears in the operation field.

The operation field is punched beginning in column 8. Column 7 separates the name field from the operational field. Column 7, which is usually left blank, is ignored by the assembly program.

The character asterisk (*) may be used immediately to the right of some operation codes to indicate indirect addressing. Those machine instructions that are indirectly addressable are indicated in Appendix A. If indirect addressing is specified for an instruction in which it is not permitted, the asterisk (*) is ignored and a low-severity error message is issued.

The operation field is usually restricted to a maximum of six characters. However, an operation code of six characters defined by one of the operation-defining pseudo-operations may be followed by an asterisk (*) to indicate indirect addressing.

THE VARIABLE FIELD

The variable field of a symbolic instruction may contain subfields, separated by commas.

In machine instructions, these subfields contain the address, tag, and/or decrement (or count) parts of instruction, depending on the requirements of the particular instruction. These parts of the variable field are supplied in the order: address, tag, decrement.

The subfields that are required, optional, or not permitted in the variable fields of all 7090/7094 machine instructions, extended machine operations, and special operations are indicated in Appendix A.

In pseudo-operations, the subfields of the variable field may contain symbols, symbolic expressions, and literals. The contents of the variable field specified for each of the MAP pseudo-operations is given in Parts II and III.

A null subfield is indicated as being present but as having no value. If a null subfield is at the beginning of the variable field, it is indicated by a single comma. If it is between two other subfields, it is expressed by two consecutive commas. A null subfield at the end of the variable field is represented by a single comma followed by a blank.

If a subfield that is not used in the variable field (an irrelevant subfield) is to be followed by a subfield that is required (a relevant subfield), the irrelevant subfield must be indicated. Irrelevant subfields at the end of the variable field may be indicated as null or may be omitted entirely. For example, the following pairs of instructions are equivalent:

TXH	0,0,1
TXH	,,1
IORP	ALPHA,0,1
IORP	ALPHA,,1
CLA	ALPHA,0
CLA	ALPHA
TXH	ALPHA,0,0
TXH	ALPHA,,
PXA	0,0
PXA	

In the last two pairs, the commas may not be omitted, since the assembly program checks for a minimum number of subfields. The TXH instruction requires three subfields, while the PXA instruction requires two. These subfields are not irrelevant and must be included.

The variable field is separated from the operation field by at least one blank column. The variable field may begin in column 12 but may never begin after column 16. The variable field cannot extend beyond column 72. An instruction having a variable field extending into column 72 may not have a comments field. However, the variable field of most instructions may be extended over more than one card, each having its own comments field, by using the ETC pseudo-operation.

THE COMMENTS FIELD

The comments field is included for the convenience of the programmer and does not affect execution of the program. This field is generally used for explanatory remarks. (See also the section "The Asterisk (*) Remarks Cards.")

A blank precedes the comments field to separate it from the variable field. This field extends through column 72 on the card. If there is a blank variable field, the comments field may begin as soon as column 17. An example of the use of the comments field is shown in Figure 1.

NAME (Location)	OPERATION	VARIABLE FIELD (Address, Tag, Decrement/Count)	COMMENTS
1 6 7 8	14 15 16	20 25 30	35 40 45 50 55 60 65
XINSTRUCTION	REQUIRES	ADDRESS ONLY.	THE THREE EXAMPLES
XBELOW	ARE EQUIVALENT.		
CASE1A	CLA	ALPHA, 0	
CASE2A	CLA	ALPHA,	
CASE3A	CLA	ALPHA	
XINSTRUCTION	REQUIRES TAG ONLY.	MAY BE CODED WITH THE	
XADDRESS	FIELD AN IMPLICIT ZERO.		
CASEB	PAX	, 2	
XINSTRUCTION	REQUIRES ADDRESS AND COUNT.	THE TWO	
XEXAMPLES	BELOW ARE EQUIVALENT.		
CASE1D	VDH	DIV, 0, COUNT	ZERO FIELD EXPLICIT
CASE2D	VDH	DIV, , COUNT	ZERO FIELD IMPLICIT

Figure 1. Example of MAP Coding Shows Use of Comments Field

THE SEQUENCE FIELD

Symbolic instructions may be numbered for identification in the sequence field, which includes columns 73 through 80 on the card.

THE ASTERISK (*) REMARKS CARD

The remarks card is a special source card with an asterisk (*) in column 1 and any desired information in the rest of the card.

Any card with an asterisk in column 1 is treated by the assembly program as a remarks card, and its contents are printed out in the assembly listing. It has no other effect on the assembly.

Remarks cards may be grouped and may appear anywhere in a program except in macro-operations or between ETC cards. They are frequently used at the beginning of a program to state the problem to be solved, to describe the technique used, etc. (MAP also makes a remarks card available by using the pseudo-operation REM, which is described in the section "The REM Pseudo-Operation.")

Examples of remarks cards are shown in Figure 1, as well as methods of coding a variable field.

Symbols

The symbolic names used in the name and variable fields of symbolic instructions consist of one to six non-blank BCD characters (see Appendix E). At least one nonnumeric character must be included, but none of the following ten characters may be used:

- | | | | |
|----|---------------|---|---------------------|
| + | (plus sign) | = | (equal sign) |
| - | (minus sign) | , | (comma) |
| * | (asterisk) | ' | (apostrophe) |
| / | (slash) | (| (left parenthesis) |
| \$ | (dollar sign) |) | (right parenthesis) |

Parentheses in a symbol cause a low-severity warning message to be printed, but assembly is not affected. However, the ()OK option specified on the \$IBMAP

control card (see the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form: C28-6275) indicates that parentheses in symbols are desired, and no message will be printed.

Examples of valid symbols are:

```
A      3.2XY
37B2   DECLOC
DELTA
```

Conversely, the following are *not* valid symbols for the reasons indicated:

```
A+B      (invalid character)
3921     (no nonnumeric characters)
A2B4C6D (more than six characters)
```

Defining Symbols

When a symbol has been assigned a value, it is said to be defined. The assigned value can be the address of a location within core storage, an arbitrary quantity specified by the programmer, or a dependent value assigned by the assembly program. Values are assigned to symbols during and after the first of the two passes made by the assembly program over the source program. Further information about the assembly program is provided in the publication *IBM 7090/7094 Operating System: IJOB Processor*, Form C28-6275.

Ordinary Symbols

Several types of symbols are used in the variable fields of machine instructions and in most of the pseudo-operations.

1. Location symbols are so called because of their appearance in the name field of an instruction. During the first pass of the assembly program, location symbols in the variable field of an instruction are immediately assigned a value called an S-value. The S-value is 1 if the symbol has previously appeared in the name field of an instruction and 0 if it has not. After the first pass has been completed, these symbols are assigned

the value of the address of the instruction in which they appeared as a name-field symbol.

Absolute symbols are location symbols having fixed values that are independent of any relocation of the program segment.

2. Virtual symbols are used in the variable field of an instruction and never appear in any name field. Virtual symbols, which have special functions in MAP, are defined at load time. The S-value is 0. (For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form C28-6275.) Virtual symbols are permitted only in a relocatable assembly. In an absolute assembly, virtual symbols are flagged as undefined.

Immediate Symbols

Immediate symbols are created by using them in the name field of the SET pseudo-operation. Immediate symbols are assigned a value (S-value) during the first pass of the assembly program. Immediate symbols may also be redefined throughout a program by using additional SET pseudo-operations. (See the section "The SET Pseudo-Operation.") The final value of an immediate symbol is used in the second pass.

Relocation Properties of Symbols

An absolute origin may be specified in a relocatable assembly, which should not be confused with an absolute assembly. If an absolute origin is given in a relocatable assembly, any symbols whose definitions depend on that origin are absolute. However, instructions under the absolute origin may refer to symbols elsewhere in the program. The assembly can be returned to the relocatable mode by subsequently specifying a relocatable origin.

Under the following conditions, symbols are absolute even if they appear within a relocatable assembly:

1. Symbols whose values depend on an absolute origin (as a result of using the ORG or BEGIN pseudo-operations)
2. Symbols defined by the BOOL, RBOOL, and LBOOL pseudo-operations
3. Symbols defined by the EQU or SYN pseudo-operations and whose values reduce to a constant
4. Symbols defined by a MAX or MIN pseudo-operation that yield a constant
5. Symbols used in the variable field of type D instructions

Literals

Literals provide a simple means for introducing data words and constants into a program. For example, if a programmer wishes to add the number 1 to the contents of the accumulator, he must have the number 1 at some location in storage.

In contrast to other types of subfields, the contents of a literal subfield is itself the data to be operated on. The appearance of a literal directs the assembly program to prepare a constant equal in value to the content of the literal subfield. The assembly program replaces the subfield of the variable field of the instruction containing the literal with the address of the constant thus generated.

There are three types of literals — decimal, octal, and alphameric.

DECIMAL LITERALS

A decimal literal consists of the character = followed by a decimal data item. Three types of decimal data items are recognized by MAP:

Decimal Integers. A decimal integer is one or more of the digits 0 through 9, and it may be preceded by a plus or minus sign. Maximum size of the decimal integer is $2^{36} - 1$.

Floating-Point Numbers. A floating-point number has two components.

1. The *principal part* is a signed or unsigned decimal number, which may be written with or without a decimal point. The decimal point may appear at the beginning, at the end, or within the decimal number. If an exponent part is present, the decimal point may be omitted, in which case it is assumed to be at the right end of the decimal number. The principal part cannot exceed twenty digits. If it does, the number will be truncated and only the first twenty digits will be used.

2. The *exponent part* consists of the letters E or EE followed by a signed or unsigned decimal integer. (The letters EE indicate a double-precision floating-point number.) The exponent part may be omitted. If the exponent part is used, it must follow the principal part. The exponent part cannot exceed two digits. If it does, it will be truncated and only the first two digits will be used.

A floating-point number is converted to a normalized floating-point binary word. The exponent part, if present, specifies a power of ten, by which the principal part is multiplied during conversion. For example, all of the following floating-point numbers are equivalent and are converted to the same floating-point binary number.

3.14159
31.4159E-1
314159.E-5
314159E-5
.314159E1

The octal representation of this number is

202622077174

Similarly, the number .314159EE1 is converted to a double-precision floating-point number. Its octal representation is

202622077174
147015606335

Fixed-Point Numbers. A fixed-point number has three components.

1. The *principal part* is a signed or unsigned decimal number, which may be written with or without a decimal point. The decimal point may appear at the beginning, at the end, or within the decimal number. If the decimal point is omitted, it is assumed to be at the right end of the decimal number. The principal part cannot exceed twenty digits. If it does, the number will be truncated and only the first twenty digits will be used.

2. The *exponent part* consists of the letters E or EE followed by a signed or unsigned decimal integer. (The letters EE indicate a double-precision fixed-point number.) The exponent part may be omitted. If the exponent part is used, it must follow the principal part. The exponent part cannot exceed two digits. If it does, it will be truncated and only the first two digits will be used.

3. The *binary-place part* consists of the letters B or BB followed by a signed or unsigned decimal integer. (The letters BB indicate a double-precision fixed-point number.) The binary-place part must be present in a fixed-point number and must come after the principal part. If the number has an exponent part, the binary-place part may either precede or follow the exponent part. The binary-place part may not exceed two digits. If it does, the number will be truncated and only the first two digits will be used.

A fixed-point number is converted to a fixed-point binary number that contains an understood binary point. The binary-place part specifies the location of this understood binary point within the word. The number that follows the letters B or BB specifies the number of binary places in the word at the left of the binary point. The sign bit is not counted. Thus, a binary-place part of zero specifies a 35-bit binary fraction. B2 specifies two integral places and 33 fractional places. B35 specifies a binary integer. B2 specifies a binary point located two places to the left of the leftmost bit of the word; that is, the word would contain the low-order 35 bits of a 37-bit binary fraction. As with floating-point numbers, the exponent part, if present, specifies a power of ten, by which the principal part will be multiplied during conversion.

For example, the following fixed-point numbers all specify the same bit configuration, but not all of them specify the same location for the understood binary point:

```
22.5B5
11.25B4
1125E-2B4
9B7E1
```

All of the above fixed-point numbers are converted

to the binary configuration having the octal representation

```
264000000000
```

The following double-precision fixed-point numbers

```
10BB35
1B35EE1
1BB35E1
1BB35EE1
```

are converted to the binary configuration having the octal representation

```
000000000012
000000000000
```

Double-precision literals are stored in consecutive locations. The first or high-order part is automatically stored in an even location relative to the beginning of the Literal Pool. If these literals are to be used as operands in double-precision operations (7094), an EVEN pseudo-operation must be inserted immediately before the LOGC pseudo-operation if there is one; otherwise it must be inserted before the END pseudo-operation.

OCTAL LITERALS

An *octal literal* consists of the two characters =O followed by an octal integer.

An *octal integer* is a string of not more than twelve of the digits 0 through 7, and it may be preceded by a plus or minus sign.

Examples of octal literals are:

```
=O123      000000000123
=O+123     000000000123
=O-123     400000000123
```

ALPHAMERIC LITERALS

An *alphameric literal* consists of the two characters =H followed by exactly six alphameric characters. The six characters following the H are treated as data even if one or more of them is a comma or a blank.

Examples of alphameric literals are:

```
=H12ABCD
=HTADbbb, where b represents a blank
```

Writing Expressions

The programmer writes expressions to represent the subfields of the variable field of symbolic instructions. Expressions are also used in the variable fields of many of the pseudo-operations in accordance with the rules set forth for each specific case.

Expressions are comprised of elements, terms, and operators.

ELEMENTS

An element is the smallest component of an expression and is either a single symbol or a single integer less than 2^{15} . The asterisk (*) may be used as an element representing the location of the instruction in which it appears.

Examples of valid elements are:

A
427
ALPHA

TERMS

A term is a group of one or more elements and the operators * (indicating multiplication) and / (indicating division).

A term consists of one or more elements, with each element separated by an operator. A term must begin and end with an element. Two operators or two elements in succession are never permissible.

Examples of valid terms are:

A A*B
427 C/1409
ALPHA BETA*GAMMA/DELTA

There is no ambiguity between using the asterisk as an element and its use to denote multiplication, since position always makes clear its intended function. For example, a field coded

**B

would be interpreted as "the location of this instruction multiplied by B." Since a term must begin with an element, the first asterisk must be an element. The second asterisk must be an operator, which is required between two elements.

EXPRESSIONS

An expression is a group composed of one or more terms and the operators + (signifying addition) and - (signifying subtraction).

An expression consists of one or more terms, with each term separated by a plus or minus sign. Two operators or two terms in succession are never permissible. However, an expression may begin with a plus or minus sign. Examples of valid expressions are:

A
ALPHA
ALPHA*BETA
-A/B
A*B-C/D+E*2303
*-A+B*C

The asterisk in the last example is used first as an element and then as an operator.

Evaluating Expressions

In evaluating expressions, elements are evaluated first, then individual terms, and finally the complete expression. The following procedure is used in evaluating expressions:

1. Each element is replaced with its numeric value.
2. Each term is evaluated by performing the indicated multiplications and divisions from left to right. In division, the integral part of the quotient is retained and any remainder is discarded immediately. For example, the value of the term $5/2*2$ is 4.

In evaluating a term, division by zero is the same as division by one and results in the original dividend. Division by zero is not regarded as an error.

3. Terms are combined from left to right in the order in which they occur, with all intermediate results retained as 35-bit signed numbers.

4. Finally, if the result is negative, it is complemented; in either case, only the rightmost 15 bits are retained.

Grouping of terms by parentheses or any other means is not permitted. However, a product such as $A(B-C)$ can be written simply $A*B-A*C$.

The expression ** may be used to designate a field the value of which is to be computed and inserted by the program. It is an absolute expression having a value of zero.

Rules for Forming Expressions

The use of expressions is sometimes affected by whether elements within the expression are relocatable, absolute, or a combination of both.

In a relocatable assembly, an expression that contains more than one symbol is generally complex. An expression that includes a control-section name is also complex. In addition, any expression that contains a complex element is itself complex.

In an absolute assembly, all expressions are absolute.

Relocatable and complex expressions are usually evaluated at load time, when absolute values have been assigned to symbols as part of the loading process. However, in pseudo-operations that affect location counters (such as BES, BSS, and BEGIN) or that define symbols (such as MAX and MIN), the variable field must be evaluated before load time. For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IJOB Processor*, Form C28-6275. The rules that must be followed in using expressions are provided in the discussions of the pseudo-operations.

Boolean Expressions

A Boolean expression is evaluated as an 18-bit Boolean quantity, unlike the 15-bit integer that normally results from the evaluation of an expression. Elements within a Boolean expression must be constant. All integers are specified as octal integers. An expression is Boolean if:

1. It appears in the variable field of a Boolean pseudo-operation (BOOL, RBOOL, LBOOL; see the section "Boolean Pseudo-Operations");
2. It appears as an octal subfield of a vFD pseudo-operation (see the section "The vFD Pseudo-Operation"); or
3. It forms the variable field of a Type D or extended Type D machine instruction (see Appendix A).

References to a relocatable symbol in a Boolean expression result in an error.

In a Boolean expression, the four operators (+, -, *, /) have Boolean rather than arithmetic meanings, as shown in the table.

OPERATOR	MEANING	DEFINITION
+	“inclusive or” (also, “union”)	0+0=0 0+1=1 1+0=1 1+1=1
-	“exclusive or” (also, “symmetric difference”)	0-0=0 0-1=1 1-0=1 1-1=0
*	“and” (also, “intersection”)	0*0=0 0*1=0 1*0=0 1*1=1
/	“complement” (also, “not” or “ones’ complement”)	/0=1 /1=0

The four Boolean operations are defined in the table for 1-bit quantities. The operation is extended to 18-bit quantities by handling each bit position independently.

The following conventions also apply in using Boolean expressions:

The / is a unary or one-term operator. The expression A/B means /B, and the A is ignored. However, the presence of the A is not regarded as an error by the assembly program. The definitions of / in this case are:

0/0=1
0/1=0
1/0=1
1/1=0

If the other operators (+, -, *) are used as unary operators, the definitions are as follows:

+A=A+=A
-A=0-A, A-=A-0
A=error, A=A*0=0

For the special case of the slash, the definition is:

A/A/0=1

In expressions where both terms are missing, definitions are as follows:

+ = 0+0 = 000000
- = 0-0 = 000000
* = Location counter
/ = 0/0 = 777777

In evaluating a Boolean expression, all integers are treated as 18-bit quantities. The operation / is performed first, followed by *, then by + and -.

The operators +, -, and * may immediately precede the slash in a Boolean expression. For example,

A-/B

is a valid Boolean expression. However, in no other case are two operators or two elements in succession permitted.

Using Symbols in Expressions

In MAP, ordinary symbols are not assigned values until a pass over the entire program has been completed. Therefore, there are no restrictions in the order of symbol definition. For example,

```

      ORG      A
      EQU     10000
  A

```

is a valid sequence in IBMAP.

Symbols in the variable field of pseudo-operations that affect location counters must be definable at assembly time. In the sequence

```

      BEGIN   ,A
      BSS     B
      BES     C

```

A, B, and C may not be virtual symbols. (The org pseudo-operation is not subject to this restriction.) The values of symbols B and C are always treated as constant.

In general, any valid expression may appear in the variable field of machine instructions. In a relocatable assembly, final evaluation of complex arithmetic expressions containing virtual symbols actually takes place at load time, when all symbols have been defined.

Relative Addressing

After an instruction has been named by the presence of a symbol in the name field, references to that instruction can be made in other instructions by using the symbol. Instructions preceding or following the named instruction can also be referenced by indicating their position relative to the named instruction. This procedure is called relative addressing. A relative address is, effectively, a type of expression. For example, in the sequence

```

      ALPHA   TRA      BETA
              CLA      GAMMA
              SUB      DELTA
      STGAM   STO      GAMMA
              TPL      LOCI

```

control may be transferred to the instruction CLA GAMMA by either of the following instructions:

```

      TRA     ALPHA+1
      TRA     STGAM-2

```

It is also possible to use the asterisk (*) as an element in a relative address. For example, in the sequence

```

      LOOP    AXT      10,1
              CLA      A,1
              SUB      B,1
              SUB      C,1
              STO      SUM,1
              TIX      LOOP,1,1

```

the last instruction indicates a conditional transfer to location LOOP. This could also be written

```

      TIX     *-4,1,1

```

The address $*-4$ is interpreted as “the location of this instruction minus 4.”

Relative addressing must be used carefully in combination with pseudo-operations, since some pseudo-operations may generate more than one word or no words in the object program. For example, the instruction

```
ALPHA      OCT      2732,427,12716
generates three words of octal data, with ALPHA assigned to the address of the first word generated. Thus
```

the address $ALPHA+2$ refers to the third word generated (12716).

Reference can also be made to a word in a block of storage reserved by a BSS or BES pseudo-operation by using relative addressing. For example, the instruction

```
BETA      BSS      50
reserves a block of 50 words, where BETA is assigned to the first word of the block. The address  $BETA+1$  refers to the second word, and  $BETA+n$  refers to the  $(n+1)$ st word.
```

Part II. MAP Pseudo-Operations

MAP provides the programmer with more than sixty pseudo-operations that can perform a variety of programming functions with greatly reduced programming effort. They have been grouped according to function, and the structure and purpose of most of the MAP pseudo-operations are described in this part of the publication. The macro-operation facility is covered separately in Part III.

Location-Counter Pseudo-Operations

Location counters enable instructions that are written in one sequence to be loaded in a different sequence. MAP enables a programmer to establish an indefinite number of location counters, which can be represented by symbols of his choice. The symbol used to represent a location counter may duplicate any other symbol in the program except another location-counter symbol.

The blank location counter, so called because it has no associated symbol, is the basic location counter. If the USE pseudo-operation is not used, instructions are assembled under the blank location counter. In addition, a location counter represented by two slashes (//) is reserved for use with blank COMMON.

The USE Pseudo-Operation

The USE pseudo-operation places succeeding instructions under control of the location counter represented by the symbol in the variable field. The format of the USE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	USE	Either: 1. A signal symbol, or 2. Blanks, or 3. The word PREVIOUS

The location counter in control at the time of the USE pseudo-operation is suspended at its current value. It is temporarily preserved as the "previous" counter. It continues from this value if it is reactivated by another USE. If USE with the word PREVIOUS in the variable field is coded, the previous location counter is reactivated. For example, the effect of the sequence

```
USE      A
USE      B
USE      PREVIOUS
```

is identical to that of

```
USE      A
USE      B
USE      A
```

This option provides a means of returning to a location counter even if the counter symbol is not known.

A USE pseudo-operation with a blank variable field must precede the first instruction of the deck if the blank counter is set to a value other than zero by the operation

```
BEGIN      ,expression
```

The sequence of location counters is: the blank counter first, the other symbolic counters in the order of their first appearance in a USE or BEGIN pseudo-operation, and finally the // counter.

The BEGIN Pseudo-Operation

The BEGIN pseudo-operation specifies a location counter and establishes its initial value. The format of the BEGIN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	BEGIN	Two subfields, separated by a comma: 1. A location counter symbol, 2. Any expression

The expression in the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The value of the second subfield of the variable field is used as the initial value for the location counter represented by the symbol in the first subfield. For example, the instruction

```
BEGIN      ALPHA,BETA
```

would cause the instructions following

```
USE      ALPHA
```

to be assembled beginning at location BETA.

If no BEGIN is given for the blank location counter, its initial value is defined as 0 (absolute 0 in an absolute assembly and relative 0 in a relocatable assembly). If no BEGIN is given for the n th location counter (taken in location counter order), its initial value is given as the last value by the $(n-1)$ st location counter. If more than one BEGIN appears for a given location counter, only the first one is used and all others cause error messages to be issued.

A `BEGIN` may appear anywhere in the program regardless of the location counter in control.

Note that if the blank location counter is set to a value other than zero by the operation

```
BEGIN      ,expression
```

the `USE` pseudo-operation with a blank variable field must precede the first instruction of the deck.

The order in which location counters are used is illustrated in the example:

```
instruction 1
BEGIN      A,*
USE        A
instruction 2
instruction 3
BEGIN      C,*
instruction 4
instruction 5
USE        //
instruction 6
instruction 7
USE        B
instruction 8
instruction 9
USE        C
instruction 10
END
```

In this sequence, instruction counters are used in the order: blank, A, C, B, and //. At load time, the sequence of instructions will be:

```
instruction 1
instruction 2
instruction 3
instruction 10 (instruction 4 will be
                overlaid)
instruction 5
instruction 8
instruction 9
instruction 6
instruction 7
```

The `ORG` Pseudo-Operation

The `ORG` (Origin) pseudo-operation redefines the value of the current location counter. The format of the `ORG` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	<code>ORG</code>	Any expression

The `ORG` pseudo-operation causes the current location counter to be reset to the value of the variable field. If there is a symbol in the name field, it is given this value.

Absolute origins are permitted in a relocatable assembly. An origin is treated as absolute if the value of the variable field of the `ORG` pseudo-operation is constant. Thus,

```
ORG      5000
```

sets the location counter to 5000. In a relocatable assembly, references to symbols under the control of an absolute origin (`ORG` or `BEGIN`) are absolute.

For example, the location counter is set at the sixth location of the program by

```
ORG      START+5
```

where `START` is the first location of the program.

Storage-Allocation Pseudo-Operations

The storage-allocation pseudo-operations reserve core storage areas within the sequence of the program.

The `BSS` Pseudo-Operation

The `BSS` (Block Started by Symbol) pseudo-operation reserves a block of consecutive storage locations. The format of the `BSS` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	<code>BSS</code>	Any expression

The `BSS` pseudo-operation increases the value of the current location counter by the defined value of the variable field expression. The expression in the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero. If there is a symbol in the name field, its defined value is that of the location counter just before the increase.

For example, in the sequence

```
ALPHA      IORD      BETA,,4
BETA       BSS       4
GAMMA      IORD      DELTA,,6
```

if `ALPHA` has been assigned to location 1001, `BETA` will be assigned to location 1002 and `GAMMA` to location 1006. Thus, four locations are reserved for `BETA`.

The area reserved by the `BSS` pseudo-operation is not zeroed.

The `BES` Pseudo-Operation

The `BES` (Block Ended by Symbol) pseudo-operation also reserves a block of consecutive storage locations. The format of the `BES` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	<code>BES</code>	Any expression

The expression in the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The `BES` pseudo-operation functions almost identically to a `BSS` pseudo-operation except that the symbol

in the name field is defined after the location counter increases and thus refers to the first word following the reserved block.

For example, in the sequence

```
ALPHA    IORD    BETA,,4
BETA     BES     4
GAMMA    IORD    DELTA,,4
```

if ALPHA has been assigned to location 1001, both BETA and GAMMA will be assigned to location 1006 and four locations will be reserved.

The difference between BES and BSS can be seen in the sequence of instructions

```
ALPHA    BES     25
          CLA     BETA
```

which is effectively the same as

```
ALPHA    BSS     25
          CLA     BETA
```

The area reserved by the BES pseudo-operation is not zeroed.

The EVEN Pseudo-Operation

The EVEN pseudo-operation forces the current location counter to an even value to ensure an even address for the next instruction or data—usually a double-precision floating-point number. It is used only in the 7094 and has no effect in the 7090 or 7094 II. The format of the EVEN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	EVEN	Ignored

In a 7094 relocatable assembly, the EVEN pseudo-operation causes the instruction

```
AXT     0,0
```

to be inserted at load time if the load address of the AXT instruction is not even. The AXT instruction has no other effect on the program.

In a 7094 absolute assembly, the EVEN pseudo-operation causes the insertion of the instruction

```
AXT     0,0
```

at assembly time so that it is available at load time in the event that the AXT instruction load address is not even. The AXT instruction has no other effect on the program.

The LORG Pseudo-Operation

The LORG (Literal Pool Origin) pseudo-operation places the Literal Pool in the program at the point where LORG occurs. The format of the LORG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LOGR	Ignored

A symbol in the name field is assigned to the first location of the Literal Pool (see the section "Literals"). If no LORG is given, the Literal Pool origin is one beyond the final value of the location counter in use at the end of the program. If more than one location counter has been used, LORG can be used to prevent the Literal Pool from overlapping part of the program. For example, in the sequence

```
          USE     Y
A         BSS     1
          USE     X
B         CLA     =1
          USE     Y
          END
```

the Literal Pool would be placed at symbolic location B (one beyond the final value of location counter Y).

If more than one LORG is given, only the first is effective. If the // location counter is used, caution must be used in locating the Literal Pool.

An EVEN pseudo-operation should precede LORG if double-precision literals are used in 7094 programs to ensure their entry at an even address.

The LDIR Pseudo-Operation

The LDIR (Linkage Director) pseudo-operation places the Linkage Director in the program at the point of the LDIR. The format of the LDIR pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LDIR	Ignored

The Linkage Director is a unique location for each assembly, which is one beyond the final value of the location counter if the LDIR pseudo-operation is not used. If the LDIR pseudo-operation is used with a symbol in the name field, the programmer may refer to the Linkage Director.

The Linkage Director serves as a cross-reference for the CALL and SAVE pseudo-operations. If neither the LDIR nor LORG pseudo-operations is used, the Linkage Director precedes the Literal Pool. If the LDIR pseudo-operation appears more than once, only its first appearance is effective.

For example,

```
ALPHA    LDIR
```

would cause

```
ALPHA    PZE
          BCI     1,deckname
```

to be generated. The second subfield in the BCI operation is the deckname specified on the \$IBMAP card (see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6275).

The COMMON Pseudo-Operation

The COMMON pseudo-operation has been preserved solely for compatibility with existing programs. It reserves an area called blank COMMON for use in common with such programs. The format of the COMMON pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	COMMON	Any expression

The expression in the variable field may contain any symbol or constant. Relocatable symbols are given their assembly value, and this value becomes absolute. Control-section symbols are given a value of zero.

The COMMON operation causes:

1. Location counter // to be activated
2. A symbol in the name field, if any, to be defined as having the current value of location counter //
3. Location counter // to be increased by the defined value of the variable field expression
4. The location counter in use prior to the COMMON operation to be reactivated

The effect of the sequence

```
A          COMMON E
```

is equivalent to

```
A          USE      //
           BSS      E
           USE      PREVIOUS
```

Data-Generating Pseudo-Operations

Five pseudo-operations (OCT, DEC, BCI, LIT, and VFD) provide the programmer with a convenient means of introducing data expressed in a variety of forms into a program during assembly. Numbers introduced by these operations are often referred to as constants. A sixth pseudo-operation, DUP, permits a sequence of symbolic cards to be duplicated a specified number of times.

The OCT Pseudo-Operation

The OCT (Octal Data) pseudo-operation introduces binary data expressed in octal form into a program. The format of the OCT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OCT	1. One or more octal integers, separated by commas, or 2. Blanks

Each subfield in the variable field contains a signed or an unsigned octal integer of n digits, where $n \leq 12$.

The only limit on the number of subfields is that they must all be contained in the variable field of one card.

A blank variable field results in a word of all zeros.

The OCT operation converts each subfield to a binary word. These words are assigned to successively higher storage locations as the variable field is processed from left to right. If a symbol is used in the name field, it is assigned to the first word of data generated.

For example, each of the instructions

```
ALPHA      OCT      777777777777
ALPHA      OCT      -777777777777
ALPHA      OCT      -377777777777
```

would result in a binary word of 36 consecutive ones at location ALPHA.

In the instruction,

```
ALPHA      OCT      43,25,64
```

the binary equivalent of octal number 43 would appear at location ALPHA, the binary equivalent of 25 at location ALPHA+1, and the binary equivalent of 64 at ALPHA+2.

The DEC Pseudo-Operation

The DEC (Decimal Data) pseudo-operation introduces data expressed as decimal numbers into a program. The format of the DEC pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	DEC	1. One or more decimal data items, separated by commas, or 2. Blanks

The only limit on the number of subfields is that they must all be contained in the variable field of one card.

A blank variable field results in a word of all zeros.

The DEC operation converts each subfield to one or two binary words, depending on whether the decimal data item is single or double precision. These words are stored in successively higher storage locations as the variable field is processed from left to right. A symbol used in the name field is assigned to the first word of data generated.

For example, the instruction

```
ALPHA      DEC      43,25
```

would result in the binary equivalent of decimal number 43 appearing at location ALPHA and of decimal number 25 appearing at location ALPHA+1.

The BCI Pseudo-Operation

The BCI (Binary Coded Information) pseudo-operation introduces binary-coded decimal data into a program. Each data word generated consists of six 6-bit char-

The data item in a symbolic subfield is converted as a symbolic expression. Decimal integers must not exceed 32767.

The data item in an octal subfield may be any valid Boolean expression. A single signed or unsigned octal integer is a valid Boolean expression, which, in this case, may exceed 18 bits.

The data item in an alphameric subfield may consist of any combination of characters other than a comma or a blank. Each character is converted to its 6-bit binary code equivalent. If the converted data item occupies more than n bits, only the rightmost n bits are used. If the converted data item occupies fewer than n bits, sufficient 6-bit groups of the form 110000 (the BCD code for blank) are placed at the left of the converted data item to form an n -bit binary number. If n is not a multiple of 6, the leftmost character or blank is truncated. None of these conditions is regarded as an assembly error.

For example, the VFD pseudo-operation could be used to break up a 36-bit word as follows: Positions S and 1 through 9 must contain the binary equivalent of the decimal integer 895, positions 10 through 14 must contain the binary equivalent of the octal integer 37, positions 15 through 20 must contain the binary equivalent of the character C, and positions 21 through 35 must contain the value of the symbol ALPHA. The instruction to generate this word is

VFD 10/895,O5/37,H6/C,15/ALPHA

The LIT Pseudo-Operation

The LIT (Literal) pseudo-operation places data items from the subfields of the variable field into the Literal Pool in successively higher storage locations.

The format of the LIT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LIT	Data subfields, separated by commas

Rules for the contents of the data subfields are the same as those governing literals except that the equal sign (=) is omitted.

A Literal Pool entry made using a LIT pseudo-operation is assumed to be double precision if the variable field generates only two consecutive words of data. If a double-precision entry is made in the Literal Pool by either a LIT pseudo-operation or a double-precision literal, the number is placed in an even location relative to the beginning of the Literal Pool. (In this respect, the assembly program does not distinguish double-precision floating-point numbers from double-precision fixed-point numbers.)

For example,

LIT 1,2

causes the number 1 to be placed in an even location relative to the beginning of the Literal Pool (which can result in duplicate entries in the Literal Pool).

The instruction

LIT 1EE1

results in a double-precision entry beginning in an even location in the Literal Pool, but the instruction

LIT 1EE1,2

results in a three-word entry with the first word not necessarily entered into an even location.

Thus, double-precision floating-point numbers may be used as constants if an EVEN pseudo-operation is used immediately preceding the LORG operation or, if no LORG is present, immediately before the END pseudo-operation.

The DUP Pseudo-Operation

The DUP (Duplicate) pseudo-operation causes an instruction or sequence of instructions to be duplicated. An important application is in generating tables. The format of the DUP pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	DUP	Two subfields, separated by a comma: 1. An expression 2. An expression

The first subfield represents instruction count, and the second subfield represents iteration count. Integers are generally used in these subfields. Symbols in the instruction count and iteration count subfields are evaluated for their S-values.

If m represents instruction count and n represents iteration count, the DUP pseudo-operation has the effect of duplicating the next m instructions n times.

The group of m instructions following the DUP establish the range of the DUP. The effect of the DUP pseudo-operation is that the set of m symbolic cards making up the range is copied $n-1$ times and placed in the symbolic deck behind the original set. (The name field of the symbolic card is duplicated.) An iteration count of zero causes the entire range to be omitted.

For example, the sequence

DUP 2,3
PZE X
PZE Y

results in the sequence

PZE X
PZE Y
PZE X
PZE Y
PZE X
PZE Y

With the sole exception of the END pseudo-operation, any operation may appear within the range of a DUP, including another DUP.

If a DUP pseudo-operation occurs within the range of a preceding DUP, the two (or more) DUP pseudo-operations are said to be nested. As in most cases of nesting, the effect of nested DUP pseudo-operations must be determined beginning with the innermost one and working out. If the explicit range (the instruction count) of the inner DUP extends beyond the range of an outer DUP, the implicit range of the outer DUP is extended to the farthest point covered by the inner DUP. The first card to be processed after such a series of DUP pseudo-operations is the next card beyond both explicit and implicit DUP ranges.

For example, the operation

```
DUP      m,n
```

duplicates the effect of the next *m* cards *n* times.

In the nested DUP pseudo-operations in the sequence

```
DUP      1,2
DUP      1,2
PZE      X
PZE      Z
```

the single card to be duplicated by the outer DUP is the inner DUP, and the effect of the inner DUP is actually the two operations

```
PZE      X
PZE      X
```

The sequence generated when the outer DUP is expanded is

```
PZE      X
PZE      X
PZE      X
PZE      X
PZE      Z
```

where the last card in the sequence is the first card beyond both the explicit and implicit ranges of the outer DUP.

In the sequence

```
DUP      3,2
DUP      1,2
PZE      X
PZE      Y
PZE      Z
```

the effect of the three cards following the outer DUP is actually the four operations

```
PZE      X
PZE      X
PZE      X
PZE      Y
```

When the outer DUP is expanded, the resulting sequence is

```
PZE      X
PZE      X
PZE      X
PZE      Y
PZE      X
PZE      X
```

```
PZE      X
PZE      Y
PZE      Z
```

where the last symbolic card is the first card beyond the explicit range of the outer DUP.

The range of a DUP that occurs within the range of another DUP must be fixed before the *outer* DUP is encountered. This can be done by using the SET pseudo-operation. (See the section "The SET Pseudo-Operation.") For example, the sequence

```
K        SET      1
          DUP      2,2
K        SET      K+1
          DUP      K,n
```

will result in an error message and assembly will be terminated. However, the iteration count may be variable. For example, the sequence

```
K        SET      1
          DUP      2,2
K        SET      K+1
          DUP      m,K
```

is valid and will be assembled correctly. For example, the sequence

```
K        SET      1
          DUP      2,2
K        SET      K+1
          DUP      3,K
          PZE      X
          PZE      Y
          PZE      Z
```

would result in

```
PZE      X
PZE      Y
PZE      Z
PZE      X
PZE      Y
PZE      Z
PZE      X
PZE      Y
PZE      Z
PZE      X
PZE      Y
PZE      Z
PZE      X
PZE      Y
PZE      Z
PZE      X
PZE      Y
PZE      Z
```

Symbol-Defining Pseudo-Operations

MAP provides a group of pseudo-operations specifically designed to define the symbols that appear in their name fields. They are useful in a variety of programming applications, such as equating symbols to combine separately written program segments or changing parameters referred to symbolically throughout a program by redefining the symbol.

The EQU and SYN Pseudo-Operations

The EQU and SYN pseudo-operations are identical. The format of the EQU and SYN pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	EQU or SYN	Any expression

The EQU and SYN pseudo-operations give the name field symbol the same definition – and the same structure – as the variable field expression. Thus, if A is defined as $x+y-z$ and the instruction

```
B          EQU      A
```

is given, B is also defined as $x+y-z$.

The instruction

```
LCS          EQU      *
```

defines LCS as having the current value of the location counter.

The NULL Pseudo-Operation

The format of the NULL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	NULL	Ignored

The NULL pseudo-operation defines the symbol in the name field, if any, as having the current value of the location counter. The operation

```
LCS          NULL
```

is equivalent to

```
LCS          EQU      *
```

except that NULL is preferred.

The MAX Pseudo-Operation

The MAX pseudo-operation gives the symbol in the name field an absolute value equal to the expression in the variable field that has the maximum defined value. The format of the MAX pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	MAX	Expressions, separated by commas

The maximum value is computed as if all symbols were absolute. The comparison is made after negative values have been complemented. For example, the sequence

```
A          BSS      A
ALPHA      MAX      100,ALPHA,ALPHA-100
ALPHA      EQU      150
```

is equivalent to

```
BSS      150
```

The MIN Pseudo-Operation

The effect of the MIN pseudo-operation is opposite to that of MAX. The symbol in the name field is given an absolute value equal to the expression in the variable

field having the minimum defined value. The format of the MIN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	MIN	Expressions, separated by commas

The minimum value is computed as if all symbols were absolute. The comparison is made after negative values have been complemented. For example, the sequence

```
A          BSS      A
ALPHA      MIN      100,ALPHA,ALPHA-100
ALPHA      EQU      150
```

is equivalent to

```
BSS      50
```

The SET Pseudo-Operation

The SET pseudo-operation causes the symbol in the name field to be defined immediately. The SET pseudo-operation, which can be used to define symbols in both machine instructions and pseudo-operations, is often used to define the symbols in the variable fields of the DUP, VFD, IFT, and IFF pseudo-operations. The format of the SET pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SET	Any expression

Qualified symbols may not be used in the variable field.

The symbol in the name field is immediately assigned the value (called the S-value) of the variable field expression during the first pass of the assembly program. Thus, the SET pseudo-operation enables the programmer to use sequences of instructions in which decisions depend on the value assigned to a symbol during the first pass of the assembly program. It also permits symbols to be redefined repetitively. The value assigned to the symbol is always a 15-bit integer.

Use of the SET pseudo-operation is subject to the following conditions:

1. Immediate symbols may not be qualified.
2. An immediate symbol used in the variable field of a pseudo-operation affecting location counters (such as BSS) assumes the final value assigned to it in the program. For example, the sequence

```
A          SET      100
          BSS      A
A          SET      1000
          END
```

is equivalent to

```
BSS      1000
```

3. An immediate symbol should not normally be given a name identical to an ordinary symbol, since doing so can result in multiple definition.

An example of the use of the SET pseudo-operation to assign a value to a symbol during the first pass of the assembly program is shown in the following sequence.

```
ALPHA      SET      50
           VFD      ALPHA/BETA
```

By using the SET pseudo-operation, the value of ALPHA can be changed without altering the VFD instruction. A similar use of immediate symbols is in making conditional assembly decisions with the IFF/IFT pseudo-operations.

The SET pseudo-operation permits a symbol to be redefined repeatedly for such programming functions as constructing tables and writing macro-operations. For example, in the sequence

```
ALPHA      SET      1
           DUP      2,9
           PZE      ALPHA
ALPHA      SET      ALPHA+1
```

ALPHA is first assigned a value of 1 and then redefined nine times with its value incremented by 1 at each iteration.

Boolean Pseudo-Operations

The Boolean pseudo-operations define symbols as Boolean quantities.

The BOOL Pseudo-Operation

The BOOL (Undesignated Boolean) pseudo-operation functions like the EQU pseudo-operation except that the variable field expression is Boolean and the name field symbol becomes a Boolean symbol. The format of the BOOL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	BOOL	A Boolean expression

BOOL defines the symbol in the name field as an 18-bit constant. Relocatable symbols or virtual symbols used in the variable field result in an error. Octal integers in the variable field may not exceed six characters.

The RBOOL and LBOOL Pseudo-Operations

The format of the RBOOL (Right Boolean) and LBOOL (Left Boolean) pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	RBOOL or LBOOL	A Boolean expression

Relocatable symbols or virtual symbols used in the variable field result in an error. Octal integers in the variable field may not exceed six characters.

These pseudo-operations are similar to BOOL except that the symbol in the name field is defined as right (left) Boolean. They are normally used to determine the correct machine operation for the special type D instructions (SIB, BNT, BFT, IIB, and RIB). The following mechanism is used.

1. If the expression in the variable field of an SIB instruction is entirely left (right) Boolean, the instruction is assembled as SIL (SIR). Constants are considered to be both left and right Boolean. If the expression is a mixture of both left and right Boolean, SIL is assembled but a warning message is issued.

2. If the variable field of an SIL (SIR) instruction is not purely left (right) Boolean, left (right) and undesignated Boolean, or purely undesignated Boolean, a warning message is issued.

For example, following the instructions

```
X          LBOOL   123
Y          RBOOL   456
Z          RBOOL   321
```

the instruction

```
BFT      X      assembles as LFT 123
BNT      Y      assembles as RNT 456
IIB      Z      assembles as IIR 321
RIB      Y+Z    assembles as RIR 777
SIB      Y+Z    assembles as SIL 323
```

A warning message is issued for the last instruction (SIB) because of the mixture of left and right Boolean.

Conditional-Assembly Pseudo-Operations

Two pseudo-operations provided by MAP enable the programmer to specify that the next instruction is to be assembled only if certain criteria are met.

The IFT and IFF Pseudo-Operations

The IFT (If True) and IFF (If False) pseudo-operations specify conditions that determine whether the next sequential instruction will be assembled. The format of the IFT and IFF pseudo-operations is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	IFT or IFF	1. element—relational operator—element 2. If present, either of the words OR or AND, preceded by a comma

The IFT (IFF) pseudo-operation assembles the next instruction if the condition expressed by the operation and the first subfield is met.

A relational operator consists of one or two adjacent symbols signifying:

```
=      Equals
= +    Greater than
= -    Less than
```

The elements at the left and right of these relations must not be qualified. The element is used in one of two ways:

1. To represent a numerical value equal to its S-value
2. To represent literal BCD information, in which case it is surrounded by slash (/) marks

Interpretation of the relational operator depends on the context. If the elements represent BCD, the relation is a scientific collating sequence comparison. For example,

```
IFT      /A/=+/B/
```

is false and would therefore not permit assembly of the next instruction. However,

```
IFT      /A/=-/B/
```

is true and would permit assembly of the next instruction.

Also,

```
IFF      //=/A/
```

compares blank to A and would permit assembly of the next instruction.

If the elements represent a numeric quantity, the relation is a numeric comparison. The programmer must avoid noncomparable elements.

Presence of the second subfield signifies that another IFT or IFF is to follow, in which case the combined effect of the two is either a logical OR or a logical AND.

The S-value and not the definition is used in numeric evaluation of symbols. The SET pseudo-operation may be used to control IFF or IFT pseudo-operations, as in the sequence

```
K          SET      4
           IFT      K=4
```

This statement is true, and the next instruction will be assembled.

The fact that the conditional assembly extends over only one instruction is not a serious restriction, since the following instruction may be either another IFT or IFF pseudo-operation or a macro-operation that expands to any length (see the section "Conditional Assembly in Macro-Operations").

The variable field of an IFF or IFT pseudo-operation may not be extended by using the ETC pseudo-operation.

Symbol-Qualifying Pseudo-Operations

MAP provides two pseudo-operations, QUAL and ENDQ, that enable a programmer to qualify symbols within sections of a program.

The QUAL Pseudo-Operation

All symbols between the QUAL pseudo-operation and its associated ENDQ pseudo-operation are qualified. The format of the QUAL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	QUAL	Symbol

The symbol in the variable field qualifies all symbols defined within the section controlled by the QUAL pseudo-operation. References to a symbol defined in a qualified section from within the same section need not be qualified. References from outside the section are qualified by placing the section symbol (variable field symbol of the QUAL pseudo-operation) in front of a connecting dollar sign followed by the desired symbol. For example, the symbol QS*ALPHA refers to symbol ALPHA defined in qualified section QS. The notation \$BETA refers to symbol BETA, which is not qualified. The unqualified section effectively has a blank qualifier.

Qualified sections may be nested to provide multiple qualification. The range (from a QUAL to its corresponding ENDQ) of a lower-level QUAL must fall completely within the range of the next higher QUAL. A symbol is automatically qualified by any qualifiers of a higher level than the highest one specified in using the symbol. A multiply qualified symbol can be referenced without using all the qualifiers if enough qualifiers are given to determine the symbol uniquely. In any case, the qualifiers must be specified in the same order that nesting occurs within that section.

A sequence illustrating qualification is

```
A          QUAL      H
           BSS        1
           CLA        X
           ENDQ       H
A          QUAL      J
           BSS        1
           ENDQ       J
```

} Qualified Section H
} Qualified Section J

In this case, if X is written as A or H\$A, it refers to the first definition of A; X written as J\$A refers to the second definition of A.

In the sequence of nested qualification

```
A          QUAL      M
           BSS        1
           QUAL      N
           CLA        X
           ENDQ       N
           ENDQ       M
A          BSS        1
           CLA        Y
```

} Qualified Section M\$N } Qualified Section M
} Qualified Section N

X written as A refers to the first definition of A; X written as \$A refers to the second nonqualified A.

Y written as A refers to the second A; Y written as M\$A refers to the first A.

In the more complicated sequence

```
A          QUAL      ONE
           BSS        1
           QUAL      TWO
A          BSS        1
           CLA        X
           ENDQ       TWO
           CLA        Y
           ENDQ       ONE
```

} Qualified Section ONE\$TWO } Qualified Section ONE
} Qualified Section TWO

```

A      QUAL  THREE
      BSS   1
A      QUAL  TWO  } Qualified
      BSS   1      } Section
      ENDQ  TWO  } THREE$TWO }
      ENDQ  THREE }

```

X refers to the first A by `ONE$A`; to the second A by `A`, by `TWO$A`, or by `ONE$TWO$A`; to the third A by `THREE$A`; and to the fourth A by `THREETWOA`.

Y refers to the first A by `A` or by `ONE$A`; to the second A by `TWO$A` or by `ONE$TWO$A`; to the third A by `THREE$A`; and to the fourth A by `THREETWOA`. In this sequence, the two sections `TWO` are distinct and not separate parts of the same section. The first is section `ONE$TWO`, and the second is section `THREE$TWO`.

The ENDQ Pseudo-Operation

The format of the `ENDQ` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ENDQ	Either: 1. A symbol, or 2. Blanks

`ENDQ` delimits the range of the qualified section whose symbol is in the variable field of this instruction. If the variable field is blank, the innermost qualified section is terminated. However, a low-severity warning message is issued, since a variable field inadvertently left blank can result in errors when using nested qualification.

In nested qualified sections, a separate `ENDQ` is required to terminate each qualified section. Also, qualified sections must be terminated in order beginning with the lowest level section as shown in the following sequence, or an error message will be issued.

```

      QUAL  ALPHA
      .
      .
      QUAL  BETA
      .
      .
      QUAL  GAMMA
      .
      .
      ENDQ  GAMMA
      .
      .
      ENDQ  BETA
      .
      .
      ENDQ  ALPHA

```

Control-Section Pseudo-Operations

Relocatable programs can be divided into segments. By dividing large programs into relocatable segments,

individual segments can be coded and checked in parallel, with consequent savings in time. Also, a segment can be modified without requiring reassembly of the entire program.

The control-section pseudo-operations provide the means for making references to and from such segments. `IBLDR` makes the cross-references among program segments that are assembled separately but loaded together. (For further information, see the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6275.)

Each program segment is a control section. In addition, sections within segments may be designated as control sections by the programmer.

`IBLDR` treats control sections as being variable. A control section may be replaced by another control section or even deleted entirely. If more than one control section is given the same designation, generally only the first control section is retained.

The CONTRL Pseudo-Operation

The `CONTRL` pseudo-operation designates a program or a part of a program as a control section. The format of the `CONTRL` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	CONTRL	One of the following: 1. A location counter symbol, or 2. A qualification symbol, or 3. Two subfields, separated by a comma, each containing an ordinary symbol

The `CONTRL` pseudo-operation delimits the control section named in the name field in accordance with the contents of the variable field. If a location-counter symbol is used in the variable field, all instructions under control of the specified location counter are delimited. The blank location counter cannot be used as a control section. If a qualification symbol is used, all instructions between the specified `QUAL` pseudo-operation and its associated `ENDQ` pseudo-operation are delimited. If two subfields are used, all instructions are delimited beginning at the location specified by the first symbol and ending at, but not including, the location specified by the second symbol.

If there is no symbol in the name field, the first symbol in the variable field is taken as the external name of the control section and a low-severity message is issued. The length of a control section is always the difference between the value of the location counter in control at the end of the section and its value at the beginning of the section. Hence, the use of `ORG` or `USE` pseudo-operations within control sections may result in incorrect length calculations, in effect, "losing" in-

structions from the section. The `CONTRL` pseudo-operation may appear anywhere in the program. In an absolute assembly, a low-severity error message is printed, but `CONTRL` is otherwise ignored. For example,

```
X          CONTRL  A,B
```

defines the portion of the program from A to, but not including, B as control section X.

Control sections may be nested.

To obtain the blank `COMMON` area, as used by 7090/7094 FORTRAN IV, an instruction of the form

```
CONTRL  //
```

must be used. For example, in the sequence

```
CONTRL  //
USE     A
.
.
USE     B
.
.
USE     //
BSS    20
USE     C
.
.
USE     A
.
.
END
```

the blank `COMMON` counter `//` will have its initial location defined as the last value reached by location counter C. The area under control of the `//` counter is a control section.

The ENTRY Pseudo-Operation

The `ENTRY` pseudo-operation provides a reference from outside a program segment to a point within the program segment. The format of the `ENTRY` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	ENTRY	Symbol

The name field symbol becomes the external name of the entry point. The variable field symbol is the internal name of the entry point and must be an ordinary symbol, although it may be qualified. If the name field is blank, the variable field symbol serves as the external name. If the variable field symbol is qualified, the (left-most) qualifier is used. For example,

```
ALPHA     ENTRY     BETA
```

specifies that `ALPHA` is the external name of an entry point into this program from another program and that `BETA` is the internal name of this entry point.

File-Description Pseudo-Operations

Two pseudo-operations are provided by `MAP` for specifying input/output file requirements in relocatable assemblies. These pseudo-operations describe files that are used in conjunction with Library `IOCS`. (See the publication *IBM 7090/7094 IBSYS Operating System: Input/Output Control System*, Form C28-6345.)

`IBLDR` generates a file control block and assigns the file to a buffer pool. File control blocks described in one program segment may be referenced in other segments. If the same file is described more than once, only the first description is effective.

The FILE Pseudo-Operation

The `FILE` pseudo-operation enables the programmer to specify input/output file requirements. The `FILE` pseudo-operation causes generation of a `$FILE` card, as well as any `$ETC` cards needed. The format of the `FILE` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	FILE	External file name, options, . . .

The symbol in the name field of the `FILE` pseudo-operation is the internal name of the file used by the programmer within his program. Whenever this name appears in the variable field of an instruction, the relocatable reference is to the generated file control block for this file.

The first subfield of the variable field is the external file name. The order of the subsequent subfields is arbitrary.

In describing the subfields, options that may be included or omitted are shown in brackets. When an option is not specified, the standard option, which is shown underlined>, is assumed. Braces indicate that a choice of the enclosed options is to be made by the user. Options are shown in all upper-case letters in the form in which they must be specified.

External File Name is an alphanumeric literal of up to 18 characters used to determine equivalence between files. This subfield must be specified as the first subfield in the variable field. It may be null (the variable field may start with a comma), in which case the six-character name field (left-justified with trailing blanks) is inserted as the external name.

Unit-Assignment Option

```
[, primary unit]    [, secondary unit]
```

Two symbolic units may be specified for each file: the primary unit, and a secondary unit to be used as a reel-switching alternate. The format used for these specifications is indicated below, where the following notation is used:

- X a real channel (specified by one of the letters A through H)
- P a symbolic channel (specified by one of the letters S through Z)
- I an intersystem channel (specified by one of the letters J through Q)
- k a unit number (specified by one of the numbers 0 through 9)
- a access mechanism number (specified by the number 0)
- m module number (specified by one of the numbers 0 through 9)
- s data channel switch or interface (specified by either of the numbers 0 or 1)
- M model number of 729 Magnetic Tape Unit (specified by II, IV, V, or VI)
- D 1301 Disk Storage (specified by the letter D)
- N 7320 Drum Storage (specified by the letter N)
- H 7340 Hypertape Drive (specified by the letter H)

The following format is used for assigning units:

SPECIFICATION	EFFECT
blank	Use any available unit.
M	Use any available 729 Magnetic Tape Unit of this model.
X	Use any available unit on this channel.
P	Use any available unit on this channel.
X(k)	Use <i>k</i> th available unit on this channel. Parentheses are required.
PM	Use any available 729 Magnetic Tape Unit of specified model on designated symbolic channel.
P(k)M	Use <i>k</i> th available 729 Magnetic Tape Unit of specified model on designated symbolic channel. Parentheses are required.
I	Use any available unit on channel I. This specification can be used for input and output units.
IM	Use any available 729 Magnetic Tape Unit of specified model on channel I. This specification can be used only for output units.
I(k)	Use <i>k</i> th available unit on channel I. Parentheses are required. This specification can be used for input and output units.
I(k)M	Use <i>k</i> th available 729 Magnetic Tape Unit of specified model on channel I. Parentheses are required. This specification can be used only for output units.
I(k)R	Use <i>k</i> th available unit on channel I, and release unit from reserve status after use. Parentheses are required.
XDam/s	Use 1301 Disk Storage on channel X, access mechanism number <i>a</i> (which must be 0), and module number <i>m</i> .
XNam/s	Use 7320 Drum Storage on channel X, access mechanism <i>a</i> (0), module number <i>m</i> (0, 2, 4, 6, 8) and data channel switch setting <i>s</i> (0, 1).
XHk/s	Use 7340 Hypertape Drive on channel X, unit number <i>k</i> , and data channel switch <i>s</i> .
IN, IN1, IN2	Use system input unit.
OU, OU1, OU2	Use system output unit.
PP, PP1, PP2	Use system punch output unit.
UTk	Use system utility unit number <i>k</i> .
CKk	Use system checkpoint unit number <i>k</i> .
RDX	Use card reader on channel X.
PRX	Use printer on channel X.

- PUX Use card punch on channel X.
- INT File is internal.
- * An asterisk in the secondary unit field indicates that the secondary unit of a file is to be any unit on the same channel and of the same model as the primary unit.
- NONE No units are assigned. A file control block is generated but does not refer to a unit control block.

File-Mounting Option

$$\left[\left. \begin{array}{c} \text{MOUNT} \\ \text{READY} \\ \text{DEFER} \end{array} \right\} \right] \text{ and/or } \left[\left. \begin{array}{c} \text{MOUNT}_i \\ \text{READY}_i \\ \text{DEFER}_i \end{array} \right\} \right]$$

The file-mounting option governs the on-line message to the operator indicating the impending use of an input/output unit. The first form applies to both units; the second applies to the primary unit when *i*=1 and to the secondary unit when *i*=2. Two standard options are indicated—one is for units assigned to system unit functions (READY) and the other is for nonsystem units (MOUNT).

The effects of these operations are:

- MOUNT A message is printed before execution, and a stop occurs for the required operator action. MOUNT is the standard option for nonsystem units.
- READY A message is printed before execution, but no stop occurs. READY is the standard option for all input/output units assigned to system unit functions.
- DEFER A message and operator stop are deferred until the file is opened by the IOCS calling sequence.
TSX .OPEN, 4
PZE internal file name

The *i* form of this option overrides for unit *i* any general option specified.

As an example of the file-mounting option.

MOUNT1, DEFER2

causes the MOUNT action for the primary unit and the DEFER action for the secondary unit.

Operator File-List Option

$$\left[\left. \begin{array}{c} \text{LIST} \\ \text{NOLIST} \end{array} \right\} \right]$$

- LIST This file will appear in the operator's mounting instructions.
- NOLIST No message will be printed unless the DEFER option has been specified.

File-Usage Option

$$\left[\left. \begin{array}{c} \text{INPUT} \\ \text{OUTPUT} \\ \text{INOUT} \\ \text{CHECKPOINT (or CKPT)} \end{array} \right\} \right]$$

- INPUT This is an input file.
- OUTPUT This is an output file.
- INOUT This file may be either an input or an output file. The object program sets the appropriate bits in the file block. The file is initially set at input.
- CHECKPOINT (or CKPT) This is a checkpoint file.

Block-Size Option

[, BLOCK=xxxx (or, BLK=xxxx)]

xxxx is an integer (0-9999) that specifies block size for this file. If the block-sequence and/or check-sum options (see below) are specified, a word must be added in determining block size. If the BLOCK option is omitted, the assembly program assumes a block size of 14 for BCD or MXBCD files and 256 for BIN and MXBIN files.

Activity Option

[, ACT=xx]

xx is an integer (0-99) that specifies activity of this file in relation to other files. If the activity subfield is omitted, activity is assumed to be 1. The activity value is used in determining the number of input/output buffers assigned to each buffer pool in the object program.

Reel-Handling Option

[, { ONEREEL
MULTIREEL }
(or REELS)] for unlabeled files only

ONEREEL No reel switching should occur.
MULTIREEL Reel switching will occur. Every output file will switch reels if an end-of-tape condition occurs.
(or REELS)

[, { NOSEARCH }
SEARCH] for labeled files only

NOSEARCH If an incorrect label is detected when opening an input file, IOCS causes a stop for operator action.

SEARCH If an incorrect label is detected, IOCS enters a multireel search for the file with the desired label.

File-Density Option

[, { HIGH
LOW }
200
556
800]

HIGH Tape-density switch is assumed to be set so that execution of an SDH will result in using correct density.

LOW Tape-density switch is assumed to be set so that execution of an SDL will result in using correct density.

200 File-recording density is 200 cpi.

556 File-recording density is 556 cpi.

800 File-recording density is 800 cpi.

If a system unit is assigned to this file, system set density supersedes the density specified by these options.

Mode Option

[, { BCD
BIN
MXBCD }
MXBIN]

BCD File is in BCD mode.

BIN File is in binary mode.

MXBCD File is in mixed mode, and first record is BCD.

MXBIN File is in mixed mode, and first record is binary.

Label-Density Option

[, { SLABEL
HILABEL }
LOLABEL
FLABEL]

SLABEL All header label operations performed at installation standard density, which is currently high density.

HILABEL All header label operations performed at high density.

LOLABEL All header label operations performed at low density.

FLABEL All header label operations performed at same density as file.

Regardless of these options, the LABEL pseudo-operation must be used to specify a labeled file. If label density is not specified, all label options are performed at the density that is high density at the particular installation.

Block-Sequence Option

[, { NOSEQ
SEQUENCE }
(or SEQ)]

NOSEQ Block-sequence word neither checked if reading, nor formed and written if writing.

SEQUENCE Block-sequence word checked if reading, or formed and written if writing.
(or SEQ)

Check-Sum Option

[, { NOCKSUM }
CKSUM]

NOCKSUM Check sum neither checked if reading, nor formed and written if writing.

CKSUM Check sum checked if reading, or formed and written if writing.

Check-sum options may not be specified unless a block-sequence option has been specified.

Checkpoint Option

[, { NOCKPTS }
CKPTS]

NOCKPTS No checkpoints initiated by this file.

CKPTS Checkpoints initiated by this file.

Checkpoint-Location Option

[, AFTER LABEL]

Checkpoints are written following the label on this file when reel switching occurs. If CKPTS is specified and this field is omitted, checkpoints are written on the checkpoint file when reel switching occurs.

File-Close Option

[, { SCRATCH }
PRINT
PUNCH }
HOLD]

SCRATCH File is rewound at end of application.

PRINT File is to be printed and is rewound and unloaded at end of application. PRINT will appear in on-line removal message at end of execution.

PUNCH File is to be punched and is rewound and unloaded at end of application. PUNCH will appear in on-line removal instructions.

HOLD File is to be saved and is rewound and unloaded at end of application. HOLD will appear in on-line removal instructions.

If the unit assigned is system input unit 1, system output unit 1, or system peripheral punch unit 1, the unit will not be rewound and the removal message will not be printed.

Starting Cylinder-Number Option

[, CYLINDER=xxx (or, CYL=xxx)]

xxx is the number (000-249 for disk, 000-009 for drum) of the starting cylinder for this file. The equals sign is required. When disk or drum storage is specified for a file, the starting cylinder number must be specified by the user.

Cylinder-Count Option

[, CYLCOUNT=xx (or, CYLCT=xxx)]

xxx is the number (000-250 for disk, 000-010 for drum) of consecutive cylinders to be used by this file. The equals sign is required. When disk or drum storage is specified for a file, cylinder count must be specified by the user.

Disk Write-Checking Option

[, WRITECK]

Write-checking is performed after each disk-write or drum-write sequence for this file.

Hypertape Reel-Switching Options

[{ HRFP
HRNFP
HNRFP
HNRNFP }]

These options may be used in conjunction with the Hypertape option, HYPER, where reel switching is likely to occur. If any of these options are used but HYPER is not specified, a warning message is issued.

The effects of these options are:

HRFP Hypertape, rewind, file protect.
HRNFP Hypertape, rewind, no file protect.
HNRFP Hypertape, no rewind, file protect.
HNRNFP Hypertape, no rewind, no file protect.

Four subfields provide information for cross-checking by IBLDR. These subfields, the conversion, block-size check, nonstandard label routine, and Hypertape options, are not placed on the \$FILE card.

Conversion Option

[{ NOHCVN
REQHCV
OPTHCV }]

NOHCVN Alphameric-to-BCD conversion routine not necessary. File may not be assigned to card equipment.

REQHCV Alphameric-to-BCD conversion routine required. File must be assigned to card equipment.

OPTHCV Alphameric-to-BCD conversion optional.

Regardless of the conversion options specified, it is the responsibility of the programmer to provide the required conversion routines. File may be assigned to any input/output device.

Block-Size Check Option

[{ MULTI=xxxx }
{ MIN=xxxx }]
MULTI=xxxx Block size is a multiple of xxxx.
MIN=xxxx Minimum block size is xxxx.

Only one of the block-size check options may appear. The quantity specified is used by IBLDR to check the block size indicated by the BLOCK option. If neither option appears, block size is assumed to be exactly that specified by the BLOCK option.

Nonstandard-Label-Routine Option

[, NSLBL=symbol]

The symbol is the name of a nonstandard-label routine. If the label routine is part of the program segment being assembled, the label routine must be made a control section with the symbol used as its external name. If the label routine is not part of this program segment, the symbol must be a virtual symbol.

Hypertape Option

[, HYPER]

HYPER must be specified if a program requires Hypertape for a particular file. If reel switching may occur, the Hypertape reel-switching options may be used in conjunction with HYPER. However, use of Hypertape reel-switching options without specifying HYPER results in a warning message.

If a file may be attached to a Hypertape or a 729 Magnetic Tape Unit, the HYPER specification is not necessary.

For example, the options for an input file might be specified in the instruction

INPUT FILE ,A(1),READY,BLK=20,
556,HOLD

Since the first subfield is null, the symbol INPUT in the name field is regarded as the external name. The remaining subfields specify the first available unit on channel 1, the file-mounting option, a block size of 20 words, a file density of 556 characters per inch, and the file is to be saved and must be rewound and unloaded at the end of the application.

The LABEL Pseudo-Operation

The LABEL pseudo-operation enables the programmer to label a file and causes generation of the \$LABEL control card. Whereas the FILE pseudo-operation describes the file characteristics, LABEL simply labels the file. The

format of the LABEL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	LABEL	Five subfields: 1. File name, 2. File serial number or disk or drum Home Address-2, 3. Reel sequence number, 4. Retention period (in days) or date, 5. File identification name

The file name is an alphameric name of eighteen or fewer BCD characters. If this subfield is null (the variable field begins with a comma), the symbol in the name field is inserted as the file name. If the name field is also blank, 000000 is inserted as the file name.

The file serial number is an alphameric subfield of five or fewer characters, and it may be null. If the label is for a file on disk, this subfield must contain two BCD characters to specify the Home Address-2. (For further information, see the publication *General Information Manual, IBM 1301 Disk Storage With IBM 7000 Series Data Processing Systems*, Form D22-6576.) The reel-sequence number is a numeric subfield of four or fewer digits, and it may be null.

For retention period in days, four or fewer numeric characters are used. For date, two or fewer numeric characters represent the year, and three or fewer numeric characters represent the day of the year. The year and the day of the year are separated by the character / (slash).

The file identification name is an alphameric subfield of eighteen or fewer BCD characters. This subfield may contain blanks but not commas. A comma will terminate this subfield, and excessive subfields will be flagged as errors. This subfield may also be null.

For example,

LABEL INVOICE,,241,63/248,PRIMARY FILE

specifies that the INVOICE file be labeled, provides its reel-sequence number of 241, dates it as the 248th day of 1963, and specifies PRIMARY FILE as the file identification name.

The variable field of the LABEL pseudo-operation must be contained on one card. No ETC cards may be used following LABEL.

The variable field is checked for errors. If there are more than five subfields, the variable field is truncated, only the first five subfields are used, and a warning message is printed. If there are fewer than five subfields, an appropriate number of commas is supplied so that the LABEL card always has the required subfields and a warning message is printed.

Each subfield is then checked for length except for the last one. Subfields that are longer than the specified maximums are truncated to the maximum number of

characters allowed for each, and a format error message is printed. Numeric subfields are also checked for validity, and the presence of any nonnumeric characters causes a format error message to be printed.

Operation-Defining Pseudo-Operations

Three pseudo-operations that define symbols as operation codes are provided by MAP.

The OPD Pseudo-Operation

The OPD (Operation Definition) pseudo-operation defines the symbol appearing in the name field as an operation code. The format of the OPD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPD	12-digit octal machine operation code definition

The 12-digit machine operation code definition in the variable field must be specified according to the general format given in Appendix C.

The OPD pseudo-operation defines the symbol in the name field as an operation code. The symbol must be defined by the OPD pseudo-operation before its use in an operation field.

For example,

ALPHA OPD 430106004500

defines ALPHA as an operation code having the same effect as the machine instruction CLA.

The OPVFD Pseudo-Operation

The OPVFD (Operation Variable Field Definition) pseudo-operation defines the symbol in the name field as the operation code represented by the expression in the variable field. The format of the OPVFD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPVFD	From 1 to 36 subfields, separated by commas

The format of the variable field is the same as that given for the VFD pseudo-operation. The variable field expression must result in a 36-bit word having the format given in Appendix C.

The symbol in the name field becomes the mnemonic operation code of the instruction. The symbol must be defined by OPVFD before being used in an operation field.

For example,

ALPHA OPVFD O6/43,O12/0600,O18/4500

defines ALPHA as an operation code having the same effect as the machine instruction CLA.

The OPSYN Pseudo-Operations

The OPSYN (Operation Synonym) pseudo-operation equates the symbol in the name field to the mnemonic operation code in the variable field. The format of the OPSYN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	OPSYN	Mnemonic operation code

The mnemonic operation code in the variable field must be a valid operation code (i.e., a machine operation code, a pseudo-operation code, a macro-operation code, or a code that has been defined previously by OPD, OPVFD, or another OPSYN).

If a previously defined operation code is redefined with OPD, OPVFD, or OPSYN, a warning message is issued. For example,

```
CLA      OPSYN  CAL
```

redefines CLA as CAL. The message warns the programmer of possible inadvertent redefinition of an existing operation code.

Miscellaneous Pseudo-Operations

The END Pseudo-Operation

The END pseudo-operation signals the end of the symbolic deck and terminates assembly. The END operation must be present and must be the last card in the symbolic deck. The format of the END pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	END	1. An element, or 2. Blanks

In a relocatable assembly, the value of the element in the variable field is the nominal starting point of the program segment.

The END pseudo-operation performs the following functions in an absolute assembly:

1. Any binary output waiting in the punch buffer is written out.

2. A binary transfer card to which control is transferred is produced. It has a transfer address that is the value of the expression in the variable field.

If UNPNCH is in effect, no cards are punched.

The ETC Pseudo-Operation

The variable field of most instructions may be extended over additional cards by using the ETC pseudo-operation. The format of the ETC pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Ignored	ETC	Subfields, separated by commas, or partial subfields

The ETC pseudo-operation appends its variable field as a continuation of the variable field of the previous instruction. The blank that separates the variable field from the comments field of a card is an end-of-card indicator and not an end-of-variable-field indicator. The number of ETC cards in one group is generally limited by the size of the resultant expression and/or the number of subfields. A variable-field expression is limited to about 100 elements, operators, and/or subfields. No element of an expression may be split between two cards. For example, the instruction

```
TIX      NAME+1,4,1
```

could be written

```
TIX      NAME+1
ETC      ,4,1
```

or

```
TIX      NAME
ETC      +1,4
ETC      ,1
```

or

```
TIX      NAME+1,4,
ETC      1
```

but could not be written

```
TIX      NA
ETC      ME+1,4,1
```

The following operations may *not* be followed by an ETC card:

ABS	IFT	PCC
BCI	LABEL	PCG
DEC	LBL	PMC
DETAIL	LDIR	PUNCH
*DUP	LIST	QUAL
EJECT	LORG	REM
END	NOCRS	TITLE
ENDM	NULL	TTL
ENDQ	OCT	UNLIST
EVEN	OPD	UNPNCH
FUL	OPSYN	USE
IFF	ORGCRS	

*A DUP within the range of another DUP should not be followed by an ETC pseudo-operation.

If an ETC follows any of these operations except END, the ETC will be ignored and a low-severity warning message issued.

The REM Pseudo-Operation

The REM (Remarks) pseudo-operation permits remarks to be entered into the assembly listing. The format of the REM pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Any information	REM	Any information

The contents of columns 8-10 (the operation field) are replaced by blanks, and the remaining contents of the card are copied onto the assembly listing. The REM pseudo-operation supplements the remarks card that has * in column 1. In a macro-definition, the variable field of the REM card is scanned for substitutable parameters, whereas the * card causes an error message but is otherwise completely ignored.

Absolute-Assembly Pseudo-Operations

The pseudo-operations ABS, FUL, PUNCH, UNPNCH, and TCD are effective in absolute assemblies only. They are ignored in a relocatable assembly.

The ABS Pseudo-Operation

The ABS (Absolute) pseudo-operation specifies card output in the standard 22-word-per-card column-binary card format. The format of the ABS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ABS	Ignored

Binary cards are normally punched in the ABS mode unless otherwise specified. The ABS pseudo-operation always causes the next output word to start a new card. Any words remaining in the punch buffer are written out in the previously specified format.

Column-binary card format is described in the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6275.

The FUL Pseudo-Operation

The FUL pseudo-operation specifies card output in the 24-word-per-card "full" mode. The format of the FUL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	FUL	Ignored

The FUL pseudo-operation always causes the next output word to start a new card. Any words remaining in the punch buffer are written out in the previously specified format.

The full mode card format is described in the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6275.

The PUNCH and UNPNCH Pseudo-Operations

The PUNCH and UNPNCH pseudo-operations cause resumption and suspension, respectively, of binary card punching. The format of the PUNCH and UNPNCH pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PUNCH or UNPNCH	Ignored

The TCD Pseudo-Operation

A binary transfer card directs an absolute loader program to stop loading cards and to transfer control to a designated location. In most cases, a transfer card is required at the end of the binary deck. In absolute assemblies, the END pseudo-operation causes a binary transfer card to be punched. However, the TCD pseudo-operation can cause a transfer card to be produced before the end of the binary deck.

The format of the TCD pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TCD	A symbolic expression

The TCD pseudo-operation performs the following two functions:

1. Any binary output waiting in the punch buffer is written out.
2. A binary transfer card is produced having a transfer address that is the value of the expression in the variable field. See the publication *IBM 7090/7094 IBSYS Operating System: IBJOB Processor*, Form C28-6275, for a description of the format of a transfer card.

If UNPNCH is in effect, no cards are punched.

List-Control Pseudo-Operations

The PCC Pseudo-Operation

The PCC (Print Control Cards) pseudo-operation has the following format:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PCC	Either: 1. ON 2. OFF 3. Blanks 4. Any information

PCC ON causes listing of the following control cards: TTL, TITLE LBL, LIST, INDEX, SPACE, EJECT, DETAIL, PCC, and PMC *unless the UNLIST pseudo-operation is in effect*. PCC OFF suppresses listing of these cards and is the normal mode. The PCC card is always listed *unless*

UNLIST is in effect. If the variable field is blank or contains anything other than ON or OFF, the current setting of the PCC switch is inverted.

The UNLIST Pseudo-Operation

The UNLIST pseudo-operation causes all listing to be suspended. The format of the UNLIST pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	UNLIST	Ignored

The UNLIST pseudo-operation is itself listed unless a previous UNLIST is still in effect. After an UNLIST, no lines are listed by the assembly program until a LIST or END pseudo-operation is encountered.

The LIST Pseudo-Operation

The LIST pseudo-operation causes listing to be resumed following an UNLIST. The format of the LIST pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LIST	Ignored

The LIST pseudo-operation does not appear in the assembly listing unless the mode of PCC is ON, but it does cause one blank line to appear in the listing whether or not UNLIST is in effect.

The TITLE Pseudo-Operation

The TITLE pseudo-operation abbreviates the assembly listing by eliminating certain kinds of information. The format of the TITLE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TITLE	Ignored

TITLE causes the assembly program to exclude the following information from the listing:

1. Any line that contains octal information except the instruction that causes it, i.e., all but the first word generated by OCT, DEC, BCI, and VFD
2. All but the entire first iteration of each instruction in the range of a DUP
3. All complex fields in a relocatable assembly
4. The expansion of SAVE and all but the first three instructions in the expansion of CALL.
5. All literals in the Literal Pool except the first

A TITLE pseudo-operation is effective until the assembly program encounters a DETAIL operation. TITLE is not listed except when the mode of PCC is ON.

The DETAIL Pseudo-Operation

The DETAIL pseudo-operation causes the listing of generated data to be resumed after it has been suspended by a TITLE pseudo-operation. The format of the DETAIL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	DETAIL	Ignored

The sole effect of the DETAIL operation is to cancel the effect of a previous TITLE pseudo-operation. If TITLE is not in effect, the DETAIL operation is ignored by the assembly program. The DETAIL operation does not appear in the assembly listing unless the mode of PCC is ON.

The EJECT Pseudo-Operation

The EJECT pseudo-operation causes the next line of the listing to appear at the top of a new page. The format of the EJECT pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	EJECT	Ignored

The EJECT pseudo-operation appears in the assembly listing only if the mode of PCC is ON.

The SPACE Pseudo-Operation

The SPACE pseudo-operation permits one or more blank lines to be inserted in the assembly listing. The format of the SPACE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	SPACE	1. A symbolic expression, or 2. Blanks

The definition of the expression in the variable field determines the number of blank lines in the assembly listing. If the value of the expression is zero or the variable field is blank, one blank line appears. SPACE itself is listed only if the mode of PCC is ON.

The LBL Pseudo-Operation

Serialization of a deck normally begins with the first four characters of the deck name, which are left-justified and filled with trailing zeros. However, serialization can be altered by using the LBL pseudo-operation. The format of the LBL (Label) pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	LBL	Up to 8 BCD characters, ended by a blank or comma

LBL causes binary cards to be identified and serialized in columns 73-80, as follows:

1. Serialization begins with the characters appearing in the variable field, which is left-justified and filled with terminating zeros.

2. Serialization is incremented by one for each card until the rightmost nonnumeric character or the seventh character is reached, after which the numeric portion recycles to zero. The two leftmost characters are regarded as fixed, even though they may be numeric.

For example, if the variable field is coded as ID, the first card is identified and serialized as ID000000.

If the variable field is coded as INSTR03, serialization is as follows:

```

INSTR030
INSTR031
.
.
INSTR999
INSTR000
.
.

```

At the beginning of each card, the assembly program normally prints the phrase:

```
BINARY    CARD    ID. Number
```

If a comma is used to terminate the variable field, printing of this phrase is suppressed. Printing of this phrase can be reinitiated by using an LBL pseudo-operation ending in a blank.

Serialization can be altered at any point in the source program by using additional LBL pseudo-operations. However, since LBL does not force punching of the current card, reserialization is not effective until the next card is normally punched.

LBL is listed only if the mode of PCC is ON.

The INDEX Pseudo-Operation

The INDEX pseudo-operation provides a table of contents of important locations within an assembly. The format of the INDEX pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	INDEX	Symbols, separated by commas

The first appearance of an INDEX card causes the message

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to be listed. Each subfield of an INDEX pseudo-operation causes the symbol and its definition to be listed. If a virtual symbol is used, its definition will be the control section number assigned to the symbol.

INDEX pseudo-operations may appear anywhere in the source program and need not be grouped. The

listing generated by INDEX pseudo-operations is inserted where the pseudo-operations appear.

For meaningful commentary, INDEX pseudo-operations can be grouped and interspersed with explanatory remarks cards.

Listing of the INDEX card itself is governed by the mode of the PCC switch.

The PMC Pseudo-Operation

The PMC pseudo-operation causes (or suppresses) listing of the card images generated by macro-instructions and by the RETURN pseudo-operation. The format of the PMC (Print Macro Cards) pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PMC	Any one of: 1. ON 2. OFF 3. Blanks 4. Any information

ON in the variable field causes listing of the card images generated by macro-instructions; OFF, which is the normal mode, suppresses such listing. A blank variable field or one containing any information other than ON or OFF inverts the current setting of the PMC switch.

ETC cards extending the variable field of a macro-instruction are listed even if the mode of PMC is OFF.

Listing of the PMC card is controlled by the PCC pseudo-operation.

The TTL Pseudo-Operation

The TTL (Subtitle) pseudo-operation generates a subheading in the listing. The format of the TTL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	TTL	A string of BCD characters starting in card column 12

Card columns 13-72 are used in words 4-13 of a generated subheading, which will appear on each page. TTL also forces a page ejection.

A subheading may be replaced by the variable field of another TTL and may be deleted by a TTL with a blank variable field.

Listing of the TTL card is controlled by the PCC pseudo-operation.

The PCG Pseudo-Operation

The PCG (Print Control Group) pseudo-operation causes listing of the relocatable control bits of each

assembled word. The format of the PCG pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	PCG	Any one of: 1. ON 2. OFF 3. Blanks 4. Any information

ON in the variable field causes listing and OFF suppresses listing of the relocatable control bits for each assembled word. ON is the normal mode. A blank variable field or one containing any information other than ON or OFF inverts the current setting of the PCG switch. PCG is ignored in an absolute assembly.

PCG is listed if the mode of PCG is ON.

Special Systems Pseudo-Operations

Users of the MAP language are provided with a wide range of subroutines which are included in the systems library. A group of system pseudo-operations permits the transfer of control and data between the main program and the subroutine. Details about specific calling sequences are provided in the publications *IBM 7090/7094 IBYSY Operating System: IBJOB Processor*, Form C28-6275 and *IBM 7090/7094 Operating System: Input/Output Control System*, Form C28-6345.

The CALL Pseudo-Operation

The CALL pseudo-operation produces the standard IBJOB subroutine calling sequence. The format of the CALL pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	CALL	One or more subfields: 1. Symbol or ** 2. Calling sequence parameters 3. Error returns 4. Identification number

The first subfield in the variable field must contain an unqualified symbol (the name of a subroutine) or **. The next subfield contains the parameters of the calling sequence (if any), enclosed in parentheses and separated by commas. These may be any symbolic expression.

Error returns (if any), separated by commas, occupy the next subfield. The last subfield is an identification number (if desired), less than 32,768 and delimited by apostrophes. If specified, this number appears in the calling sequence in place of the assembly line number.

When an identification number is not specified, the assembly line number appears.

For example, a typical CALL operation might be coded

```
LCS          CALL    name(arg1,arg2,...,argn)
              ETC     ret1,ret2,...,retn'id'
```

where name is the name of a subroutine; arg1, arg2, . . . , argn are the parameters of the calling sequence; ret1, ret2, . . . , retn are the error returns; and 'id' is the identification number.

A comma should not precede the left parenthesis, follow the right parenthesis, nor precede the 'id'.

If the subroutine is part of the program being assembled, the reference is to the routine in the program. However, if the subroutine is not part of the program being assembled, the symbol in the first subfield of the variable field becomes the external name of the subroutine called. If ** is used, a constant zero becomes the called address.

The remaining subfields generate the calling sequence.

Expansions of the CALL Pseudo-Operation

The linkage produced by

```
LCS          CALL    NAME(P1,...,Pn)R1,
              ETC     ...,'Rm'ID'
is
LCS          TSX     NAME,4
              TXI     *+2+n+m,,n
              PZE     ID,,Linkage Director
              PZE     P1
              .
              .
              PZE     Pn
              TRA     Rm
              .
              .
              TRA     R1
```

where P is a subroutine parameter, R is an error return, n is the number of parameters and m is the number of error returns. The Linkage Director is a location unique for each assembly, and has no associated symbol. It may be given a symbolic designation using the LDIR pseudo-operation.

The operation

```
LCS          CALL    NAME(P1,P2)
```

produces

```
LCS          TSX     NAME,4
              TXI     *+2+2+0,,2
              PZE     Line number,,Linkage Director
              PZE     P1
              PZE     P2
```

The statement

```
LCS          CALL    NAME,R1
```

produces

```
LCS      TSX      NAME,4
          TXI      *+2+0+1,,0
          PZE      Line number,,Linkage Director
          TRA      R1
```

The statement

```
LCS      CALL     NAME
```

generates

```
LCS      TSX      NAME,4
          TXI      *+2+0+0,,0
          PZE      Line number,,Linkage Director
```

The SAVE Pseudo-Operation

The SAVE pseudo-operation produces the instructions necessary to save and restore the index registers and indicators, to disable and restore all operative traps, to provide error returns used by a subprogram, and to store the contents of index register 4 in SYSLOC and in the Linkage Director. The format of the SAVE pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SAVE	Up to 7 subfields containing integers or immediate symbols and any or all of the letters I, D, E

The order in which the subfields in the variable field of the SAVE pseudo-operation are used is not important. All subfields are optional.

As many as 7 numeric subfields may be used to specify the index registers that are to be saved and restored. Immediate symbols may also be used to specify index registers. Any or all index registers may be specified in any order.

Index registers are saved in the order 4, 1, 2, 3, 5, 6, 7 and are restored in the opposite order. Index register 4 is automatically saved and restored, although it may still be specified.

One of the three remaining subfields is literally the character I; another is literally the character D; and the last is literally the character E.

The presence of I signifies that the sense indicators are to be saved and restored.

The presence of D causes all operative traps to be disabled and restored.

The presence of E generates the instructions necessary to facilitate use of error returns in the CALL pseudo-operation.

The contents of index register 4 are stored in the Linkage Director each time the SAVE pseudo-operation is executed. SYSLOC is a standard communication location used by all programs loaded under IBLDR. If the assembly is absolute (the ABSMOD option is specified),

the symbol SYSLOC must be defined by the programmer.

The general form of the SAVE pseudo-operation is:

```
locsym   SAVE     (X1, . . . ,Xk)I,D,E
```

or

```
locsym   SAVE     Xi, . . . ,Xk,I,D,E
```

Expansions of the SAVE Pseudo-Operation

The instruction

```
LCS      SAVE     2,1,I
```

or its equivalent

```
LCS      SAVE     (2,1)I
```

specifies that index registers 2 and 1 and the sense indicators are to be saved.

The expansion is:

```
LCS      ENTRY    LCS
          TXI      . .0003,,0
          AXT      **,2
          AXT      **,1
.0001    AXT      **,4
          LDI      . .00102+1
.0002    TRA      1,4
          PZE
.0003    STI      . .00102+1
          SXA      SYSLOC,4
          SXA      Linkage Director,4
          SXA      . .0001,4
          SXA      . .0001-1,1
          SXA      . .0001-2,2
```

The instruction

```
LCS      SAVE     2
```

generates

```
LCS      ENTRY    LCS
          TXI      . .0003,,0
          AXT      **,2
          AXT      **,4
.0001    TRA      1,4
.0002    SXA      SYSLOC,4
.0003    SXA      Linkage Director,4
          SXA      . .0001,4
          SXA      . .0001-1,2
```

In the next two examples, the instructions generated because of using the letters I, D, or E in the subfield of a SAVE pseudo-operation are identified by the appearance of the particular letter in the comments field of the generated instruction.

The instruction

```
LCS      SAVE     2,I,D
```

generates

```
LCS      ENTRY    LCS
          TXI      . .0003,,0
          AXT      **,2
.0001    AXT      **,4
          LDI      . .0002+1   I
          NZT      .TRPSW     D
          ENB*     .TRAPX     D
.0002    TRA      1,4
```

```

        PZE          I
.0003  XEC          SYSDSB D
        STI          .0002+1 I
        SXA          SYSLOC,4
        SXA          Linkage Director,4
        SXA          .0001,4
        SXA          .0001-1,2

```

Locations SYSDBS, .TRPSW, and .TRAPX are in the System Monitor (see the publication *IBSYS Operating System: System Monitor (IBSYS)*, Form C28-6248). A switch at .TRPSW indicates whether enabling is permissible at this time; .TRAPX gives the address of the location that contains the bits for proper enabling. (Note that the enabling instruction below refers to .TRAPX indirectly.)

The following sequence illustrates the expansion that is generated when the E option is specified:

```

LCS      SAVE      (2)I,D,E
generates

```

```

LCS      ENTRY     LCS
        TXI        .0003,**
        LDC        LCS,4      E
        SXD        *+5,4      E
        LAC        .0001,4    E
        TXI        *+1,4,1    E
        SXA        *+1,4      E
        LXA        **,4       E
        TXI        *+1,4,**    E
        SXA        .0002,4     E
.0001    AXT        **,2
        AXT        **,4
        LDI        .0002+1    I
        NZT        .TRPSW     D
        ENB*       .TRAPX     D
.0002    TRA        **        E
        PZE        I          I
.0003    XEC        SYSDSB     D
        STI        .0002+1    I
        SXD        LCS,0      E
        SXA        SYSLOC,4
        SXA        Linkage Director,4
        SXA        .0001,4
        SXA        .0001,1,2

```

If the SAVE pseudo-operation has no symbol in the name field, a symbol will be generated and an error message will be printed.

The SAVEN Pseudo-Operation

The SAVEN pseudo-operation produces the instructions necessary to save and restore the index registers used by a subprogram. The format of the SAVEN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Symbol	SAVEN	Up to 10 subfields

The SAVEN pseudo-operation is similar to SAVE except that the instructions

```

        ENTRY     LCS
        SXA        Linkage Director,4

```

are not generated. SAVEN is generally used when entering a subroutine from another subroutine without

destroying the linkage information. If the SAVEN pseudo-operation has no symbol in the name field, a symbol will be generated and an error message will be printed. If the variable field is blank, index register 4 is saved and restored.

The RETURN Pseudo-Operation

The RETURN pseudo-operation is designed for use with CALL and SAVE, making use of the error (or alternate) returns used in these operations.

The format of the RETURN pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	RETURN	1 or 2 subfields separated by a comma: 1. A symbol, 2. An integer, a symbol, or an immediate symbol

The first subfield in the variable field of the RETURN pseudo-operation is required. It contains the name of the associated SAVE pseudo-operation. If the second subfield is present, it specifies the particular error return.

The RETURN pseudo-operation often takes the general form

```

name      RETURN   locsym,i

```

where locsym is the symbolic address of the associated SAVE pseudo-operation, and i is the desired error return (i=0 is the normal return).

The form of the RETURN instruction may vary. For example, to specify a particular error return (e.g., 2), the instruction

```

LOC      RETURN   LCS,2

```

is written, where LCS is the location of the SAVE pseudo-operation to be used. The following instructions are generated:

```

LOC      AXT      2,4
        SXD      LCS,4
        TRA      LCS+1

```

If the E option of the SAVE or SAVEN pseudo-operation is not used, the following form should be used:

```

RETURN   LCS

```

which generates

```

TRA      LCS+1

```

This form should also be used even where the E option is specified if the error return is inserted into the decrement of the SAVE or SAVEN pseudo-operation at execution time.

The variable field of the RETURN pseudo-operation may not be left blank, since it results in a TRA instruction with a blank variable field. The PMC pseudo-operation governs the listing of the instructions generated by the RETURN pseudo-operation.

Part III. The Macro-Operation Facility

Macro-operations are special types of pseudo-operations that provide the MAP user with a powerful programming tool. After a programmer has defined a macro-operation, he can cause a whole sequence of instructions to be called into a program by coding a single instruction. The sequence can be repeated as often as desired. Moreover, any field or subfield of any instruction in the sequence can be changed each time the sequence is repeated.

Any machine instruction, pseudo-operation, or macro-operation can be included in a macro-operation. The sequence of instructions generated (usually called a macro-expansion) is an open subroutine. The instructions are executed in-line with the rest of the program.

Two general requirements must be met to take advantage of the macro-operation facility. First, the macro-operation must be defined by a macro-definition. Then, wherever the sequence of instructions is desired in the program, it must be called by a macro-instruction.

Defining Macro-Operations

A macro-definition provides a name for the macro-operation, determines the instructions that will be included in the macro-expansion, and establishes the parts of the instructions that are to be variable.

Three kinds of instructions must be coded to define a macro-operation. The first is the `MACRO` pseudo-operation. (The card containing this instruction is sometimes called the macro-definition heading card.) Prototype instructions (sometimes called prototype card images) immediately follow the `MACRO` pseudo-operation to establish the instructions that will be generated in the macro-expansion. Finally, the `ENDM` pseudo-operation ends the macro-definition.

The `MACRO` Pseudo-Operation

The `MACRO` pseudo-operation establishes the name of a macro-operation. The format of the `MACRO` pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
BCD name up to 6 characters long	MACRO	Up to 63 substitutable arguments (groups of not more than 6 characters) separated by punctuation characters

The name in the name field becomes the name of the macro-operation that is being defined. This name is later used to call the macro-operation and thus, in effect, becomes an operation code. Any valid symbol may be used in the name field of the `MACRO` pseudo-operation, or all numeric characters may be used. However, six zeros may not be used.

The name in the name field of a `MACRO` pseudo-operation may be the same as a symbol used anywhere in the program, even in this or any other macro-operation. However, if this name is the same as any other machine operation code, pseudo-operation code, or macro-operation code, the operation code is re-defined.

The subfields in the variable field of the `MACRO` pseudo-operation contain substitutable arguments.

SUBSTITUTABLE ARGUMENTS IN THE `MACRO` PSEUDO-OPERATION

Much of the flexibility of the macro-operation facility results from the principle of substitutable arguments. These subfields in the variable field of the `MACRO` pseudo-operation are dummy names that will be replaced in the macro-expansion.

Substitutable arguments permit any field or subfield of any instruction to be changed each time the macro-operation is called. The programmer can also change parts of subfields and even add entire instructions.

A substitutable argument is from one to six characters long. Any valid symbol may be used, and the name of a substitutable argument may consist of all numeric characters. For example, in the `MACRO` pseudo-operation

```
ALPHA      MACRO  ABC,123
```

each of the two groups of three characters in the variable field is a substitutable argument.

No punctuation characters except the period may be used as part of a substitutable argument.

A substitutable argument may be the same as a symbol or an operation code, including the operation code for this or any other macro-operation. However, substitutable arguments should not be identical to symbols or operation codes used in the prototype that immediately follows unless the symbols or operation codes are actually intended to be substitutable arguments.

DELIMITING SUBSTITUTABLE ARGUMENTS IN THE MACRO PSEUDO-OPERATION

Substitutable arguments in the variable field of the MACRO pseudo-operation may be separated by any of the following punctuation (special) characters:

= + - * / () , ' ,

If parentheses are used, they must be used in pairs.

The use of these characters permits meaningful notation in a macro-definition. For example,

```
ALPHA      MACRO    23,RATE,TIME,DIST,
                    QUSYM
```

could also be written

```
ALPHA      MACRO    23(RATE*TIME=DIST)
                    QUSYM
```

The variable field of the MACRO pseudo-operation may be extended over more than one card by using the ETC pseudo-operation. When the substitutable arguments appear on more than one card, the blank character acts as a separator. Hence, no punctuation character is needed between consecutive substitutable arguments that appear on separate cards. For example,

```
BETA      MACRO    A,B,C
```

could also be written

```
BETA      MACRO    A,B
          ETC      C
```

This usage of the ETC pseudo-operation differs from the usual case, in which all punctuation characters must be written.

Consecutive punctuation characters or an explicit zero are ignored and do not result in a substitutable argument of zero.

Prototypes in Macro-Definitions

The prototype of a macro-definition determines the instructions that will be included in the macro-expansion, their sequence in the expansion, and the positions of the substitutable portions of the instructions. The prototype, which consists of one or more prototype instructions, immediately follows the MACRO pseudo-operation.

A prototype instruction is similar to any other instruction. It has a name field, an operation field, and a variable field. It may also have a comments field, although this field does not appear in the card image generated in the macro-expansion. The distinguishing feature of a prototype instruction is that parts of it can be made variable.

The fields or subfields of a prototype instruction may contain text or substitutable arguments.

TEXT IN PROTOTYPES

Text represents the fixed parts of the instructions that will be generated in the macro-expansion. Any part of

a prototype instruction that has not been made a substitutable argument by its appearance in the variable field of the MACRO pseudo-operation is treated as text. For example, in the prototype

```
ALPHA      MACRO    A,B
          CLA      A
          B        BUFFER
          .
          .
          .
```

the operation code CLA and the location BUFFER are text. (BUFFER has been defined elsewhere in the program.)

Text is reproduced in the macro-expansion exactly as it appears in the prototype instruction. Thus, if only text is used in a field of an instruction, it must conform to the rules governing that field of the instruction in which it is used. For example, if the operation field of a prototype instruction is text, it must be a valid operation code.

Since parentheses can be used to delimit substitutable arguments within the prototype, parentheses must be used carefully as part of text to avoid confusing the enclosed characters with a substitutable argument.

SUBSTITUTABLE ARGUMENTS IN PROTOTYPES

Substitutable arguments represent the variable parts of the instructions that will be generated in the macro-expansion. The same substitutable arguments are used in the prototype that appeared in the variable field of the MACRO pseudo-operation. However, in the prototype, substitutable arguments appear in the fields or subfields of the prototype instructions that are to be variable. A substitutable argument may appear in any field or subfield of a prototype instruction. For example, in the sequence.

```
BETA      MACRO    ONE,TWO,THREE
ONE      CLA      PART1
          TWO      PART2
          STO      THREE
          .
          .
          .
```

ONE, TWO, and THREE are substitutable arguments in the name, operation, and variable fields, respectively, of prototype instructions.

DELIMITING SUBSTITUTABLE ARGUMENTS IN PROTOTYPES

The same punctuation (special) characters may be used in prototype instructions that were used to separate the substitutable arguments in the variable field of the MACRO pseudo-operation. Except for the apostrophe, these characters are reproduced in the macro-expansion. Only the apostrophe may be used to delimit substitutable arguments in the variable fields of REM

and TTL pseudo-operations and the data subfields of BCI pseudo-operations. (Another use of the apostrophe in macro-operations is explained in the section "Combining Substitutable Arguments and Text.")

A comma or a left parenthesis immediately following the operation code (as near the beginning of the card as column 11) signifies the end of the operation field and the beginning of the variable field.

A blank delimits a substitutable argument in a prototype. For example, in the macro-definition (where b represents a blank)

```
XYZ      MACRO  A,B,C
          AbbbB
```

three blanks separate A (in the operation field) from B (in the variable field). It is not always necessary that three blanks separate these two fields, but at least three characters are used for an operation field code. In this example, A and two blanks are used, whereas the third blank is required to terminate the operation field. If fewer blanks separated A from B, both would be taken as part of the operation code, causing errors.

If a blank is encountered before card column 72 in the variable field of a prototype instruction other than a BCI, REM, or TTL pseudo-operation, the card is terminated. Substitutable arguments may appear anywhere from column 1 through column 72 on BCI, REM, and TTL cards. Any information to the right of the blank will not be included in the macro-definition.

If a BCI, TTL, or REM pseudo-operation has been re-defined in a macro-definition or by an operation-defining pseudo-operation, it should not be used within a macro-definition. Also, if an operation code has been defined to have the effect of a BCI, TTL, or REM pseudo-operation and is used within a macro-definition, the variable field will be terminated by a blank.

Every field or subfield of six or fewer characters in any field of a prototype instruction is compared with the substitutable arguments in the variable field of the MACRO pseudo-operation. Therefore, care must be taken to avoid confusing fields intended as text with fields intended as substitutable arguments.

Remarks cards having an asterisk in column 1 may be included in macro-definitions, but they cause a warning message to be issued.

The ENDM Pseudo-Operation

The ENDM pseudo-operation terminates a macro-definition. The format of the ENDM pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ENDM	Either: 1. One or two subfields, separated by a comma, or 2. Blanks

The ENDM pseudo-operation immediately follows the last instruction and ends the macro-definition. An ENDM pseudo-operation is required for every MACRO pseudo-operation.

The first of the two subfields permitted in the variable field of the ENDM pseudo-operation is a BCD name of up to six characters. If a name is used in this subfield, it must be the same as the name used for the corresponding MACRO pseudo-operation. If the first subfield is not used, but the second is, a comma must precede the second subfield.

If the second subfield in the variable field of the ENDM pseudo-operation is present, it specifies either CRS (create symbols) or NOCRS (no created symbols). The second subfield controls symbol creation for this macro-operation only, overriding the effect of the NOCRS and ORGCRS pseudo-operations (see the section "Created Symbols"). CRS in this subfield always causes and NOCRS always suppresses symbol creation each time the macro-operation is called. Any symbol other than CRS or NOCRS has no effect.

For example, in the macro-definition

```
ALPHA    MACRO  A,B
          CLA    A
          ADD    B
          STO    SUM
          ENDM   ALPHA,NOCRS
```

the ENDM pseudo-operation is coded so that symbol creation is suppressed whenever this macro-operation is called.

If the variable field or the first subfield of the variable field is blank, this and all unterminated macro-definitions are terminated (see the section "Nested Macro-Operations").

Calling Macro-Operations

After a macro-operation has been defined, it may be called so that the generated sequence of instructions is brought into a program at a desired point. In the macro-expansion, each prototype instruction in the macro-definition is reproduced. Text and all punctuation characters except the apostrophe are reproduced exactly as they appeared in the prototype. However, the substitutable arguments that appeared in the variable field of the MACRO pseudo-operation and in the prototype are replaced by the actual parameters that the programmer wishes to appear in the expansion. These parameters are provided in the macro-instruction, which is used to call the macro-operation.

The Macro-Instruction

The macro-instruction calls a previously defined macro-operation into a program. The format of the macro-instruction is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
1. A symbol, or 2. Blanks	Macro-operation name	Parameters, separated by commas or parentheses

If there is a symbol in the name field, it is assigned to the first instruction of the macro-expansion.

The name that was assigned in the name field of the MACRO pseudo-operation is an operation code and is used in the operation field of the macro-instruction.

The variable field of the macro-instruction contains the actual parameters that the programmer wishes to appear in the macro-expansion.

PARAMETERS IN MACRO-INSTRUCTIONS

The parameters in the variable field of the macro-instruction replace the substitutable arguments that appeared in the macro-definition. These parameters must appear in the same order as the substitutable arguments they are to replace originally appeared in the variable field of the MACRO pseudo-operation.

The length of a parameter in the variable field of a macro-instruction is not limited to six characters as is a substitutable argument. The variable field of a macro-instruction may be extended over more than one card by using the ETC pseudo-operation. However, a single parameter must appear completely on one card unless it is enclosed in parentheses.

Macro-instruction parameters consist of any appropriate character or group of characters that would normally appear in the particular instruction. For example, in the macro-definition.

QPOLY	MACRO	COEFF,LOOP,DEG,T,OP
	AXT	DEG,T
	LDQ	COEFF
LOOP	FMP	GAMMA
	OP	COEFF+DEG+1,T
	XCA	
	TIX	LOOP,T,1
	ENDM	QPOLY

mnemonic symbols represent the substitutable arguments. LOOP appears in a name field, OP in an operation field, and COEFF, DEG, and T appear in subfields of the variable field. GAMMA is text and not a substitutable argument, since it does not appear in the variable field of the MACRO pseudo-operation. In this macro-instruction, a symbol should be substituted for LOOP and a valid operation code for OP. Such a macro-instruction might be written

X015	QPOLY	C1-4,FIRST,5,4,FAD
------	-------	--------------------

The macro-expansion would cause the following six card images to be generated.

X015	AXT	5,4
	LDQ	C1-4

FIRST	FMP	GAMMA
	FAD	C1-4+5+1,4
	XCA	
	TIX	FIRST,4,1

The symbol x015 is assigned to the first instruction, and each substitutable argument is replaced by the corresponding parameter that appeared in the variable field of the macro-instruction.

DELIMITING MACRO-INSTRUCTION PARAMETERS

The parameters in the variable field of a macro-instruction are separated either by commas or parentheses. A single comma following a right parenthesis or preceding a left parenthesis is redundant and may be omitted. Neither of these combinations results in a null parameter. A null parameter is indicated by two consecutive commas or by a single comma at the beginning of the variable field. If the blank terminating the variable field is preceded by a comma, the last subfield is not null (see the example in the section "Created Symbols"). An explicit zero must be used to obtain a zero parameter.

Parentheses around data used as a macro-instruction parameter signify that everything within the parentheses, including blanks, is to replace the corresponding substitutable argument in the prototype. (In fact, if blanks are to be included in a macro-instruction parameter, the parameter must be enclosed in parentheses.) For example, the macro-definition

XYZ	MACRO	A,B
	A	
B		
	ENDM	XYZ

followed by the macro-instruction

XYZ	(AXTbbbb10,1)
ETC	(ALPHAabbTRAbbbbBETA,1)

results in the expansion

ALPHA	AXT	10,1
	TRA	BETA,1

If parentheses are to appear in a macro-expansion, they must be enclosed in an outer pair of parentheses. The outer parentheses are removed in the expansion.

Pairs of parentheses must be balanced. For example, given the macro-definition

CALLIO	MACRO	IOCOM,T1,OP,LABEL,T2
	ETC	TAPNO,PFX,ERRET
	TSX	(TAPE),4
	PZE	IOCOM,T1,OP
	PZE	LABEL,T2,TAPNO
	IFT	ERRET=1
	PFX	ERRET
	ENDM	CALLIO

and using the following parameters in place of the substitutable arguments

IOCOM – CITIO	T2 – null
T1 – 2	TAPNO – CITTAP
OP – (RBEP)	PFX – null
LABEL – CITLB	ERRET – null

the corresponding macro-instruction would be

```
CALLIO  CITIO,2,( (RBEP) ),CITLB
ETC     ,CITTAP,,
```

This macro-instruction could also be written

```
CALLIO  CITIO,2( (RBEP) )CITLB
ETC     ,CITTAP,,
```

since the commas around ((RBEP)) are redundant.

Note that TAPE must not be a substitutable argument and that (RBEP) must be enclosed in outer parentheses. Also, an explicitly null parameter appears in the macro-instruction at a position corresponding to the substitutable argument ERRET in the macro-definition. This null parameter causes the fifth word of the expansion to be omitted.

Inserting Instructions into Macro-Expansions

A single parameter in a macro-instruction may include more than one field or even an entire instruction to replace a single substitutable argument that appeared in a field of a prototype instruction. The parameter is inserted into the field in which the original substitutable argument appeared, and it may extend to other fields to the right of the field in which it is inserted. For example, if a substitutable argument appeared in the operation field of a prototype instruction, a parameter could be inserted that would have an operation field and a variable field.

When a parameter consists of more than one field or is an entire instruction, the programmer must provide enough blanks in the parameter so that the fields of the instruction appear in their proper positions in the macro-expansion.

In the following example, a substitutable argument in the operation field of a prototype instruction is replaced by an instruction having an operation field and a variable field. The macro-definition.

```
XYZ      MACRO  A,B,C,
          CLA   A
          B
          STO   C
          ENDM  XYZ
```

followed by the macro-instruction

```
SUM      XYZ      ALPHA(ADDbbbbbbBETA)
          ETC     GAMMA
```

results in the macro-expansion

```
CLA     ALPHA
ADD     BETA
STO     GAMMA
```

Conditional Assembly in Macro-Operations

The IFT and IFF pseudo-operations may be used to de-

termine whether instructions within a macro-expansion are assembled. For example, the sequence

```
ADDM    MACRO  B,C,D
          CLA   B
          ADD   C
          IFF   /D/= /AC/
          STO   D
```

allows the sum to be stored if the name substituted for D is not literally the characters AC and prevents it from being stored if the name is the characters AC.

If the IFF pseudo-operation in the above example were replaced by

```
IFT     D=1
```

the sum would be stored only if the parameter substituted had already appeared in the name field of some instruction (i.e., if the S-value of D is 1).

The two conditions can be combined to obtain

```
IFF     /D/= /AC/,AND
IFT     D=1
```

which assembles the store operation only if D is not literally AC and has appeared before in a name field.

Combining Substitutable Arguments and Text

The apostrophe can be used to combine substitutable arguments and text to form a single prototype subfield. The apostrophe delimits a substitutable argument in a macro-definition prototype but is not itself included in the macro-expansion. However, the apostrophe may not be used to combine partial subfields in lower-level nested macro-definitions (see the section "Nested Macro-Operations").

For example, given the macro-definition

```
ALPHA    MACRO  A,B,C
          BCI   A,bb'B'bERROR,b
                CONDITION'C'b
                IGNORED
          ENDM  ALPHA,NOCRS
```

the macro-instruction

```
ALPHA    6,(FIELD),,
```

causes the following instruction to be generated:

```
BCI      6,bbFIELDbERROR,b
          CONDITIONb
          IGNORED
```

By using the apostrophe, instructions within macro-operations can be altered and even name field symbols can be changed. For example, the macro-definition

```
FXYCY    MACRO  B,W,Z,Y,T
          N'B   PXA  Y,T
          PAC   0,4
          'W'X'Z Y,4
          ENDM  FXCY
```

after the macro-instruction

```
FXYCY    AME,S,A,DATA,1
```

results in the sequence

NAME	PXA	DATA,1
	PAC	0,4
	SXA	DATA,4

The name field may not exceed six characters in the prototype, including substitutable arguments, text, and punctuation characters. The operation field may not exceed six characters or six characters and an asterisk.

Nested Macro-Operations

A macro-definition may be included completely within the prototype of another higher-level macro-definition. When the higher-level macro-operation is expanded, the `MACRO` pseudo-operation and the prototype of the lower-level macro-operation are generated. Thus, a macro-instruction for a lower-level macro-operation cannot be used until all higher-level macro-operations have been expanded.

A new macro-operation may be defined or an existing macro-operation redefined, depending on whether the name of the lower-level macro-operation appears as text or as a substitutable argument in the higher-level macro-operation. For example, in the macro-definition

MAC1	MACRO	MAC2,ALPHA,BETA
	ETC	GAMMA,DELTA
MAC2	MACRO	ALPHA
	BETA	A
	GAMMA	B
	DELTA	C
	ENDM	MAC2
	ENDM	MAC1

the lower-level macro-operation, `MAC2`, appears as a substitutable argument. The macro-instruction

```
MAC1 ABC,(A,B,C),CLA,ADD,STO
```

generates

ABC	MACRO	A,B,C
	CLA	A
	ADD	B
	STO	C
	ENDM	ABC

which defines a macro-operation, `ABC`, where `A`, `B`, and `C` are substitutable arguments; and `CLA`, `ADD`, and `STO` are text.

However, had `MAC2` appeared as text rather than as a substitutable argument in the macro-definition of `MAC1`, `MAC2` would be redefined each time `MAC1` was expanded.

There is no significant limit to the depth of nesting permitted.

Macro-Instructions in Macro-Definitions

The prototype of a macro-definition may include macro-instructions for which macro-operations have not yet been defined. However, these macro-instructions must be defined before using a macro-instruction that expands the macro-operation. Circular definition

must be avoided. For example, a macro-operation, `A`, may not include a macro-instruction for `A`. Also, a macro-operation may not include its own macro-instruction within the prototype.

Data enclosed within parentheses may be used as a parameter in a macro-instruction. When a macro-instruction is used within another macro-definition, special handling of data containing blanks is required. Such data must be replaced by a substitutable argument in the outer macro-definition. The actual data must appear as a parameter in the macro-instruction. An additional pair of parentheses must surround the data (already within a single pair of parentheses) to ensure proper substitution.

For example, in the macro-definition

MAC1	MACRO	A,C
	CLA	C
	MAC	A,(AXTbb**,4b)
	STO	A
	ENDM	MAC1

`MAC` is a previously defined macro-operation. Proper substitution would not occur, because a blank terminates the variable fields of prototype instructions except for the `BCI`, `REM`, and `TTL` pseudo-operations. Instead, the following sequence should be used:

MAC1	MACRO	A,C,D
	CLA	C
	MAC	A,D
	STO	A
	ENDM	MAC1

When using the macro-instruction `MAC1`, the substitution would be

```
MAC1 X,Y,((AXTbb**,4b))
```

The resulting generated sequence is

CLA	Y
MAC	X,(AXTbb**,4b)
STO	X

The macro-instruction for `MAC` can now cause the data to be substituted properly.

Qualification Within Macro-Operations

The qualification in effect when the macro-instruction is used will be used for symbols in the macro-expansion. If a qualification symbol is required within a macro-definition, it may be a substitutable argument, as may the symbols it qualifies.

If a macro-expansion having a qualified section falls within the range of a qualified section in the program, the rules for nested qualification apply when referring to symbols within the macro-expansion.

Macro-Related Pseudo-Operations

The `IRP` pseudo-operation is used to supplement the definition of macro-operations, whereas `ORCCRS` and `NOCRS` are used in macro-expansions.

The IRP Pseudo-Operation

The IRP (Indefinite Repeat) pseudo-operation causes a sequence of instructions within a macro-operation to be repeated with one parameter varied at each repetition. The format of the IRP pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	IRP	1. A single substitutable argument, or 2. Blanks

To repeat a sequence of instructions, two IRP pseudo-operations are required within a macro-definition — one to initiate the sequence and the other to end it. A single substitutable argument that originally appeared in the variable field of the preceding MACRO pseudo-operation must appear in the variable field of the initial IRP pseudo-operation. The variable field of the second IRP pseudo-operation is left blank.

For example, the operation

```
IRP    A
```

initiates a sequence, whereas

```
IRP
```

ends the sequence.

Substitutable argument A governs the iteration of the instructions. If a symbol other than a single substitutable argument or more than one subfield appears in the variable field of the first IRP pseudo-operation, the pseudo-operation is ignored and a warning message is issued.

In the macro-instruction, substitutable argument A is replaced by one or more subarguments enclosed in parentheses and separated by commas. Each time the macro-instruction is used, the assembly program generates the sequence of instructions with each of the subarguments used successively in place of suitable argument A. If only one subargument is used, the sequence of instructions will be generated only once. If no subarguments are given, the whole sequence will be skipped. If a blank appears within the parentheses, only the arguments to the left of the blank will be effective. For example, given the macro-definition

```
XYZ    MACRO  ARG,B
      IRP    ARG
      CLA   ARG
      ADD   B
      STO   ARG
      IRP
      ENDM  XYZ
```

the macro-instruction

```
XYZ    (J,K,L),CONST
```

generates

```
CLA    J
ADD    CONST } (First iteration, with
STO    J      } subargument J)
CLA    K
ADD    CONST } (Second iteration, with
STO    K      } subargument K)
CLA    L
ADD    CONST } (Third iteration, with
STO    L      } subargument L)
```

If the substitutable argument does not appear between the two IRP pseudo-operations, the generated sequences will be identical, their number depending on the number of subarguments given.

For example, given the macro-definition

```
BBB    MACRO  C,D,E
      IRP    C
      CLA   D
      STO   E
      IRP
      ENDM  BBB
```

the macro-instruction

```
BBB    (1,2,3),DATA1,DATA2
```

generates

```
CLA    DATA1
STO    DATA2
CLA    DATA1
STO    DATA2
CLA    DATA1
STO    DATA2
```

An IRP pseudo-operation may not occur explicitly within the range of another IRP. Such a nested pair causes termination of the first range and opening of a second range. However, a macro-instruction within the range of an IRP pseudo-operation may itself cause pairs of IRP pseudo-operations to be generated at a lower level.

Created Symbols

If parameters are missing from the end of the variable field of the macro-instruction, symbols are created to fill the vacancies. These symbols take the form

```
..0001
..0002
.
.
.
..nnnn
```

No created symbols are supplied for an explicitly null argument. Created symbols are supplied only at the end of the parameters.

For example, if the MACRO pseudo-operation

```
ALPHA  MACRO  A,B,C
```

is followed by the macro-instruction

```
ALPHA  X,,
```

substitutable argument A is replaced by X, substitutable argument B is omitted since the parameter is explicitly void, and substitutable argument C is replaced by a symbol of the form . . nnnn. This symbol is created to replace the omitted parameter at the end of the variable field of the macro-instruction.

Given the macro-definition

```

XFAD      MACRO  N,B,C,D,E,A,X
          SXA   A,4
          AXT   N,4
X         CLA   B,4
          IFF   /C/=//
          F'C   D,4
          STO   E,4
          TIX   X,4,1
A         AXT   **,4
          ENDM  XFAD,CRS

```

the macro-instruction

```

          XFAD  4,DATA,AD,DATA1,DATA2

```

generates

```

          SXA   ..0001,4
          AXT   4,4
..0002   CLA   DATA,4
          FAD   DATA1,4
          STO   DATA2,4
          TIX   ..0002,4,1
..0001   AXT   **,4

```

However, the macro-instruction

```

          XFAD  4,DATA,,,DATA2

```

generates

```

          SXA   ..0001,4
          AXT   4,4
..0002   CLA   DATA,4
          STO   DATA2,4
          TIX   ..0002,4,1
..0001   AXT   **,4

```

In this example, the number of instructions can vary between references, making a relative-address reference difficult. However, by permitting the assembly

program to generate the names, the references are correct without requiring programmer-specified names.

The NOCRS Pseudo-Operation

The NOCRS pseudo-operation suppresses symbol creation, which causes missing parameters at the end of the variable field of the macro-instruction to be treated as if they were explicitly null. The format of the NOCRS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	NOCRS	Ignored

The ORGCRS Pseudo-Operation

The ORGCRS pseudo-operation may be used to alter the form of created symbols. This pseudo-operation also causes symbol creation to be resumed if it has been suppressed by a NOCRS. The format of the ORGCRS pseudo-operation is:

NAME FIELD	OPERATION FIELD	VARIABLE FIELD
Blanks	ORGCRS	1. Blanks, or 2. Up to 4 numeric digits, or 3. One BCD character and up to 4 numeric digits.

If a BCD character appears in the variable field, it replaces the second period of the created symbols. If digits appear, they will be the origin of the new set of created symbols. This origin will be one lower than the first symbol actually created. If fewer than four digits are used, they will be right-justified with leading zeros. If no digits are supplied or if the variable field is blank, the number will continue from the last created symbol.

With a blank variable field, the ORGCRS pseudo-operation causes resumption or continuation of symbol creation.

Appendix A: Machine Operations

All machine operations recognized by MAP are tabulated in this appendix, including supplementary information about their format and use. Listings are provided of the 7090 machine operations, extended machine operations, special operations, 7094 machine operations, 7909 data channel commands, 1301 disk file orders, and 7340 Hypertape orders.

The code letters used under identical column headings have the same significance in all tables. The bcd name of the machine operation is given in the column headed Mnemonic.

Type indicates machine-instruction format characteristics by code letters having the following meanings:

CODE	MEANING
A	15-bit decrement field
B	No decrement field
C	8-bit decrement field
D	18-bit address field
E	13-bit address field
K	4-bit prefix field
L	Disk orders

The codes in the address (Addr), tag, and decrement (Decr) columns signify:

CODE	MEANING
R	Subfield required. If missing, error message FIELD REQUIRED is issued.
P	Subfield permitted. Neither its presence nor absence results in a message.
U(n)	Subfield unexpected. If present, message FIELD NOT EXPECTED is issued. Assembly program truncates definition value of subfield to number of bits (n) shown in parentheses and, treating this value as a constant, adds it to value normally appearing in subfield.
N	Subfield not allowed. If present and its value is not zero, message FIELD NOT ALLOWED is issued. Its value is always treated as a constant zero.

If the size of a subfield differs from normal, field size is indicated in parentheses following the subfield letter code.

In the column headed Ind, the letter (P) indicates that indirect addressing is permitted and (N) indicates that it is not permitted.

7090 Machine Operations

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
ACL	B	R	P	U(4)	P
ADD	B	R	P	U(4)	P
ADM	B	R	P	U(4)	P
ALS	B	R	P	U(6)	N
ANA	B	R	P	U(4)	P
ANS	B	R	P	U(4)	P

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
ARS	B	R	P	U(6)	N
AXC	B	R	R	U(6)	N
AXT	B	R	R	U(6)	N
BSF	B	R	P	U(6)	N
BSR	B	R	P	U(6)	N
BTT	E	R	P	U(6)	N
CAL	B	R	P	U(4)	P
CAQ	C	R	P	R(8)	N
CAS	B	R	P	U(4)	P
CHS	E	N	P	U(6)	N
CLA	B	R	P	U(4)	P
CLM	E	N	P	U(6)	N
CLS	B	R	P	U(4)	P
COM	E	N	P	U(6)	N
CRQ	C	R	P	R(8)	N
CVR	C	R	P	R(8)	N
DCT	E	N	P	U(6)	N
DVH	B	R	P	U(4)	P
DVP	B	R	P	U(4)	P
ECTM	E	N	P	U(6)	N
EFTM	E	N	P	U(6)	N
ENB	B	R	P	U(4)	P
ENK	E	N	P	U(6)	N
ERA	B	R	P	U(4)	P
ESNT	B	R	P	U(4)	P
ESTM	E	N	P	U(6)	N
ETM	E	N	P	U(6)	N
ETT	E	R	P	U(6)	N
FAD	B	R	P	U(4)	P
FAM	B	R	P	U(4)	P
FDH	B	R	P	U(4)	P
FDP	B	R	P	U(4)	P
FMP	B	R	P	U(4)	P
FRN	E	N	P	U(6)	N
FSB	B	R	P	U(4)	P
FSM	B	R	P	U(4)	P
HPR	B	P	P	U(6)	N
HTR	B	R	P	U(4)	P
IIA	B	P	P	U(6)	N
IIL	D	R(18)	N	U(6)	N
IIR	D	R(18)	N	U(6)	N
IIS	B	R	P	U(4)	P
IOT	E	N	P	U(6)	N
IOCD	A	R	N	R	P
IOCP	A	R	N	R	P
IORP	A	R	N	R	P
IOCT	A	R	N	R	P
IORT	A	R	N	R	P
IOSP	A	R	N	R	P
IOST	A	R	N	R	P
LAC	B	R	R	U(6)	N
LAS	B	R	P	U(4)	P
LBT	E	N	P	U(6)	N
LCHx	B	R	P	U(4)	P
LDC	B	R	R	U(6)	N
LDI	B	R	P	U(4)	P
LDQ	B	R	P	U(4)	P
LFT	D	R(18)	N	U(6)	N
LFTM	E	N	P	U(6)	N
LGL	B	R	P	U(6)	N
LGR	B	R	P	U(6)	N
LLS	B	R	P	U(6)	N
LNT	D	R(18)	N	U(6)	N
LRS	B	R	P	U(6)	N

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
LSNM	E	N	P	U(6)	N
LTM	E	N	P	U(6)	N
LXA	B	R	R	U(6)	N
LXD	B	R	R	U(6)	N
MPR	B	R	P	U(4)	P
MPY	B	R	P	U(4)	P
MSE	E	R	P	U(6)	N
NOF	B	P	P	U(6)	N
NZT	B	R	P	U(4)	P
OAI	B	P	P	U(6)	N
OFT	B	R	P	U(4)	P
ONT	B	R	P	U(4)	P
ORA	B	R	P	U(4)	P
ORS	B	R	P	U(4)	P
OSI	B	R	P	U(4)	P
PAC	B	P	R	U(6)	N
PAI	B	P	P	U(6)	N
PAX	B	P	R	U(6)	N
PBT	E	N	P	U(6)	N
PDC	B	P	R	U(6)	N
PDX	B	P	R	U(6)	N
PIA	B	P	P	U(6)	N
PSE	E	R	P	U(6)	N
PXA	B	P	R	U(6)	N
PXD	B	P	R	U(6)	N
RCHx	B	R	P	U(4)	P
RCT	E	N	P	U(6)	N
RDCx	E	N	P	U(6)	N
RDS	B	R	P	U(6)	N
REW	B	R	P	U(6)	N
RFT	D	R(18)	N	U(6)	N
RIA	B	P	P	U(6)	N
RIL	D	R(18)	N	U(6)	N
RIR	D	R(18)	N	U(6)	N
RIS	B	R	P	U(4)	P
RND	E	N	P	U(6)	N
RNT	D	R(18)	N	U(6)	N
RQL	B	R	P	U(6)	N
RUN	B	R	P	U(6)	N
SBM	B	R	P	U(4)	P
SCHx	B	R	P	U(4)	P
SDN	B	R	P	U(6)	N
SIL	D	R(18)	N	U(6)	N
SIR	D	R(18)	N	U(6)	N
SLQ	B	R	P	U(4)	P
SLW	B	R	P	U(4)	P
SSM	E	N	P	U(6)	N
SSP	E	N	P	U(6)	N
STA	B	R	P	U(4)	P
STD	B	R	P	U(4)	P
STI	B	R	P	U(4)	P
STL	B	R	P	U(4)	P
STO	B	R	P	U(4)	P
STP	B	R	P	U(4)	P
STQ	B	R	P	U(4)	P
STR	A	P	P	P	N
STT	B	R	P	U(4)	P
STZ	B	R	P	U(4)	P
SUB	B	R	P	U(4)	P
SXA	B	R	R	U(6)	N
SXD	B	R	R	U(6)	N
TCH	A	R	N	U(6)	P
TCNx	B	R	P	U(4)	P
TCOx	B	R	P	U(4)	P
TEFx	B	R	P	U(4)	P
TIF	B	R	P	U(4)	P
TIO	B	R	P	U(4)	P
TIX	A	R	R	R	N
TLQ	B	R	P	U(4)	P
TMI	B	R	P	U(4)	P
TNO	B	R	P	U(4)	P
TNX	A	R	R	R	N

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
TNZ	B	R	P	U(4)	P
TOV	B	R	P	U(4)	P
TPL	B	R	P	U(4)	P
TQO	B	R	P	U(4)	P
TQP	B	R	P	U(4)	P
TRA	B	R	P	U(4)	P
TRCx	B	R	P	U(4)	P
TSX	B	R	R	U(6)	N
TTR	B	R	P	U(6)	P
TXH	A	R	R	R	N
TXI	A	R	R	R	N
TXL	A	R	R	R	N
TZE	B	R	P	U(4)	P
UAM	B	R	P	U(4)	P
UFA	B	R	P	U(4)	P
UFM	B	R	P	U(4)	P
UFS	B	R	P	U(4)	P
USM	B	R	P	U(4)	P
VDH	C	R	P	R(6)	P
VDP	C	R	P	R(6)	P
VLM	C	R	P	R(6)	P
WEF	B	R	P	U(6)	N
WRS	B	R	P	U(6)	N
XCA	B	P	P	U(6)	N
XCL	B	P	P	U(6)	N
XEC	B	R	P	U(4)	P
ZET	B	R	P	U(4)	P

Extended Operations

MAP provides a group of sense and select-type extended operation codes for programmer convenience. These codes permit the address portion of certain instructions to be specified symbolically as part of the operation code, rather than octally in the address portion of the instruction. These codes also provide more meaningful mnemonics for some machine instructions.

MAP also recognizes a group of prefix codes that can be used in such programming applications as forming constants or in subroutine calling sequences.

SENSE TYPE

The following extended operation codes of the sense type are recognized by the assembly program. The tag subfield is permitted in all these operation codes, but indirect addressing is not permitted in any of them. The letter x is to be replaced by one of the channel letters.

MNEMONIC	ADDR	DECR
BTTx	N	U(6)
ETTx	N	U(6)
SLF	N	U(6)
SLN	R	U(6)
SLT	R	U(6)
SPRx	R	U(6)
SPTx	N	U(6)
SPUx	R	U(6)
SWT	R	U(6)

SELECT TYPE

The following extended operation codes of the select type are recognized by the assembly program. The tag subfield is permitted in all these operation codes, but

cross-referencing problems of multiple source decks and their required subroutines from the Subroutine Library, and with overlay analysis. It processes the control information tables that are built by Section 1 and builds up the object program file blocks from the \$FILE cards stored in that control information storage block.

The principal task of Section 3 is to provide unit assignment for the object program; to give absolute location assignments to each program deck, each subroutine, and the control sections of both; to apportion the unused part of core storage as input/output buffers for the object program; to generate the iocs calling sequences to define those buffer pools; and to provide a map of the complete object program core storage use. (The map feature of the Loader provides an outline-like picture of the assignment of core storage to the object program).

The input/output unit assignment provides for absolute channel, symbolic channel, and between-application symbolic or reserve channel specification of input/output devices. Provision is also made for absolute assignment of disk areas, drum areas, and Hypertape drives. If necessary, file mounting instructions to the operator are printed by Section 3.

Section 4 of the Loader is read into the core storage area occupied by Section 2. Its main function is to form the final, absolute instructions from the relocatable binary text of the input program and from any subroutine on the library unit which is required by the program.

The input to Section 4 consists of the relocatable binary text of both the input program and subroutines. Input program text may appear as follows:

1. In an internal file.
2. In an internal file and on the System Utility Unit (SYSUT3) — the source text overflow tape, or
3. On the System Utility Units (SYSUT3 and SYSUT4) — the internal text overflow.

Subroutine texts are read from the Subroutine Library tape and are processed in the same manner as program texts. Subroutines are called as determined by their appearance in the required Subroutine Name Table that was formed by Section 2 of the Loader.

The final text is put into an internal file, and onto the System Utility Unit (SYSUT1) if necessary, for pre-execution loading by Section 5 of the Loader. For overlay applications, output can also be on one of the System Library Units. A call to the program to be executed first is generated according to the \$ENTRY card or, in its absence, to the section whose name is ' ' or, in its absence, to the first program deck encountered.

Section 5, the final phase of the Loader, loads the processed absolute program text into its proper core

storage locations and prepares for its execution. The lower half of the program area is set to STRS, and the absolute text contained in the internal file in the upper portion of core storage is scatter-loaded into this lower half. The internal file area is then set to STRS. Absolute text will not be loaded above the locations required by Section 5 for loading the overflow text appearing on the System Utility Unit (SYSUT1). At the completion of the program load, the function of the Loader ends and control is transferred to the generated initialization instructions.

Relocatable Binary Program Deck

A relocatable binary program deck consists of relocatable binary text, the control dictionary, and the file dictionary. This section defines the deck order and format of the relocatable binary text, the control dictionary, and the file dictionary.

Binary Card Format

The following column binary card form is used:

Word 1	S, 1	11 (examine bit 3)
	2	check sum control bit
		0 = verify check sum
		1 = do not verify check sum
	3	0 (standard IBJOB Processor deck)
	4	0 (Loader or relocatable deck, not Prest)
	5-7	deck type
	8-12	01010
	13-17	word count (beginning with word 3)
	21-35	card sequence number
Word 2	S, 1-35	logical check sum of word 1 and all data words on the card
Words 3-24	S, 1-35	data

Binary Card Sections

A binary program deck is composed of three sections, each prefaced by an alphameric source card identifying the section type. The deck format, exclusive of control cards, is as follows:

COLUMN 1	COLUMN 8
\$FDICT	DECKNM Binary File Dictionary
\$TEXT	DECKNM Relocatable Binary Text
\$CDICT	DECKNM Binary Control Dictionary
\$DKEND	DECKNM

Each section of the binary deck (e.g., the control dictionary) and text is sequenced independently, beginning with sequence number 0. Within any section, the cards must be in proper sequence and the sections

MNEMONIC	TYPE	ADDR	TAG	DECR	IND
TWT	K	R	N	N	P
WTR	A	R	N	U(4)	P
XMT	A	R	N	R	P

(1) A count field in the high-order position of the decrement is assembled from the fourth subfield of the variable field.
For example,

ICC ,,,4

IBM 1301 Disk and 7320 Drum File Orders

The following disk and drum file orders are recognized by MAP. The symbolic order should be written:

Location DORD access and module, track, record
and assembles as ten BCD digits in two successive locations.

MNEMONIC	ACCESS AND MODULE	TRACK	RECORD
DEBM	P	P	P
DNOP	P	P	P
DREL	P	P	P
DSAI	P	P	P
DSBM	P	P	P
DSEK	P	P	P
DVCY	P	P	P
DVHA	P	P	P
DVSR	P	P	P
DVTA	P	P	P
DVTN	P	P	P
DWRC	P	P	P
DWRF	P	P	P

The access/module and track subfields may be any symbolic expression. They are evaluated in the normal manner and converted to BCD. The low-order two characters of the access/module subfield and the low-order four characters of the track subfield are inserted into the instruction. The record subfield is taken as alphabetic data, and the first two characters are used. A DNOP (1212₈) order is inserted in the last two character positions of the second word.

IBM 7340 Hypertape Orders

The following Hypertape orders are recognized by MAP. The symbolic order should be written:

Location HORD Tape unit (if required)

and assembles as two (or three for HSBR and HSEL) BCD characters, left-justified in the word. Locations containing two-character orders are filled with trailing HNOP (1212₈) codes. Three-character orders are repeated in the rightmost three characters.

MNEMONIC	TAPE UNIT
HBSF	N
HBSR	N
HCCR	N
HCHC	N
HCLN	N
HEOS	N
HERG	N
HFPN	N
HNOP	N
HRLF	N

MNEMONIC	TAPE UNIT
HRLN	N
HRUN	N
HRWD	N
HSBR	R
HSEL	R
HSKF	N
HSKR	N
HUNL	N
HWTM	N

Any symbolic expression may be used in the tape unit subfield. The expression is evaluated and converted to BCD, and the low-order character is used as the Hypertape unit number (0-9).

Appendix B: 7090 Macro-Expansions of 7094 Instructions

When assembling in the 7090 mode, certain 7094 instructions are replaced by equivalent 7090 macro-instructions. The expansions of these macro-instructions are provided in this appendix.

The expansions are divided into groups in which only a few instructions vary from the given operation code. The generic macro-expansion of each group is given with the necessary substitutions.

In this appendix, the symbols E.1, E.2, E.3, and E.4 are generated by the expansions as names of temporary storage locations. However, these symbols must be defined by the programmer or they will be virtual. The symbol is generated and defined by the expansion even if the mode of the created symbol switch is NOCRS.

Group 1. PCA and PCD

For PCA, take w = A and z = 20.

For PCD, take w = D and z = 2.

The expansion is then

PCw	Y,T	PXw	Y,T
		TZE	*+3
		SUB	=1Bz
		SSP	

Group 2. SCA and SCD

For SCA, take w = A.

For SCD, take w = D.

The expansion is then

SCw	Y,T	SXA	*+1,T
		AXC	**T
		SXw	Y,T
		LXA	*-2,T

Group 3. DFAD, DFSB, DFAM, and DFSM

For DFAD, take op = AD.

For DFSB, take op = SB.

For DFAM, take op = AM.

For DFSM, take op = SM.

In this and the following groups, the expansion below is also used:

(SAVE	Y,T	NOP	Y,T
		STO	E.1
		CLA*	*-2
		STA	*+2
		STT	*+1
		PXA	,0
		SUB	*-1
		SXA	CRS,4
		PAC	0,4
		CLA	E.1

There are four forms for these expansions:

DFop	Y,T	STQ	E.1
		Fop	Y,T
		STO	E.2
		XCA	
		FAD	E.1
		Fop	Y+1,T
		FAD	E.2
DFop	** ,T	NOP	,T
		STQ	E.1
		Fop*	*-2
		STO	E.2
		TXI	*+1,T,-1
		XCA	
		FAD	E.1
		Fop*	*-7
		FAD	E.2
		TXI	*+1,T,1
DFop or DFop	** ** ,0	AXT	,0
		SXA	CRS,4
		LAC	*-2,4
		DFop	0,4
		AXT	,4
DFop*	CRS Y,T	(SAVE	Y,T
		CLA	E.1
		DFop	0,4
	CRS	AXT	,4

Group 4. DLD and DST

For DLD, take op = LD, opa = CLA, and opb = LDQ.

For DST, take op = ST, opa = STO, and opb = STQ.

There are four forms for these expansions:

Dop	Y,T	opa	Y,T
		opb	Y+1,T
Dop	** ,T	opa	,T
		TXI	*+1,T,-1
		opb*	*-2
		TXI	*+1,T,1
Dop or Dop	** ** ,0	opa	0
		SXA	*+3,4
		LAC	*-2,4
		opb	1,4
		AXT	,4

Dop* Y,T

(SAVE	Y,T
IFT	/opa/= /STO/
CLA	E.1
opa	0,4
opb	1,4
AXT	** ,4

CRS

Group 5. DFMP

There are four forms for this expansion:

DFMP	Y,T	STO	E.1
		FMP	Y,T
		STO	E.2
		LDQ	Y,T
		FMP	E.1
		STQ	E.3
		STO	E.4
		LDQ	Y+1,T
		FMP	E.1
		FAD	E.2
		FAD	E.3
		FAD	E.4
DFMP	** ,T	NOP	** ,T
		STO	E.1
		FMP*	*-2
		STO	E.2
		LDQ*	*-4
		FMP	E.1
		STQ	E.3
		STO	E.4
		TXI	*+1,T,-1
		LDQ*	*-9
		TXI	*+1,T,1
		FMP	E.1
		FAD	E.2
		FAD	E.3
		FAD	E.4
DFMP or DFMP	** ** ,0	AXT	** ,0
		SXA	CRS
		LAC	*-2,4
		DFMP	0,4
		AXT	** ,4
DFMP*	CRS Y,T	(SAVE	Y,T
		CLA	E.1
		DFMP	0,4
	CRS	AXT	** ,4

Group 6. DFDP and DFDH

For DFDP, take w = P.

For DFDH, take w = H.

There are four forms for these expansions:

DFDw	Y,T	STQ	E.1
		FDw	Y,T
		STO	E.2
		STQ	E.3
		FMP	Y+1,T
		CHS	
		FAD	E.2
		FAD	E.1
		FDw	Y,T
		XCA	
		FAD	E.3

DFDw	** ,T	NOP	,T
		STQ	E.1
		FDw*	*-2
		STO	E.2
		STQ	E.3
		TXI	*+1,T,-1
		FMP*	*-6
		CHS	
		FAD	E.2
		FAD	E.1
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		FAD	E.3
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		DFDw	0,4
	CRS	AXT	** ,4

Appendix C: Operation Code Formats

The operation code formats to be used with the OPD and OPVFD pseudo-operations are given in this appendix.

Operations

Entries are made in the Combined Operations Table for all OPD and OPVFD pseudo-operations, since the lookup process is the same as for any other symbol. To specify machine operations using OPVFD, the general form of this entry is

6/A,5/0,1/IND,2/ADD,2/TAG,2/DEC,18/V

where each group of bits in the instruction word is specified by an octal number. The same general form is used for OPD except that the 36-bit word is specified as a whole by a 12-digit octal number that will result in the same bit structure.

In this format, V varies with adjective code A (described below). The fields ADD, TAG, and DEC refer to address, tag, and decrement, respectively. The following code is used:

- 0 Field required
- 1 Field permissible
- 2 Field unexpected but allowed
- 3 Field not permissible

A 1 for IND indicates that indirect addressing is permitted, and a 0 indicates that it is not permitted.

The seven bits specifying fields IND, ADD, TAG, and DEC are denoted by FR (Fields Required).

Adjective Codes

The following list of octal adjective codes gives the type of operation to which each applies.

CODE (OCTAL)	OPERATION TYPE
40	A
41	Prefix
42	Input/Output Command
43	B
44	C
45	D
46	E
47	Select
50	Disk and Drum Channel Commands (4 fields)
51	Disk and Drum Channel Commands
52	Boolean Variable
53	Disk File and Drum File Orders
54	Unexpanded 7094 Instructions
55	Hypertape Orders

TYPE A INSTRUCTIONS (40)

The entry is

O6/40,O5/0,O7/FR,O6/0,O12/OPCODE

where OPCODE is an octal machine code written with the prefix in the first digit. For example, OPCODE for the instruction TXI would be 1000.

PREFIX OPERATIONS (41)

This entry is

O6/41,O5/0,O7/FR,O6/0,O12/OPCODE

where OPCODE is written with the prefix in the first digit. For example, OPCODE for the instruction PON would be 1000.

INPUT/OUTPUT COMMANDS (42)

The entry is

O6/42,O5/0,O7/FR,O3/N,O3/0,O12/OPCODE

where OPCODE is written with the prefix in the first digit. For example, OPCODE for the instruction TCH would be 1000. If the instruction is a nontransmitting command, N = 2.

TYPE B INSTRUCTIONS (43)

The entry is

O6/43,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE C INSTRUCTIONS (44)

The entry is

O6/44,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE D INSTRUCTIONS (45)

The entry is

O6/45,O5/0,O7/FR,O6/0,O12/OPCODE

TYPE E INSTRUCTIONS (46)

The usual format is

O6/46,O5/0,O7/FR,O3/S,O15/EA

where S is the sign of the operation:

If S = 0, OPCODE would be +0760.

If S = 1, OPCODE would be -0760.

EA is the actual extended address of the instruction.

SELECT INSTRUCTIONS (47)

The entry is

O6/47,O5/0,O7/FR,O3/0,O3/E,O6/C,O6/OPCODE

OPCODE is the Select type, as follows:

- 0=Read
- 1=Write
- 2=Set Density High
- 3=Set Density Low
- 4=Rewind
- 5=Rewind Unload
- 6=Backspace Record
- 7=Backspace File
- 10=Write End of File

C is the channel number of Select, starting at 1 for Channel A.

E is the equipment code and has the following significance:

- 0=Decimal Tape
- 1=Binary Tape; or either Binary or Decimal Tape
- 2=Card Reader
- 3=Punch
- 4=Decimal Printer
- 5=Binary Printer

See "Select Type" operations for specific address field requirements.

DISK AND DRUM CHANNEL COMMANDS (50)

The entry is

O6/50,O5/0,O7/FR,O6/0,O12/OPCODE

DISK AND DRUM CHANNEL COMMANDS (51)

The entry is

O6/51,O5/0,O7/FR,O3/N,O3/0,O12/OPCODE

where N=2 if a 1 in bit position 19 is part of the operation code.

BOOLEAN VARIABLE (52)

The entry is

O6/52,O5/0,O7/FR,O6/0,O12/OPCODE

where the high-order bit of OPCODE is always ON.

DISK FILE AND DRUM FILE ORDERS (53)

The format is

O6/53,O6/0,O2/ACC,O2/TRK,O2/REC,
O6/0,O12/ORCODE

ORCODE is the order, written in external BCD notation.

For example, DREL with an order code of 04 would be written 1204.

The fields ACC, TRK, and REC refer to the access module, track, and record, respectively. Encoding is:

1 Field permissible

UNEXPANDED 7094 INSTRUCTIONS (54)

The entry is

O6/54,O5/0,O7/FR,O6/0,O12/OPCODE

HYPERTAPE ORDERS (55)

The entry is

O6/55,O6/0,O2/ADD,O10/0,O12/OPCODE

Appendix D: IBCMAP-FAP Incompatibilities

This appendix lists the incompatibilities that will occur when assembling a FAP or IBSFAP program using IBCMAP.

1. All FAP machine operations and extended machine operations will assemble properly in MAP.

2. All FAP pseudo-operations pertaining to the update facility have no counterpart in MAP. They are:

DELETE	NUMBER	UMC
ENDFIL	REWIND	UNLOAD
ENDUP	SKIPTO	UPDATE
IGNORE	SKPFIL	

3. The following FAP pseudo-operations have no counterpart in MAP. (Since MAP treats undefined operations as remarks, some of these operations do not affect assembly.)

IFEOF	TAPENO
LOC	704
PRINT	9LP
SST	

4. The following FAP pseudo-operations must be replaced by the indicated MAP equivalent:

FAP	MAP
HEAD,HED	QUAL,ENDQ
BCD	BCI
MOP	MACRO
MAC	Standard macro-instruction
END (of macro)	ENDM
RMT	USE and USE PREVIOUS

(Note that QUAL permits nesting of qualifiers, whereas HEAD does not.)

The following is an example of a program segment coded first in FAP and then in MAP.

FAP	MAP
RMT	
BSS	10
RMT	
.	
.	
.	
ALPHA	RMT *
	EXTERN
	SKP
	SPC
	TSX
	\$SUB,4

MAP

USE	RMT
BSS	10
USE	PREVIOUS
.	
.	
BEGIN	RMT, ALPHA
Leave	
symbols	
undefined	
EJECT	
SPACE	
TSX	SUB,4 (remove all \$ signs that specify external names)

5. The following pseudo-operations have identical names in FAP and MAP but differ in context or meaning:
IFF

Variable field specifications are different.

COMMON

COMMON counter increments forward in MAP.

DUP

In MAP, an S-value may be used for the instruction and iteration counts. A FAP sequence such as

N	EQU	5
	DUP	1,N

must be changed in MAP to

N	SET	5
	DUP	1,N

EQU,SYN

In MAP, these apply to symbol definitions only and cannot be used where an S-value is required; see DUP above.

OPD,OPVFD

The flag bits in the field are different (see Appendix C).

MACRO

In MAP, this is used as

NAME	MACRO	A,B,C,...
------	-------	-----------

and may not be used as

MACRO	
NAME	A,B,C,...

6. The following FAP pseudo-operations have their equivalent option specified on the \$IBMAP card:

REF
7090
COUNT

7. In MAP, the NULL pseudo-operation rather than EQU * should be used for symbol definition, because of the limited size of the Pseudo-Operation Dictionary.

8. The following FAP pseudo-operations will assemble properly in MAP:

ABS	FULL	ORGCRS
BCI	INDEX	PCC
BES	LBL	PMC
BOOL	LIST	REM
BSS	MAX	SET
*CALL	MIN	SPACE
DEC	NOCRS	TCD
DETAIL	NULL	TITLE
EJECT	OCT	UNLIST
ENTRY	OPSYN	TTL
ETC	ORG	VFD

*CALL generates a different calling sequence in MAP.

9. In MAP, virtual entries in the Control Dictionary correspond to the transfer vector of FAP except that IBLDR provides direct rather than indirect references.

10. In MAP, normal arithmetic truncates to 15 bits in the address field, 3 in the tag, and as specified in the decrement. VFD symbolic arithmetic truncates to a maximum of 20 bits. Boolean arithmetic truncates to 18 bits.

Appendix E: The MAP BCD Character Code

The MAP BCD character code is shown in octal form in the following table with the corresponding IBM punched card code.

CHARACTER	BCD CODE (OCTAL)	CARD CODE
(blank)	60	(blank)
0	00	0
1	01	1
2	02	2
3	03	3
4	04	4
5	05	5
6	06	6
7	07	7
8	10	8
9	11	9
A	21	12-1
B	22	12-2
C	23	12-3
D	24	12-4
E	25	12-5
F	26	12-6
G	27	12-7
H	30	12-8
I	31	12-9
J	41	11-1
K	42	11-2
L	43	11-3
M	44	11-4
N	45	11-5
O	46	11-6
P	47	11-7
Q	50	11-8
R	51	11-9
S	62	0-2
T	63	0-3
U	64	0-4
V	65	0-5
W	66	0-6
X	67	0-7
Y	70	0-8
Z	71	0-9
+	(plus)	20
-	(minus)	40
/	(slash)	61
=	(equals)	13
'	(apostrophe)	14
.	(period)	33
)	(right parenthesis)	34
\$	(dollar sign)	53
*	(asterisk)	54
,	(comma)	73
((left parenthesis)	74
		8-4
		12-8-3
		12-8-4
		11-8-3
		11-8-4
		0-8-3
		0-8-4

- ABS pseudo-operation 31
- Absolute assemblies 6, 31
- Absolute-assembly pseudo-operations 6, 31
- Absolute expression 11
- Absolute origin 6, 9, 15
- Absolute symbols 9
- Adjective codes 50
- Alphameric literal 10
- Alphameric subfield in VFD 18
- Assembly-program language 5
- Asterisk (*)
 - as an element 10
 - in indirect addressing 7
 - in relative addressing 12
 - remarks card 8
- BCD character code 52
- BCI pseudo-operation 17
- BEGIN pseudo-operation 14
- BES pseudo-operation 15
- Binary-place part in fixed-point number 10
- Binary transfer card 30, 31
- Bit count of VFD 18
- Blank COMMON 14, 17, 25
- Blank location counter 14
- BOOL pseudo-operation 22
- Boolean expressions 11, 22
- Boolean pseudo-operations 5, 22
- Boolean variable code format 51
- BSS pseudo-operation 15
- CALL pseudo-operation 34
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- Calling sequence 34
- Comments field 7
- COMMON pseudo-operation 17
- Compiler program 5
- Complex expression 11
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- CONTRL pseudo-operation 24
- Control section 24
- Control-section pseudo-operations 5, 24
- Created symbols in macro-operations 43
- "Current" location counter 6
- Data-generating pseudo-operations 5, 17
- Data item, decimal 9
- DEC pseudo-operation 17
- Decimal data item 9
- Decimal integer 9
- Decimal literals 9
- Defining macro-operations 37
- Defining symbols 8
- DETAIL pseudo-operation 32
- Disk channel command format 51
- Disk file order format 51
- Disk file orders 48
- Double-precision literals 10, 16, 19
- DUP pseudo-operation 19
- EJECT pseudo-operation 32
- Elements in expressions 10
- END pseudo-operation 30
- ENDM pseudo-operation 37, 39
- ENDQ pseudo-operation 24
- ENTRY pseudo-operation 25
- EQU pseudo-operation 20
- Error checking 6
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- ETC pseudo-operation 30
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 - floating-point number 9
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 - Boolean 11
 - complex 11
 - elements of 10
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 - block size 27
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 - disk starting cylinder number 28
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 - file close 27
 - file density 27
 - file mounting 26
 - file usage 26
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 - Hypertape reel switching 28
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secondary	25		
File unit-assignment option	25		
Fixed-point number	10		
Floating-point number	9		
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select instruction code	51		
type A instruction code	50		
type B instruction code	50		
type C instruction code	50		
type E instruction code	51		
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octal	10		
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decimal	9		
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IBM 7090/7094 MAP; 7320 CAPABILITY

This Technical Newsletter amends the IBM Systems Reference Library publication, IBM 7090/7094 Programming Systems: Macro Assembly Program (MAP) Language, Form C28-6311-2 to provide direction for using IBM 7320 Drum Storage.

In addition to the prerequisite and related publications listed in the subject manual, the reader is assumed to be familiar with the contents of the publication IBM 7320 Drum Storage with 7090 and 7094 Systems, Form A22-6747.

In the subject publication, replace the pages listed below with the pages that are attached to this newsletter:

1. pages 25 and 26
2. pages 27 and 28
3. pages 29 and 30
4. pages 47 and 48
5. pages 49 and 50
6. pages 51 and 52

After replacing the pages, file or discard this instruction sheet and discard all pages removed from the publication.

A vertical line immediately to the left of the column shows when the text was changed.