July 1978

This document describes how to use the TRAX COBOL compiler. It is a companion guide to the *TRAX COBOL Language Reference Manual.*

TRAX
COBOL User's Guide

Order No. AA-D339A-TC

OPERATING SYSTEM AND VERSION: TRAX Version 1.0

SOFTWARE VERSION: TRAX COBOL V03.5

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CONTENTS

CONTENTS (Cont.)

CONTENTS (Cont.)

FIGURES

Page

FIGURES (Cont.)

Page

FIGURES (Cont.)

Page

FIGURES (Cont.)

TABLES

Page

TABLES (Cont.)

PREFACE

The TRAX COBOL User's Guide is intended primarily for reference use. It is a companion guide to the TRAX COBOL Language Reference Manual. Because it is not a tutorial guide for beginning programmers, you should have a working knowledge of the COBOL language.

This guide describes the COBOL file structures, data formats, some of the features of the TRAX COBOL compiler, error messages generated by the compiler and I/O devices available with the system. Some hints on good programming practices, some techniques for debugging source programs, and a description of the TRAX COBOL utility programs ODL MERGE and REFORMAT are also discussed.

Those wishing to learn the COBOL language should obtain the following tutorial manuals:

Farina, Mario V., COBOL Simplified,
New Jersey, Prentice Hall, Inc., 1968.

McCameron, Fritz A., COBOL Logic and Programming,
Homewood, Illinois, Richard D. Irwin, Inc., 1970

McCracken, Daniel D. and Garbassi, Umberto,
A Guide to COBOL Programming, Second Edition,
New York, John Wiley and Sons, Inc., 1970

NOTE

These publication dates are the latest available. They will all probably be revised to reflect ANS-74 standards.

The TRAX COBOL compiler accepts COBOL language elements that are a true subset of ANS-74 COBOL.

ACKNOWLEDGMENT

COBOL is an industry language and is not the property of any company or group of companies, or of any organization or group of organizations.

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CHAPTER 1

INTRODUCTION

Before a program can be run on a computer, it must be translated from the form that a person can understand (near-English) into a form that a computer can understand (machine language). This translation is performed by COBOL compiler systems. Because each manufacturer's system has its own unique machine language, each system has its own COBOL compiler. The COBOL compiler for the TRAX system is the TRAX COBOL compiler.

The TRAX COBOL compiler translates ANS-74 COBOL source programs into relocatable object modules. The compiler runs under the supervision of TRAX and conforms to all TRAX conventions and restrictions.

NOTE

The purpose of this manual is to instruct you in the preparation of COBOL programs in the TRAX support environment. Detailed information pertinent to preparation of COBOL programs (TST's) in the TRAX applications environment can be found in the TRAX Application Programmer's Guide (AA-D329A-TC).

The compiler itself requires disk storage space for its work file system and temporary files. (The work file system requires a minimum of 128 blocks to a maximum of 512 blocks. The temporary file and object program file requirements grow in proportion to the size of the source program.)

To run a COBOL program, you follow a five-step process:

- Prepare a source program
- Compile a source program to produce object files
- Merge or prepare an overlay description file (optional)
- Link the object files to form an executable task
- Execute the task

The TRAX COBOL compiler accepts COBOL source statements from source input files. This means that you must manually enter your source statements into a TRAX support terminal prior to the compilation process (Section 2.2).

Once you have decided upon a format for your source input files and have created them, you compile the source program.

The TRAX COBOL compiler reads source statements from the source input file, translates them into object code modules consisting of program sections (PSECTs), and produces the following files:

- Listing (LST)
- Object (OBJ)
- Overlay Description Language (ODL)

The listing file (LST) contains a listing of source statements in the order compiled, any diagnostic error messages, and any optional special format listings, such as cross-reference listings and data and procedure maps. You obtain special format listings by appending an appropriate switch to the COBOL command line at compile-time, (see Section 2.4, Compiler Switches).

The object file (OBJ) contains a collection of program sections called PSECTs which are not executable. They must be linked into an executable task image by an operating system task called TRAX Linker. The ability to compile COBOL subprograms to produce linkable object files independently, enables you to create modular programs.

The Overlay Description Language (ODL) file contains directives that describe the overlay structure of the object module generated from the COBOL source program. ODL directives are generated into the ODL file for each overlayable object module program section.

The ODL file generated by the compiler is not a complete ODL file. You must either hand-tailor the ODL file, build your own specialized version, or specify the compiler-generated ODL file as input to the Merge Utility to complete the file (see Section 2.6, Using the Merge Utility; and Chapter 10, Hand-Tailoring ODL Files).

The compiler can compile only one source program or subprogram per command string execution. Therefore, a program which consists of a main program plus one or more subprograms requires multiple executions of the compiler. Each compilation generates a separate listing, ODL, and object file. The ODL files, in this instance, must be merged together into a single ODL file to be submitted as input to the TRAX Linker.

To accomplish this, you use the Merge Utility, which performs the following functions:

1. merges the ODL statements from one or more ODL files into a single ODL file
2. analyzes the I/O requirements for the entire task and provides directives to include only those I/O routines required
3. inserts the missing but required ODL directives not provided by the compiler

Whether you have a large segmented program, a main program plus subroutines, or a small stand-alone program, the ODL files generated by the compiler require merging or modification. You are advised to use the Merge Utility to perform this merging/modification, although you can hand-tailor your own ODL file.

NOTE

Do not attempt to hand-tailor your own ODL file unless you have in-depth knowledge of your operating system and TRAX COBOL. However, if you wish to hand tailor ODL files, the following references will provide the required information:

- The TRAX Linker Reference Manual DEC No.
- Standard ODL file Format
  Chapter 10 of this manual
- COBOL Segmentation
  Chapter 8 of this manual
- Code PSECT Naming Conventions
  Appendix E of this manual
- Interprogram Communications
  Chapter 9 of this manual

When you have a single ODL file that contains all of the required overlay descriptor language, you can execute the TRAX Linker.

The TRAX Linker provides you with a facility for linking separately compiled object modules into an executable task image. You can, depending on your knowledge of your operating system and TRAX COBOL, link object modules created by another programming language into your COBOL task image. The TRAX Linker also allows you to take full advantage of the COBOL system library to selectively link into your COBOL task only those runtime support routines actually needed to run your task.

The TRAX Linker, using the ODL file as a guide, provides the facility to build large amounts of code into a task by careful use of code segments that overlay each other. Careful use of segmentation or calls to subprograms within your COBOL source program will allow you to compile and execute large and complex COBOL programs. If you add some functionality to an existing COBOL program and find that, after task-building, the resulting task will not fit in memory, you have an alternative other than reprogramming: you can segment the program or make subprograms out of some of the existing procedures, replacing these procedures with CALL statements to the newly created subprograms. When the source program has been compiled, the ODL file merged, and linking accomplished, the task is ready to be executed (Section 2.2.4).

Figure 1-1 shows the process of preparing a COBOL program for execution:

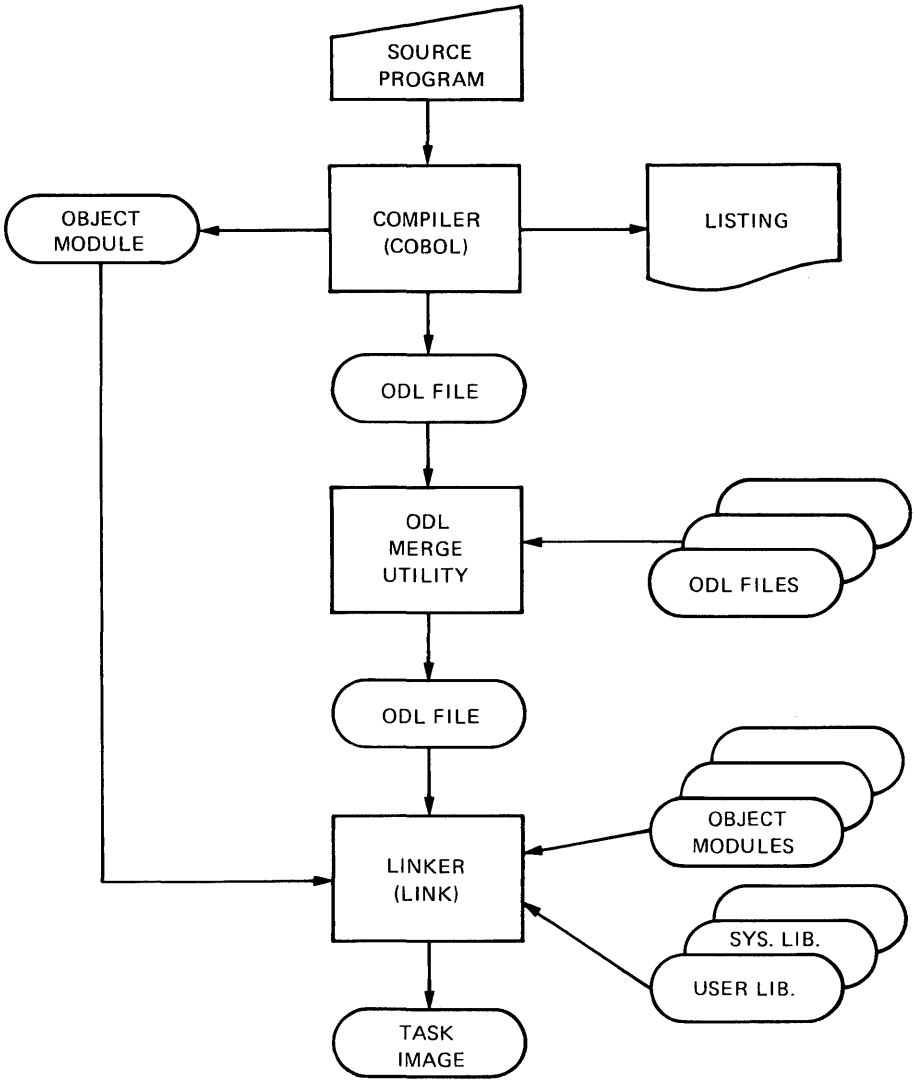


Figure 1-1 Building a COBOL Task Image

1.1 THE COBOL SOURCE PROGRAM

A COBOL source program consists of four major divisions, which must appear in the following order:

1. IDENTIFICATION DIVISION.
2. ENVIRONMENT DIVISION.
3. DATA DIVISION.
4. PROCEDURE DIVISION.

Each of the COBOL divisions is further divided into sections that may be divided into paragraphs. Paragraphs contain COBOL sentences. Sentences contain COBOL statements. The following subsections (1.1.1 through 1.1.4) individually discuss each division and its major sections.

1.1.1 The Identification Division

The Identification Division identifies the COBOL program and contains such optional documentary information as the name of the programmer, the name of the installation, and the date the program was written and last compiled.

1.1.2 The Environment Division

The Environment Division identifies the hardware configuration of the system that is compiling the program (SOURCE-COMPUTER) and the hardware configuration of the system that is running the program (OBJECT-COMPUTER). The division is divided into the following two major sections:

- Configuration Section -- This section is required and contains the names of the source and object computers and any mnemonic names that are to be assigned to devices.
- Input-Output Section -- This section is optional and contains descriptions of all the external files being manipulated by the program. The section is required if there are external files.

1.1.3 The Data Division

The Data Division contains complete descriptions of all data to be processed by the program. In this division, the programmer must assign a data-name to and describe every data item referred to in the Procedure Division.

The Data Division is composed of three optional major sections:

- File Section -- Contains the descriptions of all input and output files and their records.
- Working-Storage Section -- Contains the descriptions of temporary records and data items.

- Linkage Section -- Describes the data that is available to a called program and is referenced in both the calling and called program.

1.1.4 The Procedure Division

The Procedure Division contains the program's procedural statements. Within this division, the program specifies manipulation of the data items described in the Data Division.

The Procedure Division may begin with the DECLARATIVES, which contain USE procedure declarative sections for processing I/O errors (Section 11.3).

The programmer may divide the Procedure Division into sections and paragraphs that each perform a function.

The Procedure Division makes COBOL's advantages (excellent documentation and programming simplicity) most apparent. Figure 1-2 (sample Procedure Division coding) illustrates the documentation capabilities of COBOL programs:

```
PROCEDURE DIVISION.

BEGIN.

    OPEN INPUT TRANSACTION-FILE.

    OPEN OUTPUT MASTER-FILE.

READ-A-RECORD.

    READ TRANSACTION-FILE NEXT RECORD

         AT END GO TO CLOSE-ROUTINE.

    READ MASTER-FILE NEXT RECORD

         AT END GO TO CLOSE-ROUTINE.

PROCESS-A-RECORD.

    IF TRANS-ACCT-NUMBER IS GREATER THAN MAST-ACCT-NUMBER

         GO TO READ-MAS-RECORD.

    IF TRANS-ACCT-NUMBER IS LESS THAN MAST-ACCT-NUMBER

         GO TO ERROR-ROUTINE.

    .
    .
    .
```

Figure 1-2 Sample COBOL Procedural Coding

1.2 THE COBOL UTILITY PROGRAMS

TRAX COBOL provides two utility programs:

- ODL MERGE -- Merges ODL files created by one or more COBOL compilations into a single ODL file to be submitted as input to the TRAX Linker.
- REFORMAT -- Converts PDP-11 terminal format COBOL programs into conventional format ANSI COBOL programs.

Both of these utilities are part of the TRAX/COBOL software package. The following subsections (1.2.1 and 1.2.2) describe these utility programs.

1.2.1 ODL MERGE

The ODL Merge Utility program merges ODL files generated by COBOL compilations into a single ODL file. This file is submitted as input to the TRAX Linker, and describes the overlay structure of the resulting task image.

1.2.2 REFORMAT

TRAX COBOL accepts source programs that are coded using the terminal reference format. The REFORMAT utility program reads source programs that were coded in terminal format and converts them to 80-column ANSI-compatible source programs.

CHAPTER 2

USING TRAX COBOL

2.1 INTRODUCTION

This chapter provides you with the specific information necessary to develop, compile, link, and run COBOL programs in the TRAX support environment. Additional information is included on the use of the TRAX COBOL library, the use of the COBOL utilities ODL MERGE and REFORMAT, and on the definition and use of compile-time switches. This chapter also contains a summary of COBOL error messages and sample source program listings for all COBOL divisions.

The reference format supported by TRAX COBOL for program development is the terminal format. The TRAX COBOL compiler does process data in the conventional 80-column punched card format. However, since TRAX system configurations do not include card readers, conventionally formatted data and programs must be input from another I/O device such as magnetic tape drives capable of reading ANSI standard magnetic tapes. The terminal format is the default for TRAX COBOL. Both terminal and conventional reference formats are detailed in the TRAX COBOL Language Reference Manual.

2.2 CREATING TRAX COBOL PROGRAMS

Creating COBOL programs in the TRAX support environment involves four basic steps:

1. Create a machine readable source statement file.
2. Compile source statements into an object module. Debug and recompile source module until program is syntactically valid.
3. Link compiled object modules and required system libraries to form an executable task image file.
4. Run the completed program.

Each of these steps is described in detail in the paragraphs that follow.

2.2.1 Creating Source Language Statement Files

After you have defined your procedure and translated the definition into COBOL source language statements, the next step is to enter the source statements into the computer. In the TRAX Support Environment, this is done from a support terminal using the DEC Editor. Consult your system manager for the location of your installation's support

terminals, and the procedure required to long into the TRAX support environment. Note that in addition to the support terminal, the TRAX COBOL compiler accepts input from the following I/O devices:

1. ANSI standard magnetic tape drives

2. Disk drives

The DEC Editor is a utility program that allows you to create and maintain text files from a video or hard-copy terminal. If you are unfamiliar with the Editor's operations, consult the DEC Editor Reference Manual.

The Editor is entered by typing the command string:

```
>EDIT [file-specification]
```

When you are creating a new file, the file specification should be a new file name, and source files should have a .CBL file type. Supplying an existing file specification to the EDIT command results in the highest numbered existing version of that file being supplied so that you can modify, insert or delete source language statements in the file.

2.2.2 Compiling COBOL Programs

After you have created source language input files with the help of the DEC Editor, the next step is compilation. The TRAX COBOL compiler is a system program which translates your high level source language statements into object modules which consist of machine language instructions coded as octal numbers. To invoke the COBOL compiler you enter the following command string:

```
>COBOL/LIST file-specification
```

This command string produces an object file and a listing file with the name designated by the file specification. The extensions for these files will be .OBJ for the object file and .LST for the listing file. The listing file is spooled, then deleted after printout.

Some common errors you should avoid when entering the COBOL command string are:

- omitting the /CVF switch for programs that are in the conventional format, and causing a system error

- omitting version numbers from one or more of the file specifications, causing the system to create a new version or to compile the wrong version.

The COBOL command is described in detail in the TRAX Support Environment Programmer's Guide.

The size of a COBOL object module created from a COBOL source file depends on the amount of memory required for the following elements:

1. data-items in the Working-Storage Section

2. number of files in the File Section

3. amount of code generated for the Procedure Division

4. number and length of all unique numeric and non-numeric literals used in the Procedure Division

5. total size of all runtime modules needed to support the executing program (includes such code as arithmetic support, I/O support, segmentation support, etc.)

6. push-down stack space required to support the executable code

7. directories for all referenced data-items and literals

The maximum size of a program task on the PDP-11 is 64K bytes. On systems that support TRAX COBOL, the maximum task is 56K bytes, where the remaining 8K bytes are reserved for sharable file system code to support I/O. A COBOL program, therefore, cannot occupy more than 56K bytes of memory.

Some programs may exceed the allowable storage byte limit. In this case, the Linker issues a diagnostic and does not link your task. You may take either of two corrective measures:

1. create program overlays by using the COBOL segmentation facility (Chapter 8, Segmentation)

2. break up your program into a main program and one or more subprograms (Chapter 9, Interprogram Communication).

The listing output from your compilation will indicate errors in your source language text, and provide information regarding the cause of the error.

In addition, the compiler generates an error message summary and displays it at your terminal. This summary contains the number of errors encountered during the current compilation. The error message summary has the following format:

```
CBL -- NNNNN ERROR(S), NNNNN FATAL
```

Where:

NNNNN is the number of errors encountered.

NOTE

If fatal errors are encountered, no object file is generated, unless specifically requested via the /ACC switch. (See Section 2.4, Compiler Switches).

You then can use the DEC Editor to make the required corrections to your source statements, and recompile. Several iterations of the compile and editing process are usually needed to obtain an error free compilation. Once the compiler has reported that your compilation is error free, you can then proceed to the next program development step, which is linking the object modules to form a task.

2.2.3 Linking the Task

The Linker is a TRAX program that accepts object modules and system library modules as input, and merges this information to form a task image file. The task image file can be copied into memory and run by the operating system. Linking is the final step in the program development process.

A TRAX COBOL program that has been entered and compiled can be linked by issuing a command string having the following form:

```
>LINK file specification
```

The LINK command specifies the name of the input object file specification. This command links the object file designated by file specification and produces a task image having the same name as the specified file, but as an extension of .TSK. The task uses all the default assumptions for qualifiers and options. Link command syntax along with qualifiers and options is described in detail in the TRAX Linker Reference Manual.

2.2.4 Running Your Program

After all steps of program development, editing, compiling and linking have been successfully completed, you may run your program by entering the run command followed by the file name of the task image file that was created by the Linker. For example:

```
>RUN file specification
```

A number of RUN time qualifiers which are available to be used with the RUN command are described in the TRAX Support Environment User's Guide.

2.3 USING THE LIBRARY FACILITY (COPY)

The TRAX COBOL library facility provides you with a means of copying COBOL source language text from a library of source material into a COBOL program during compilation. One COPY statement can place large amounts of library source text into a source program, thereby saving repetitious coding. The compiler treats the copied material as though it were part of the program being compiled. The copied material, however, does not physically alter the source program file in any way.

The COBOL library facility provides two important benefits:

1. Standardization of File and Coding Conventions

   A typical data file is processed by more than one program, and each processing program must describe the characteristics of that file (file-name, blocking factor, field names, etc.). Often the programs are written by one programmer, then maintained and updated by another programmer, who has to try to understand a program that was written by someone else. Since this situation arises at most sites, it is good practice to design a standardized file description (keeping in mind the programs that process that file) and place it in the library. Then a COPY statement in each processing program can merge it into the program at compile-time.

This technique applies as well to any procedure that is used in many different applications. For example, the library could contain a standardized routine that converts calendar dates to Julian dates to be merged into each source program that uses this function.

2. Time Savings for Initial Coding and Updating

   Defining and coding file and record descriptions is a time-consuming chore. If the descriptions exist in the library, a single COPY statement will save the time required to code those entries into programs using them.

   Changing a file format is another time-consuming chore. Typically, when a file format changes, you must change and recompile all the programs that use that file. If the file description is in a library file, the programmer has to change only the library file. The source programs, of course, still have to be recompiled but require no individual coding changes.

   Putting commonly used Procedure Division procedures in a library file yields the same time-saving benefits.

2.3.1 Creating a COBOL Library File

Each line of a COBOL library file must be in a form such that, when it is merged into the source program, it forms a syntactically correct COBOL clause, phrase, or sentence. It can meet this condition either by being syntactically correct itself, or by becoming so when it is merged with the source program.

The library text must conform to the rules for the COBOL terminal reference format (Library Module in the TRAX COBOL Reference Manual). When writing text for library files, place at least four space characters or a tab character before any entry that normally begins in Area B of the COBOL source program. Left justify, without space characters, entries that normally begin in Area A or at character position 0. In addition, the library file and the source programs it is merged into must also be in the terminal format. (A conventional format library file cannot be merged properly into a terminal format source program and vice-versa.)

Since each library file contains all the source language text to be merged into a source program by one COPY statement, the COPY statement text-name must refer to the library file-name.

To create the library file, enter it directly onto disk or DECtape through the support terminal using the DEC editor. There is no method for updating COBOL library files on magtape. The available medium for these files is disk storage.

2.3.2 The COPY Statement

The COPY statement is a compile-time function that merges a COBOL library file into a COBOL source program.

The statement must begin with the word COPY and end with a period. The compiler logically replaces the COPY statement (including the period) with the library file named by the statement. However, both

the COPY statement and the library text material appear in the source listing (Section 2.3.4, The Source Listing). The statement may appear anywhere in a source program that a COBOL word is allowed. The simplest form of the statement is:

```
COPY text-name.
```

Text-name must specify either a file-name or a alphanumeric literal. If a file-name is specified, the compiler assumes standard file specification defaults and copies the text from the latest version of that file into the source program.

The format for the full file specification is:

```
device:[UIC]file-name.file-type;version-number
```

The specification defaults are:

device:	-- the standard system device or the device specified in the batch JCL
[user-identification]	-- the UIC that you are logged in under
file-name	-- (no default)
.file-type	-- .LIB
;version-number	-- the latest version.

For example, the following text-name entry copies a library file named BILBOS.LIB from the system disk to the source program:

```
COPY BILBOS.
```

This text-name entry causes the compiler to search the system disk for a file named BILBOS.LIB. This search takes place in the user's directory only.

If a alphanumeric literal is entered, it may specify the full file specification for that file. For example, the following entry copies the library file BILBOS.LIB from DK1 into the source program:

```
COPY "DK1:BILBOS.LIB".
```

This text-name entry causes the software to search DK1 for the file named BILBOS.LIB, and merge that file with the file named BILBOS (see Figure 2-1).

Only four situations require the use of the alphanumeric literal option to indicate the full file specification for the COPY statement:

1. when the library has a file type other than .LIB
2. when there is more than one device containing a library file
3. when the LIBRARY contains more than one version of the file and you want to copy a version other than the latest.
4. when the library file is in another directory

The following examples use only the file-name option:

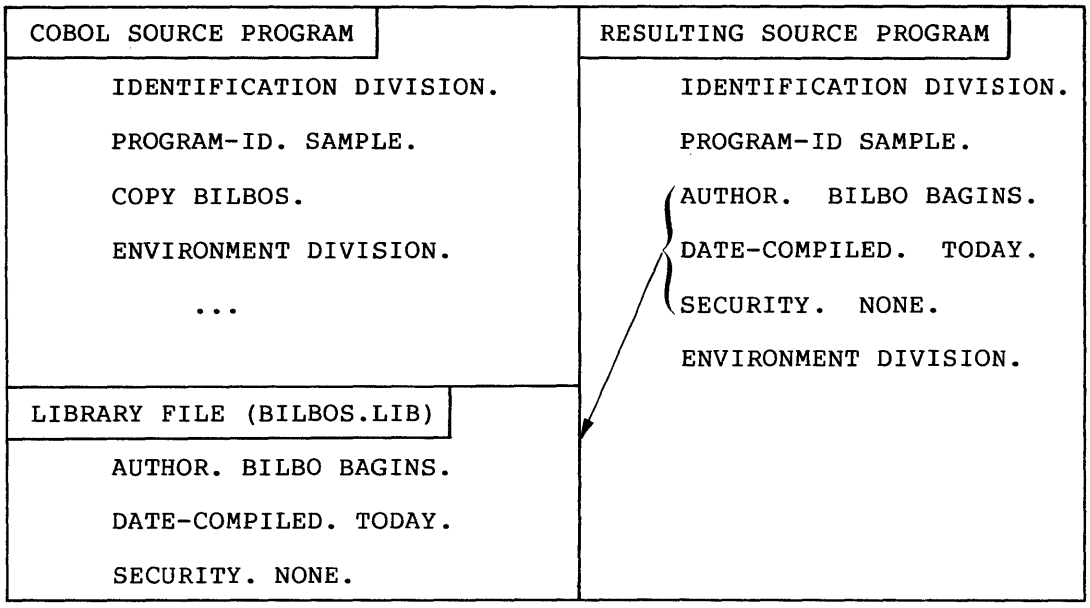


Figure 2-1 Merging a Library File

The library file in Figure 2-2 is formatted (four spaces before each entry) so that when it is merged into the source program, each entry begins in Area B. If the four spaces are not there, the text is moved into Area A and syntax errors result (Area A is reserved for headers such as division headers and paragraph headers).

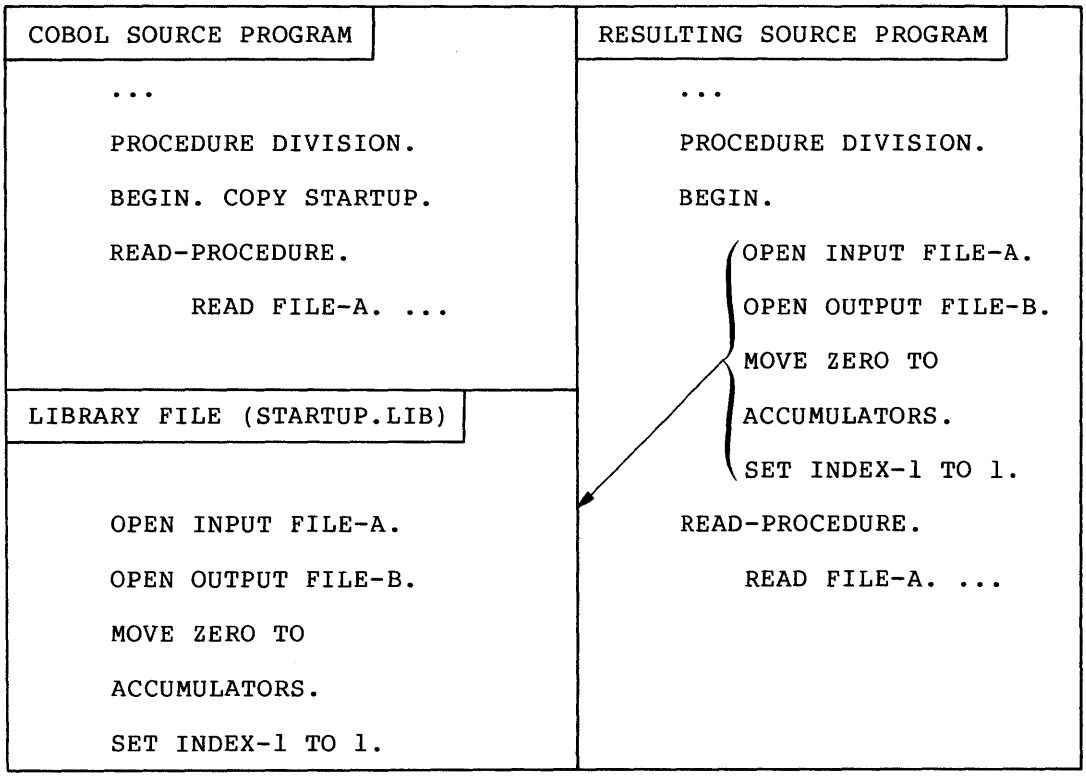


Figure 2-2 Merging a Library File Area B

Since the COPY statement may appear anywhere in a source program that a COBOL word is allowed, it can be used in various ways to solve a particular programming problem. For example, if a library file named DRACULA contains the single entry BLOOD-RATE, the entry could be used in the Data Division as shown in Figure 2-3.

SOURCE COPY STATEMENT	RESULTING SOURCE STATEMENT
02 COPY DRACULA. PIC 99V99.	02 BLOOD-RATE PIC 99V99.

Figure 2-3 Using the COPY Statement in a Data Description

The entry could be used in the Procedure Division as shown in Figure 2-4.

SOURCE COPY STATEMENT	RESULTING SOURCE STATEMENT
MULTIPLY 40 BY COPY DRACULA. GIVING PLASMA.	MULTIPLY 40 BY BLOOD-RATE GIVING PLASMA.

Figure 2-4 Using the COPY Statement in a Procedural Statement

The periods terminating the COPY statements in Figures 2-3 and 2-4 are replaced by the text file. No periods appear in the resulting source program unless they are in the text file (if a source statement needs a period, the text file must have a period at the required place).

NOTE

The examples illustrated by Figures 2-3 and 2-4 are not recommended uses of the COPY statement. This chapter includes them only to illustrate the mechanics of the TRAX COBOL library facility.

2.3.3 The COPY REPLACING Statement

Sometimes it may be necessary to tailor library text material for use in a particular program, for example, if a data description in the library text has level numbers incremented by 1 -- 01, 02, 03, .,.,n. and you want them incremented by four -- 01, 05, 06, .,.,n. The COPY statement can replace, during the copying process, all occurrences of a given literal or word with an alternate literal or word. A sample COPY REPLACING statement is:

```
COPY WALDEN REPLACING 02 BY 05.
```

This sample statement causes the compiler to scan the library file WALDEN searching for 02. Wherever it finds a 02, it replaces it with a 05. A match occurs only if the compiler finds a 02 (not just a 0 or just a 2). The REPLACING character string, which may be a literal or a word, must compare equally, character for character, with the entire character string in the library text. The following table shows some successful (YES) and unsuccessful (NO) matches:

Table 2-1
Successful and Unsuccessful Replacing Matches

GIVEN LITERAL OR WORD	LIBRARY TEXT	MATCH?
"ABC"	"ABCD"	NO
HRLY-RATE	HRLY-RATE	YES
1	1	YES
"2"	2	NO
" 15"	"15"	NO
"012"	"12"	NO
012	12	NO
SUBTRACT	SUBTRACT	YES
"012"	"012"	YES

2.3.3.1 **Examples of COPY REPLACING Statement** - The following examples of the COPY REPLACING statement all refer to the library file named NEWSBOY:

```
NEWSBOY (library filename)
          01 A.
             02 B PIC 99.
             02 C PIC 99 VALUE 2.
             02 D PIC X(5) VALUE "ABCDE".
             02 E PIC 99V99 VALUE 3.75.
             02 F PIC 99 VALUE 02.
```

Example 1

```
          COPY NEWSBOY REPLACING B BY X.
```

This statement merges the entire file named NEWSBOY into the source program and changes data-name B to X. It does not change the character B in the character string of data-name D because it is part of a nonmatching character string. This statement causes the compiler to merge the following text into the source program:

```
          01 A.
             02 X PIC 99.
             02 C PIC 99 VALUE 2.
             02 D PIC X(5) VALUE "ABCDE".
             ...
```

Example 2

```
COPY NEWSBOY REPLACING 2 BY 6.
```

This statement merges the entire file named NEWSBOY into the source program and changes the 2 in the entry for data-name C to a 6. It does not change the 02 in the literal entry for data-name F nor any of the 02 level numbers because they contain a nonmatching character 0. This statement causes the compiler to merge the following text into the source program:

```
01 A.

    02 B PIC 99.

    02 C PIC 99 VALUE 6.

    02 D PIC X(5) VALUE "ABCDE".

    02 E PIC 99V99 VALUE 3.75.

    02 F PIC 99 VALUE 02.
```

Example 3

```
COPY NEWSBOY REPLACING 02 BY 63.
```

This statement merges the entire file named NEWSBOY into the source program and changes not only the 02 literal entry in data-name F, but also all of the 02 level numbers to 63. Since level number 63 is illegal, this causes the compiler to produce syntax errors. The replacing process is not sensitive to the syntax of the text. The string of characters in the library may be literals, level-numbers, data-names, etc.; if they match the REPLACING string, character for character, the compiler replaces them. Consider the results of this statement:

```
01 A.

   63 B PIC 99.

   63 C PIC 99 VALUE 2.

   ...

   63 F PIC 99 VALUE 63.
```

Example 4

```
COPY NEWSBOY REPLACING B BY X,
                       "ABCDE" BY "HIJKL",
                       3.75 BY 4.23.
```

This statement shows how a single COPY statement can replace more than one literal or word. It causes the compiler to merge the following text into the source program:

```
01 A.
   02 X PIC 99.
   02 C PIC 99 VALUE 2.
   02 D PIC X(5) VALUE "HIJKL".
   02 E PIC 99V99 VALUE 4.23.
   02 F PIC 99 VALUE 02.
```

2.3.4 The Source Listing

Depending on how the COPY statement is written, the TRAX COBOL compiler lists library text material either before or after the COPY statement (Figures 2-5 and 2-6).

2.3.4.1 **Before the COPY Statement** - If other source material (including spaces) follows the COPY statement on the same source line, the compiler lists the library text before the COPY statement (see Figure 2-5).

SOURCE LINE	SOURCE LISTING
...	...
COPY CHANGES. ADD A TO B.	text-line-1
	text-line-2
	text-line-3
	COPY CHANGES. ADD A TO B.

Figure 2-5 Placing the Library Text Before the COPY Statement

The compiler does not print a source line until it has scanned the entire line. Therefore, in Figure 2-5 (CHANGES), the compiler takes the following steps, in order:

1. scans the COPY statement
2. recognizes that the COPY statement is followed by more information on the same line
3. prints the library text
4. scans the rest of the line
5. prints the entire source line

This results in a somewhat confusing listing and should be avoided. When the library text follows the COPY statement, a much more readable listing is produced.

2.3.4.2 **After the COPY Statement** - If the COPY statement terminates the source line, the compiler merges the library text after the COPY statement, as shown in Figure 2-6.

SOURCE LINE	SOURCE LISTING
...	...
COPY CHANGES.	COPY CHANGES.
ADD A TO B.	text-line-1
	text-line-2
	text-line-3
	ADD A TO B.

Figure 2-6 Placing the Library Text After the COPY Statement

Referring to Figure 2-6, the compiler takes the following steps, in the order shown:

1. scans the COPY statement
2. prints the COPY statement
3. prints the library text
4. prints the next sequential statement

2.3.5 Common Errors in Using the Library Facility

Common errors to avoid when using the library facility are:

- Failing to follow the rules for terminal reference format when creating the library file
- Writing the library file in one format (conventional or terminal) and the source program in the other
- Forgetting to terminate the COPY statement with a period
- Using data-names in the library file that also appear in the source program, thus causing duplicate names
- Writing the library text so that when it is merged into the source program, it becomes syntactically incorrect
- Merging the wrong library file, either because multiple versions exist or because of misspelling
- Writing other source material on the same line following the COPY statement, thus causing confusion in the source program listing
- Forgetting that numeric literals (such as 02, 77, etc.) used in the REPLACING option replace level-numbers, picture descriptions, and paragraph or section names, when they find matches.

- Forgetting that a period must appear in the text file if it is to appear in the source program (the period that terminates the COPY statement is replaced by the text).

2.4 COMPILER SWITCHES

The TRAX COBOL compiler provides a series of compile-time switches. Using these switches, you can tailor your compilation listing and assign particular characteristics to the generated object modules. Table 2-2 provides a list of the compiler switches and their meanings.

Table 2-2
COBOL Compiler Switches

Switch	Meaning
/ACC:n	Produce an object program only if the source program contains diagnostics with severities equal to or less than n. The range of n must be 0<n<2, Where: 0 = Informational diagnostics 1 = Warning diagnostics 2 = Fatal diagnostics The default is /ACC:1.
/CREF	Include a cross-reference listing as part of the listing file output. When /CREF is specified, data-names, procedure-names, and source line numbers are sorted into ascending order and appended to the end of the compilation listing. The symbol # is used to indicate the line in which the referenced name is defined. NOTE The use of /CREF significantly slows down the compilation of large programs.
/CSEG:nnnn	Allows you to specify the maximum size procedural code PSECT to be produced by the compiler where nnnn is the maximum size procedural code PSECT, in decimal bytes. The minimum value of nnnn is 100.

Table 2-2 (Cont.)
COBOL Compiler Switches

Switch	Meaning
/CVF	Indicates to the compiler that the source program is in conventional format (i.e., 80-character images with Area A beginning in character position 8).
/ERR:n	Suppress the printing of diagnostics with a severity number less than n. The range of n must be 0<n<2. Where: 0 = Informational diagnostics 1 = Warning diagnostics 2 = Fatal diagnostics The switch cannot suppress severity 2 (fatal) diagnostics. (An entry of 2 suppresses the printing of all severity numbers that are less than 2.) The default is /ERR:0.
/HELP	Display on the user terminal information about how to use the compiler switches.
/KER:kk	Instruct the compiler to generate PSECT names using the two-character kernel specified by kk to make them unique to this compilation, where kk is a two character string that may contain the numbers 0 through 9 and the letters A through Z. NOTE The sample program listed in Figure 2-7 was compiled using the /KER:kk switch. See Figure 2-10 which contains the Procedure Map generated for this program. Notice that the PSECTs generated all contain the two character kernel XX.
/MAP	Produce the following special map listings: • Data Division (Figure 2-9) • Procedure Map (Figure 2-10) • External Subprograms Referenced (Figure 2-15) • Data and Control PSECTs (Figures 2-12 and 2-14) • OTS Routines Referenced (Figure 2-13) • Segmentation Map (Figure 2-11)
/NL	Instruct the compiler not to list the source statements copied from a library file. The resultant source listing contains only the COPY statement.

Table 2-2 (Cont.)
COBOL Compiler Switches

Switch	Meaning
/OBJ	Print the object location in which the code for each verb of the program is located. The information is listed on the line preceding the source statement it describes (Figure 2-15).
/ODL	Instruct the compiler to generate an ODL file (default condition). To override the default condition, enter /-ODL.
/OV	Instruct the compiler to make all procedural PSECTs (segments) overlayable. Therefore, the root or main program will contain no procedural statements.
/PFM:nn	Allows you to define the maximum number of nested PERFORM statements in the program being compiled. If specified, the compiler generates a nested PERFORM stack equal in depth to the decimal number specified by nn. The default nested perform size is 10. It is to your advantage to use this switch to adjust the nested PERFORM stack size to the exact number required. This assures maximum utilization of memory in that only the exact amount of PERFORM stack space is generated.
/PLT	Directs the COBOL compiler to automatically pool literals to minimize the memory required to store them (default condition). Pooling of literals, however, slows down compiler execution speed. To bypass literal pooling for increased compiler speed, enter /-PLT.
/RO	Directs the compiler to generate read-only PSECTs for the Procedure Division object modules. The default status is read/write.
/SYM:n	Allows you to obtain more symbol table space for the compilation, where "n" (an integer in the range of 1 through 4) specifies the space required for the maximum number of data-names and procedure-names allowed in the compilation. See Table 2-3 for the correspondence between the integer specified by n, and the number of data-names and procedure-names assigned.

Table 2-3
/SYM:n Switch Values

n	Maximum Data-Names	Maximum Procedure-Names
1	761	761 (default)
2	1021	1021
3	1531	1531
4	2039	2039

2.5 SAMPLE TRAX COBOL OUTPUT

The following Figures 2-7 through 2-18 show and describe sample output produced by the COBOL compiler:

```
CMD:MAP,MAP/MAP=MAP/KER:XX
IDENT: 005160


  00001          IDENTIFICATION DIVISION.
  00002          PROGRAM-ID. MAP.
  00003        *
  00004        *     EXERCISE COMPILER MAP PROCESSORS.
  00005        *
  00006          ENVIRONMENT DIVISION.
  00007          CONFIGURATION SECTION.
  00008          SOURCE-COMPUTER. PDP-11.
  00009          OBJECT-COMPUTER. PDP-11.
  00010
  00011          DATA DIVISION.
  00012          WORKING-STORAGE SECTION.
  00013          77 DEC PIC 9(4).
  00014          77 BIN PIC 9(4) USAGE COMP.
  00015          77 CHR PIC X(4).
  00016          LINKAGE SECTION.
  00017          77 L1 PIC X.
  00018          77 L2 PIC X.
  00019          77 L3 PIC X.
  00020          77 L4 PIC X.
  00021          PROCEDURE DIVISION USING L1 L3 .
  00022          S0 SECTION.
  00023          P0.
  00024          STOP RUN.
  00025          P1.
  00026          DISPLAY L3.
  00027          DISPLAY "ABC".
  00028          S1 SECTION.
  00029          P2.
  00030          MOVE DEC TO DEC.
  00031          MOVE DEC TO BIN.
  00032          MOVE BIN TO BIN.
```

Figure 2-7 Sample Source Program Listing

```
  00033          MOVE BIN TO DEC.
  00034          MOVE CHR TO CHR.
  00035          MOVE ALL SPACES TO CHR.
  00036          MOVE DEC TO CHR.
  00037          ADD DEC TO DEC.
  00038          ADD DEC TO DEC ROUNDED.
  00039          SUBTRACT DEC FROM DEC.
  00040          SUBTRACT DEC FROM DEC ROUNDED.
  00041          SUBTRACT BIN FROM BIN.
  00042          SUBTRACT BIN FROM BIN ROUNDED.
  00043          MULTIPLY BIN BY BIN GIVING BIN.

I 00043 0371   POSSIBLE HIGH ORDER RECEIVING FIELD TRUNCATION.

  00044               MULTIPLY DEC BY DEC GIVING DEC.

I 00044 0371   POSSIBLE HIGH ORDER RECEIVING FIELD TRUNCATION.

  00045               DIVIDE BIN BY BIN GIVING BIN.
  00046               DIVIDE DEC BY DEC GIVING DEC.
  00047               DIVIDE DEC BY DEC GIVING DEC ROUNDED.
  00048               DIVIDE BIN BY BIN GIVING BIN ROUNDED.


  00049          P4.
  00050               CALL "A"
  00051               CALL "AB".
  00052               CALL "ABC".
  00053               CALL "ABC000".
  00054               CALL "ABC001".
  00055               CALL "ABC002".
  00056               CALL "ABC003".
  00057               CALL "ABC004".
  00058               CALL "ABC005".
  00059               CALL "ABC006".
  00060               CALL "ABC007".
  00061               CALL "ABC008".
  00062               CALL "ABC009".
  00063               CALL "ABC010".
  00064               CALL "ABC011".
  00065               CALL "ABC012".
```

Figure 2-7 (Cont.) Sample Source Program Listing

FILE-TO-LUN ASSIGNMENT TABLE

NAME	SOURCE LINE	RELATIVE LUN
SQ-FS1	00019	00001.
IX-FS1	00025	00002.
RL-FS1	00033	00003.

where:

NAME	is a file-name that appears in the SELECT clause in the Input-Output Section. The file names appear in the order in which they occur in the Input-Output Section.
SOURCE LINE	is the line on which the File Definition appears.
RELATIVE LUN	is the relative logical unit number (LUN) assigned, beginning with 1.

Figure 2-8 File-to-Relative-LUN Assignment Table

DATA MAP

	LEVEL	NAME	SOURCE LINE	DDIV LOCN	DIR LOC	USAGE	CLASS	OCC	LEN
	01	DEC	00013	000224	000000	DSP	NUM	00	0004
	01	BIN	00014	000230	000006	CMP	NUM	00	0002
	01	CHR	00015	000232	000014	DSP	AN	00	0004
L	01	LS-ALPHA-DATA	00036	000000	******	DSP	AN	00	0066
L	05	LA1	00037	000000	000000	DSP	AN	00	0006
L	05	LA2	00038	000006	000006	DSP	AN	00	0008
L	05	LA3	00039	000016	000014	DSP	AN	00	0010
L	05	LA4	00040	000030	000022	DSP	AN	00	0012
L	05	LA5	00041	000044	000030	DSP	AN	00	0014
L	05	LA6	00042	000062	000036	DSP	AN	00	0016
L	01	LS-NUM-DISP-DATA	00043	000000	******	DSP	AN	00	0021
L	05	LN1	00044	000000	000044	DSP	NUM	00	0004
L	05	LN2	00045	000004	000052	DSP	NUM	00	0005
L	05	LN3	00046	000011	000060	DSP	NUM	00	0005
L	05	LN4	00047	000016	000066	DSP	NUM	00	0002
L	05	LN5	00048	000020	000074	DSP	NUM	00	0002
L	05	LN6	00049	000022	000102	DSP	NUM	00	0003
L	01	LS-COMP-DATA	00050	000000	******	DSP	AN	00	0020
L	05	LC1	00051	000000	000110	CMP	NUM	00	0002
L	02	LC2	00052	000002	000116	CMP	NUM	00	0002
L	05	LC3	00053	000004	000124	CMP	NUM	00	0004
L	05	LC4	00054	000010	000132	CMP	NUM	00	0004
L	05	LC5	00055	000014	000140	CMP	NUM	00	0004
L	05	LC6	00056	000020	000146	CMP	NUM	00	0004

COLUMN	CONTENTS
L	Data-item is defined in linkage section
LEVEL	Level number of data-item
NAME	Data-item name
SOURCE LINE	Source line number where data-item is defined
DDIV LOCN	Octal byte offset of data-item in data storage PSECT (program section).

NOTE: 1. For Linkage Section items, this offset is always relative to the 01 entry.

2. For non-Linkage Section items, this offset is relative to data PSECT $KKDAT (KK=kernel).

Figure 2-9 Sample Data Map

COLUMN	CONTENTS
DIR LOC	Octal byte offset of data-item's directory in a directory PSECT. NOTE: 1. For Linkage Section items, this offset is relative to data PSECT $KKARG (KK=kernel). 2. For non-Linkage Section items, this offset is relative to data PSECT $KKDDD (KK=kernel). 3. If data-item is not referenced, no directory is allocated and ****** appears.
USAGE	One of the following abbreviations: DSP - Display CMP - Computational NDX - Index
CLASS	One of the following abbreviations: ALPHA - Alphabetic NUM - Numeric AN - Alphanumeric ANEDIT - Alphanumeric edited NMEDIT - Numeric edited
OCC	The number of subscripts associated with this data-item.
LEN	The length in bytes of data-item.

Figure 2-9 (Cont.) Sample Data Map

PROCEDURE NAME MAP

NAME	SOURCE LINE	PSECT	OFFSET	SEG	SECT	PARA
S0	00022	$XX001	000024	00	S	
P0	00023	$XX001	000024	00		P
P1	00025	$XX001	000036	00		P
S1	00028	$XX002	000024	00	S	
P2	00029	$XX002	000024	00		P
P4	00049	$XX002	000312	00		P

Column	Contents
NAME	Procedure-name
SOURCE LINE	Source line number where procedure appears
PSECT	Executable code PSECT name (program section) which contains the procedure
OFFSET	Octal byte offset of procedure in its executable code PSECT
SEG	The segment-number of the section containing the procedure
SECT	If the procedure is a section, an S will appear in this column
PARA	If the procedure is a paragraph, a P will appear in this column

Figure 2-10 Sample Procedure-Name Map

```
                              SEGMENTATION MAP

        SECTION NAME          SEGMENT NO.     NAME          SIZE

S0                                 00          $XX001     000116     00039
S1                                 00          $XX002     000532     00173
```

Column	Contents
SECTION NAME	The section-name.
SEGMENT NO.	The segment-number assigned to the section.
NAME	The name of the executable procedural PSECT (program section) generated for this section. If the executable code generated for a section exceeds the code segment limit (see /CSEG switch), more than one procedural PSECT is generated for the section. If this happens, the multiple PSECT names will appear in a vertical column.
SIZE	The size of the procedural psect, octal bytes followed by decimal words.

Figure 2-11 Sample Segmentation Map

```
COMPILER GENERATED PSECTS

NAME            SIZE

$XXENT     000036     00015
$XX003     000046     00019
```

Column	Contents
NAME	The name of the compiler-generated psect.
SIZE	The size of the PSECT: octal bytes followed by decimal words.

NOTE: This map lists those executable PSECTs (program sections) that are generated by the compiler. These PSECTs are not the result of anything in the Procedure Division, but are generated to provide for runtime execution initialization.

Figure 2-12 Sample of Compiler-Generated PSECT Map

REFERENCED OTS ROUTINES

$XMBB	$XMDD	$XMDB	$XMBD	$XMCC	$XMAL	$XADDD	$XADDR
$XSUBD	$XSUBR	$XMULB	$XSUBB	$XSBBR	$XMULB	$XDIVB	$XDIVR
$XEDIS	$XGO	$XENDP	$XSTPR	$XABRT	$XCALL	$XEXIT	$XSUBK
$XINIT							

Contents

This map contains the names of all COBOL OTS (Object Time System) routines that are referenced by the code generated by the compiler.

Figure 2-13 Sample Map of Referenced OTS Routines

DATA PSECT MAP

NAME		SIZE
$XXDAT	000236	00079
$XXDDD	000022	00009
$XXPDT	000014	00006
$XXARG	000006	00003
$XXWRK	000102	00033
$XXLIT	000006	00003
$XXLTD	000014	00006
$XXLST	000002	00001
$XXPFM	000214	00070
$XXSDT	000040	00016
$XXADT	000000	00000
$XXUSE	000030	00012
$CBIOT	000126	00043
$CBFA1	000000	00000
$CBXA1	000000	00000
$XXIOB	000000	00000
$CBIF1	000000	00000
$CBIR1	000000	00000
$CBKD1	000000	00000
$CBBD1	000000	00000
$CBKB1	000000	00000
$CBFD1	000000	00000
$CBSWT	000002	00001

Column	Contents
NAME	The name of the data PSECT generated by the compiler.
SIZE	The size of the data PSECT, in octal bytes, followed by decimal words.

NOTE: This map lists the data (nonexecutable) PSECTs generated by the compiler. See Appendix D for a description of the Data PSECTs generated for each compilation.

Figure 2-14 Sample Data PSECT Map

```
EXTERNAL SUBPROGRAM REFERENCES

A         AB        ABC       ABC000    ABC001    ABC002    ABC003    ABC004
ABC009    ABC010    ABC011    ABC012
```

Contents

This map contains the names of all external subprograms referenced by CALL statements in the COBOL source program.

Figure 2-15 Sample Map of External Subprogram References MAP

```
SEVERITY    ERROR COUNT

    I           9
    W           4
    F           2
```

Column	Contents
SEVERITY	Contains the error severity code. The following list contains the possible severity codes: I = Information W = Warning F = Fatal
ERROR COUNT	Contains the number of errors encountered.

NOTE: This listing is generated for every COBOL compilation.

Figure 2-16 Sample Compilation Error Count Listing

```
  COMPILER GENERATED ODL FILE

;COBOL STANDARD ODL FILE GENERATED ON: 05-JAN-78  16:05:40
;COBOBJ=MAP.OBJ
;COBKER=XX
        .NAME XX$050,GBL
        .PSECT $XX003,GBL,I,RW,CON
XX050$: .FCTR *XX$050-$XX003
XXOVR$: .FCTR         XX050$
```

NOTE

This listing is generated whenever an object file is generated.

Figure 2-17 Sample Compiler-Generated ODL File Listing

```
  00110             MOVE REPETITIONS(POWER) TO REPS.
PERFORM    : 001 000104
  00111             PERFORM TEST1 REPS TIMES.
MOVE       : 001 000122
  00112             MOVE TESTDELTA(TESTNUMBER) TO BASETIME(POWER) PEOPLE
DISPLAY    : 001 000160
  00113             DISPLAY "10**" POWER " REPETITIONS TOOK "
  00114               PEOPLETIME " HUNDREDTHS OF SECONDS.".
ADD        : 001 000206
  00115             ADD 1 TO POWER.
IF         : 001 000220
GO         : 001 000254
  00116             IF POWER NOT > POWERLIMIT GO TO I5.
GO         : 001 000264
  00117             GO TO I10.
```

For each COBOL verb, a line of the following format appears in the listing, preceding the source line that contains the verb:

VERB: PPP AAAAAA

where:

1. VERB is the verb name
2. PPP is the decimal number of the code PSECT containing the object code generated for the verb.
3. AAAAAA is the octal byte offset within the PSECT at which the object code is generated.

Figure 2-18 Sample Output Using OBJ Switch

2.6 USING THE ODL MERGE UTILITY

To convert the ODL file generated by the compiler into a complete ODL file, or to merge ODL files from more than one compilation into a single ODL file, you use the Merge Utility.

2.6.1 Invoking the Merge Utility

To invoke the ODL Merge Utility, type RUN $MRG in response to a system prompt. When the ODL Merge Utility is loaded and ready to accept input specifications, it issues the following message:

PLEASE ENTER FILE SPECIFICATION FOR OUTPUT FILE

Enter the file specification for the file that is to receive the merged ODL file. For example:

PLEASE ENTER THE FILE SPECIFICATION FOR OUTPUT FILE

BILBO.ODL (RET)

When the output file specification is received, Merge issues another prompt:

DO YOU WANT AN ABBREVIATED OR MERGED ODL FILE?

PLEASE ANSWER A (ABBREVIATED) OR M (MERGED)

If you enter M, the ODL Merge Utility generates a file that is a concatenation of all the input ODL files. If you enter an A, an ODL file containing indirect command file specifications for each input ODL file is generated.

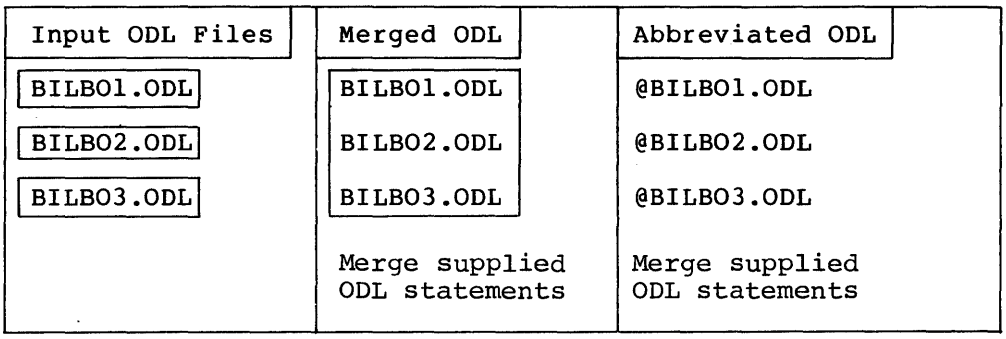


Figure 2-19 Merged vs. Abbreviated ODL File

For example, the following results in the generation of an abbreviated file:

DO YOU WANT AN ABBREVIATED OR MERGED ODL FILE?

PLEASE ANSWER A (ABBREVIATED) OR M (MERGED) A (RET)

Following the A or M specification, Merge make the following request:

DO YOU WANT TO OVERLAY I/O SUPPORT ROUTINES?

PLEASE ANSWER Y(ES) OR N(O)

Simply enter Y for yes and N for no, followed by a carriage return.

ODL Merge now requests that you enter the file specification for the first or only ODL file to be merged. The following message is issued:

PLEASE ENTER FILE SPECIFICATION FOR INPUT ODL FILE

Enter the input ODL file specification in response to this message as follows:

file-specification (RET)

For example:

PLEASE ENTER FILE SPECIFICATION FOR INPUT ODL FILE

BILBO1.ODL (RET)

When ODL Merge has completed processing this input file, it requests you to enter the device and directory under which the associated object file is stored. The following message is issued:

OBJECT PROGRAM REFERENCED IN ODL FILE IS:

object-filename.ext

PLEASE ENTER OBJECT FILE DEVICE AND PPN IN

THE FORMAT: DEV:[PROJECT,PROGRAMMER]

Enter the device code and PPN if different from the system default assignment. Otherwise, enter a carriage return only. For example:

OBJECT PROGRAM REFERENCED IN ODL FILE IS:

BILBO1.OBJ

PLEASE ENTER OBJECT FILE DEVICE AND PPN IN

THE FORMAT: DEV:[PROJECT,PROGRAMMER]

(RET)

The processing of the input ODL file is complete. ODL Merge now issues the following message:

ANY MORE INPUT ODL FILES?
PLEASE ANSWER Y(ES) OR N(O)

Enter Y for yes and N for no followed by a carriage return. If Y is entered, Merge reissues the PLEASE ENTER FILE SPECIFICATION FOR INPUT ODL FILE message, and the merging procedure is repeated. If N is entered, the output file is completed, and the following message is issued:

ODL MERGE IS COMPLETE
MERGED ODL FILE IS file-specification

Figure 2-20 shows a sample ODL file merge dialogue.

```
RUN $MRG (RET)
PLEASE ENTER FILE SPECIFICATION FOR OUTPUT FILE
DIVA.ODL (RET)
DO YOU WANT AN ABBREVIATED OR MERGED ODL FILE?
PLEASE ANSWER A(BBREVIATED) OR M(ERGED) M (RET)
DO YOU WANT TO OVERLAY I/O SUPPORT ROUTINES?
PLEASE ANSWER Y(ES) OR N(O) N (RET)
PLEASE ENTER FILE SPECIFICATION FOR INPUT ODL FILE
DIVBUG.ODL (RET)
OBJECT PROGRAM REFERENCED IN ODL FILE IS:
     DIVBUG.OBJ
PLEASE ENTER OBJECT FILE DEVICE AND UIC IN THE FORMAT:
DEV:[GROUP,MEMBER]
(RET)
ANY MORE INPUT ODL FILES?
PLEASE ANSWER Y(ES) OR N(O) N (RET)
ODL FILE MERGE COMPLETE
MERGED ODL FILE IS: DIVA.ODL
CBL -- 15: STOP RUN
```

Figure 2-20 Sample ODL File Merge Dialogue

2.6.2 **ODL Merge Utility Error Messages**

Whenever the ODL Merge Utility encounters an error in processing, it issues an error message to the user terminal. These error messages are listed in Table 2-3.

Table 2-4
Merge Error Messages

BAD FORMAT PPN:[p,p] Description — The PPN you specified does not conform to system standard syntax. User Action — Respecify the PPN using the correct syntax.
THIS ODL FILE CONTAINS A ;COBMAIN LINE A ;COBMAIN LINE HAS ALREADY OCCURRED THIS ODL FILE IS IGNORED Description — A ;COBMAN line in an ODL file that identifies the object program as a main program. This message is telling you that Merge has already processed an ODL file that contained a ;COBMAIN line. Since a task image can only contain one main program, this ODL file is ignored.
MULTIPLE ;COBKER HEADER LINE DETECTED THIS ODL FILE IS IGNORED Description — A ;COBKER line is an ODL file that specifies the 2 character kernel used to identify PSECTs for the object file corresponding to this ODL file. Only one ;COBKER line per ODL file is allowed. This ODL file is ignored.
MULTIPLE ;COBOBJ HEADER LINE DETECTED THIS ODL FILE IS IGNORED Description — A ;COBOBJ line in an ODL file that identifies the object file for which the ODL file was generated. Only one such object file specification is allowed in a compiler-generated ODL file. This ODL file is ignored.
NOT STANDARD COBOL ODL FILE FILE IS IGNORED Description — The ODL file contains nonstandard ODL lines. See Chapter 11 for ODL file format.
OPEN UNSUCCESSFUL Description — One of the following conditions exists: 1. The device is not on line 2. The device is not mounted 3. The hardware has failed 4. The file does not exist 5. The user is not allowed access to the file User Action — 1. Determine which condition exists 2. Rectify the condition 3. Reenter the command

Table 2-4 (Cont.)
Merge Error Messages

READ ERROR -- MUST ABORT	
Description	An unrecoverable read error occurred when the Merge Utility attempted to read the input ODL file. The input and output ODL files are closed, and the Merge Utility terminates. One of the following conditions exists: 1. The device is not on line 2. The device is not mounted 3. The hardware has failed 4. The volume is full
User Action	1. Determine which condition exists 2. Rectify the condition 3. Reenter the command

2.7 REFORMAT

COBOL, as implemented in the TRAX support environment, accepts source programs coded in the terminal reference format. Existing source programs in either format can be compiled, however, new support environment COBOL programs must be created in the terminal format. The REFORMAT utility program reads source programs that were coded in the terminal format and converts them to 80-column conventional format source programs.

With REFORMAT you can write source programs in the terminal format; then, if compatibility is ever required for any of those programs, it provides a simple method for conversion to the conventional format.

REFORMAT uses the following steps to expand each line of Terminal format coding to the 80-character Conventional format coding:

- It generates a 6-character line number of 000010, places that number in the first six character positions of the line, and increases it by 000010 for each subsequent line;
- It places any continuation or comment symbols (-,*, or /) into character position 7;
- It places the coding from the Terminal format line into character positions 8-72, thereby creating a line of Conventional format coding;
- It replaces any horizontal tabs with the appropriate number of space characters to simulate tab stops at character positions 5,13,21,29,37,45,53,61, and 66 of the Terminal format line:
- It moves spaces into any character positions left between the last character of coding and character position 73;
- It places either identification characters (if they were supplied at program initialization) or spaces into character positions 73-80;
- It right justifies (against margin R) the first line of a

continued non-numeric literal, thus guaranteeing that the literal will remain the same length as it was in the default format;

- It right justifies (against margin R) the first part of any COBOL word that is split over two lines;
- It creates a line containing a slash (/) in position 7 and space characters in positions 8 through 72 for every form-feed character that it encounters.

2.7.1 REFORMAT Command String

Since REFORMAT is written in COBOL, it runs as a COBOL object program. It has no logical switches. To run it, simply type in the following sequence of responses (prompting messages typed by REFORMAT are underlined):

```
RUN $RFM  RET
```

This causes REFORMAT to begin execution. REFORMAT immediately requests the file specifications for the two files (input and output) to be processed. In response to its prompting messages, type in the file specifications for your two files.

```
RFM-INPUT FILE SPEC:
RFM-OUTPUT FILE SPEC:
```

When the system has successfully opened both files, REFORMAT types the following request for an identification entry in columns 73 through 80. If you desire an identification entry, type in from one to eight characters. REFORMAT places these characters, left justified, in columns 73 through 80 of each output line. If no entry is required, type a carriage return.

```
RFM-COLS 73 TO 80:
```

Following this response, REFORMAT reads the input file and writes it as 80-character records, in Conventional reference format.

When it has processed the last record in the file, REFORMAT displays the following messages; the first indicating the number (nnnnn) of output records produced and the second requesting another input file.

```
RFM-nnnnn LINES PROCESSED.
RFM-INPUT FILE SPEC:
```

If there is another file to be reformatted, follow the same sequence with the specifications for the next file. If not, type Control Z to terminate execution.

2.7.2 REFORMAT Error Messages

If any of the responses to the prompting messages contain detectable errors, REFORMAT displays the following messages indicating the problem.

```
RFM-ERROR IN OPENING INPUT FILE
RFM-TRY AGAIN
RFM-INPUT FILE SPEC:
```

The system could not open the input file. Either the file is not present on the device specified (the default device is SY:) or the file name is typed incorrectly. The usual I/O error messages precede this message.

To continue processing that file, examine the input file spec and type in a corrected version. To process another file, type in a new input file specification. To terminate execution, type Control Z.

```
RFM-ERROR IN OPENING OUTPUT FILE
RFM-TRY AGAIN
RFM-OUTPUT FILE SPEC:
```

The system could not open the output file. An incorrectly typed file specification usually causes this error. (The default device is SY:.) The usual I/O error messages precede this message.

To continue, examine the output file specification and type in a corrected version. To terminate execution, type Control Z.

```
RFM-INPUT FILE IS EMPTY
RFM-INPUT FILE SPEC:
```

The system successfully opened the input file, but the first READ statement encountered the AT END condition.

To continue, type in a new input file specification for another file. To terminate execution, type Control Z.

```
RFM-ERROR IN READING INPUT FILE
RFM-INPUT FILE SPEC:
```

The first attempt to read the input file was unsuccessful. This error is usually caused by an input record length exceeding 86 characters. (Although terminal format records should not exceed 66 characters in length, REFORMAT provides a record area of 86 characters and ignores the right-most 20 characters.)

To continue, type in a new input file specification for another file. To terminate execution, type Control Z.

```
RFM-ERROR IN READING INPUT FILE
RFM-REFORMATTING ABORTED
RFM-nnnnn LINES PROCESSED
RFM-INPUT FILE SPEC:
```

While reading input records (other than the first record), REFORMAT was unsuccessful in an attempt to read a record. It terminates execution and closes both files.

```
RFM-ERROR IN WRITING OUTPUT FILE
RFM-REFORMATTING ABORTED
RFM-nnnnn LINES PROCESSED
RFM-INPUT FILE SPEC:
```

REFORMAT was unsuccessful in an attempt to write an output record. It terminates execution and closes both files.

To process another file, type in a new input file specification and continue with the prompting message sequence. To terminate execution, type Control Z.

CHAPTER 3

NON-NUMERIC CHARACTER HANDLING

3.1 INTRODUCTION

COBOL programs hold their data in fields whose sizes are described in their source programs. These fields are thus "fixed" during compilation to remain the same size throughout the lifespan of the resulting object program.

The data descriptions of the fields in a COBOL program describe them as belonging to any of three data classes -- alphanumeric, alphabetic, or numeric class. Numeric class data items contain only numeric values, alphabetic class only A-Z and space, but alphanumeric class data items may contain values that are all alphabetic, all numeric, or a mixture of alphabetic bytes, numeric bytes, or, in fact, any character from the ASCII character set.

Further, these three classes are subdivided into five categories: alphabetic, numeric, numeric edited, alphanumeric edited, and alphanumeric. Every elementary item except for an index data item belongs to one of the classes and further to one of the categories. The class of a group item is treated at object time as alphanumeric regardless of the classes of subordinate elementary items.

For alphabetic and numeric (data items) class and category are synonymous.

An alphabetic field is a field declared to contain only alphabetic (A-Z and space) characters.

An alphanumeric class field that is declared to contain any ASCII character is called an alphanumeric category field.

If the data description of an alphanumeric class field specifies that certain editing operations will be performed on any value that is moved into it, that field is called an alphanumeric or numeric edited category field.

When reading the following sections of this chapter, this distinction between the class or category of a data item and the actual value that the item contains should always be kept in mind.

Sometimes the text refers to alphabetic, alphanumeric, and alphanumeric edited data items as non-numeric data items. This is to distinguish them from items that are specifically described as numeric items.

Regardless of the class of an item, it is usually possible to store a value in the item, at object time, that is "illegal". Thus, non-numeric ASCII characters can be placed into a field described as numeric class, and an alphabetic class field may be loaded with non-alphabetic characters.

To increase readability, the following sections occasionally omit the word "class" when describing an item; however, the reader should regard the descriptive word, numeric, alphabetic, or alphanumeric, as referring to the class of an item unless it applies specifically to the value in the item.

This chapter discusses non-numeric class data and the non-arithmetic, non-input-output operations that manipulate this type of data.

3.2 DATA ORGANIZATION

Usually, the data areas in a COBOL program are organized into group items with subordinate elementary items. A group item is a data item that is followed by one or more data items (elementary items) with higher valued level numbers. An elementary item has no higher valued subordinate level number.

All of the data areas used by COBOL programs (except for certain registers and switches) must be described in the Data Division of the source program. The compiler allocates memory space for these fields and fixes them in size at compilation time.

The following sub-sections (3.2.1 and 3.2.2) discuss, on a general level, how the compiler handles group and elementary data items.

3.2.1 Group Items

The size of a group item is the total size of the data area occupied by its subordinate elementary items. The compiler considers group items to be alphanumeric DISPLAY items. Thus, the software manipulates group items as if they had been described as PIC X() items, and ignores the structure of the data contained within them.

3.2.2 Elementary Items

The size of an elementary item is determined by the number of allowable symbols it contains that represent character positions. For example, consider the following fields:

```
01 TRANREC.
   03 FIELD-1 PIC X(7).
   03 FIELD-2 PIC S9(5)V99.
```

Figure 3-1
Field Sizes

Both fields consume seven bytes of memory; however, FIELD-1 contains seven alphanumeric bytes while FIELD-2 contains decimal digits and an operational sign. Although certain verbs handle these two classes of data differently, the data, in either case, occupies seven bytes of TRAX memory. COBOL operations on such fields are independent of the mapping of the field into TRAX memory words (16-bit words that hold two 8-bit bytes). Thus, a field may begin in the left or right-hand byte of a word with no effect on the function of any operations that may refer to that field.

In effect, the compiler sees memory as a continuous array of bytes, not words. This becomes particularly important when declaring a table with the OCCURS clause (see Chapter 5, Table Handling).

Records (a 01 level entry and all of its subordinate entries) and data items that have a level number of 77 and all literal values given in the Procedure Division automatically begin on even byte addresses.

I/O verbs require that records be aligned on word boundaries because the TRAX COBOL file system reads and writes integral numbers of words.

Non-input-output verbs do not require alignment of the data. However, when two fields are aligned identically, the processing verb can sometimes increase its efficiency by processing them a word at a time rather that a byte at a time.

In all cases, automatic word alignment of literals, records, and/or 77 items increase the opportunity for more efficient processing.

3.3 SPECIAL CHARACTERS

COBOL allows the user to manipulate any of the 128 characters of the ASCII character set as alphanumeric data even though many of the characters are control characters, which usually control input/output devices. Generally, alphanumeric data manipulations are performed in a manner that attaches no "meaning" to an 8-bit byte. Thus, the user can move and compare these control characters in the same manner as alphabetic and numeric characters.

Although the object program can manipulate all ASCII characters, certain control characters cannot appear in non-numeric literals since the compiler uses them to delimit the source text. Further, the keyboards of the console and keypunch devices have no convenient input key for many of the special characters, thus making it difficult to place them into non-numeric literals.

Special characters may be placed into data fields of the object program by placing the binary value of the special character into a numeric COMP field and redefining that field as alphanumeric DISPLAY. Consider the following example of redefinition. (Keep in mind that the even byte of a word corresponds to the low-order bits of a binary word.)

```
01 LF-COMP PIC 999 COMP VALUE 10.
01 LF REDEFINES LF-COMP PIC X.
01 HT-COMP PIC 999 COMP VALUE 9.
01 TAB REDEFINES HT-COMP PIC X.
01 CR-COMP PIC 999 COMP VALUE 13.
01 CR REDEFINES CR-COMP PIC X.
```

Figure 3-2
Redefining Special Characters

The sample coding in Figure 3-2 introduces each character as a 1-word COMP item with a decimal value, then redefines it as a single byte. (The second byte of the redefinition need not be described at the 01 level, since redefinition at this level does not require identically sized fields.)

The following ASCII code chart may be used to determine the decimal value for any ASCII character. To use the chart, find the desired character; then add its row and column values together to determine the decimal integer to be supplied as a VALUE for the computational item.

Row Value \ Column Value	000	008	016	024	032	040	048	056	064	072	080	088	096	104	112	120
0	NUL	BS	DLE	CAN	space	(	0	8	@	H	P	X	grave	h	p	x
1	SOH	HT	DC1	EM	!	)	1	9	A	I	Q	Y	a	i	q	y
2	STX	LF	DC2	SUB	"	*	2	:	B	J	R	Z	b	j	r	z
3	ETX	VT	DC3	ESC	#	+	3	;	C	K	S	[	c	k	s	¦
4	EOT	FF	DC4	FS	$	,	4	<	D	L	T	\	d	l	t	¦
5	ENQ	CR	NAK	GS	%	-	5	=	E	M	U	]	e	m	u	¦
6	ACK	SO	SYN	RS	&	.	6	>	F	N	V	(↑)	f	n	v	(ESC)
7	BEL	SI	ETB	US	apos	/	7	?	G	O	W	(←)	g	o	w	DEL

Figure 3-3
ASCII Code Chart

3.4 TESTING NON-NUMERIC FIELDS

3.4.1 Relation Tests

An IF statement that contains a relation condition (greater-than, less-than, equal-to, etc.) can compare the value in a non-numeric data item with another value and use the result to alter the flow of control in the program.

An IF statement with a relation condition compares two operands, either of which may be an identifier or a literal, except that both cannot be literals. If the relation exists between the two operands, the relation condition has a truth value of true.

Figure 3-4 illustrates the general format of a relation condition. (The relational characters ">," "<," and "=," although required, are not underlined to avoid confusion with other symbols such as greater-than-or-equal-to.)

```
{identifier-1                    }  {IS [NOT] GREATER THAN}  {identifier-2                    }
{literal-1                       }  {IS [NOT] LESS THAN   }  {literal-2                       }
{arithmetic-expression-1         }  {IS [NOT] EQUAL TO    }  {arithmetic-expression-2         }
                                    {IS [NOT] >           }
                                    {IS [NOT] <           }
                                    {IS [NOT] =           }
```

Figure 3-4
Relation Condition

When coding a relational operator, leave a space before and after each reserved word. When the reserved word NOT is present, the software considers it and the next key word or relational character to be one relational operator that defines the comparison. Figure 3-5 shows the meanings of the relational operators.

OPERATOR	MEANING
IS [NOT] GREATER THAN IS [NOT] >	The first operand is greater than (or not greater than) the second operand.
IS [NOT] LESS THAN IS [NOT] <	The first operand is less than (or not less than) the second operand.
IS [NOT] EQUAL TO IS [NOT] =	The first operand is equal to (or not equal to) the second operand.

Figure 3-5
The Meanings of the Relational Operators

3.4.1.1 **Classes of Data** - COBOL allows comparison of both numeric class operands and non-numeric class operands; however, it handles each class of data slightly differently. For example, it allows a comparison of two numeric operands regardless of the formats specified in their respective USAGE clauses, but requires that all other comparisons (including comparisons of any group items) be between operands with the same usage. It compares numeric class operands with respect to their algebraic values and non-numeric (or a numeric and a non-numeric) class operands with respect to a specified collating sequence.

If only one of the operands is numeric, it must be an integer data item or an integer literal and it must be DISPLAY usage; further, the manner in which the software handles numeric operands depends on the non-numeric operand. Consider the following two types of non-numeric operands:

1. If the non-numeric operand is an elementary item or a literal, the software treats the numeric operand as if it had been moved into an alphanumeric data item (which is the same size as the numeric operand) and then compared. This causes any operational sign, whether carried as a separate character or as an overpunch, to be stripped from the numeric item; thus, it appears to be an unsigned quantity. In addition, if the picture-string of the numeric item contains trailing P characters indicating that there are assumed integer positions that are not actually present, these are filled with zero digits during the operation of stripping any sign that is present. Thus, an item with a picture-string of S9999PPP is moved to a temporary location where it is described with a picture-string of 9999999. If its value is 432J (-4321), the value in the temporary location will be 4321000. The numeric digits, stored as ASCII bytes, take part in the comparison.

2. If the non-numeric operand is a group item, the software treats the numeric operand as if it had been moved into a group item (which is the same size as the numeric operand) and then compared. This is equivalent to a "group move". The software ignores the description of the numeric field (except for length) and, therefore, includes any operational sign, whether carried as a separate character or as an

overpunch, in its length. (Overpunched characters are never ASCII numeric digits, but characters in the range of from A through R, {, or }.) Thus, the sign and the digits, stored as ASCII bytes, take part in the comparison, and zeroes are not supplied for P characters in the picture-string.

The compiler will not accept a comparison between a non-integer numeric operand and a non-numeric operand, and any attempt to compare these two items will cause a diagnostic message at compile time.

3.4.1.2 **The Comparison Operation** - If the two operands are acceptable, the software compares them byte for byte starting at their left-hand end. It proceeds from left to right, comparing the characters in corresponding character positions until it either encounters a pair of unequal characters or reaches the right-hand end of the longer operand.

If the software encounters a pair of unequal characters, it considers their relative position in the collating sequence. The operand with the character that is positioned higher in the collating sequence is the greater operand.

If the operands have different lengths, the comparison proceeds as though the shorter operand were extended on the right by sufficient ASCII spaces (040) to make them both the same length.

If all of the pairs of characters compare equally, the operands are equal.

3.4.2 Class Tests

An IF statement that contains a class condition (NUMERIC or ALPHABETIC) can test the value in a non-numeric data item (USAGE DISPLAY only) to determine if it contains numeric or alphabetic data and use the result to alter the flow of control in the program.

Figure 3-6 illustrates the general format of a class condition. If the data item consists entirely of the ASCII characters 0123456789 with or without the operational sign, the class condition would determine that it is NUMERIC. If the item consists entirely of the ASCII characters A through Z and space, the class condition would determine that it is ALPHABETIC.

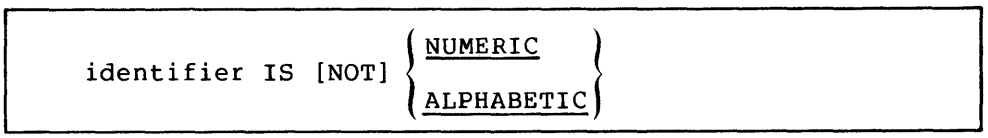


Figure 3-6
Class Condition, General Format

When the reserved word, NOT, is present, the software considers it and the next key word as one class condition that defines the class test to be executed; for example, NOT NUMERIC is a truth test for determining if an operand contains at least one non-numeric byte.

If the item being tested was described as a numeric data item, it may only be tested as NUMERIC or NOT NUMERIC. (For further information on using class conditions with numeric items, see Chapter 4.) The NUMERIC test cannot examine an item that was described either as alphabetic or as a group item containing elementary items whose data descriptions indicate the presence of operational signs.

3.5 DATA MOVEMENT

COBOL provides three statements (MOVE, STRING, and UNSTRING) that perform most of the data movement operations required by business-oriented programs. The MOVE statement simply moves data from one field to another. The STRING statement concatenates a series of sending fields into a single receiving field. The UNSTRING statement disperses a single sending field into multiple receiving fields. Each has its uses and its limitations. This section discusses data movement situations which take advantage of the versatility of these statements.

The MOVE statement handles the majority of data movement operations on character strings. However, the MOVE statement has limitations in its ability to handle multiple fields; for example, it cannot, by itself, concatenate a series of sending fields into a single receiving field or disperse a single sending field into several receiving fields.

Two MOVE statements will, however, bring the contents of two fields together into a third (receiving) field if the receiving field has been "subdivided" with subordinate elementary items that match the two sending fields in size. If other fields are to be concatenated into the third field and they differ in size from the first two fields, then the receiving field will require additional subdivisions (through redefinition).

Another method of concatenation with the MOVE statement is to subdivide the receiving field into single character fields, creating a "table" of a single character field that occurs as many times as there are characters in the receiving field, and execute a data movement loop which moves each sending field, a character at a time, using a subscript that moves continuously across the receiving field.

Two MOVE statements can also be used to disperse the contents of one sending field to several receiving fields. The first MOVE statement can move the left-most end of the sending field to a receiving field; then the second MOVE statement can move the right-most end of the sending field to another receiving field. (The second receiving field must first be described with the JUSTIFIED clause.) Characters from the middle of the sending field cannot easily be moved to any receiving field without extensive redefinitions of the sending field or a character-by-character movement loop (as with concatenation).

The concatenation and dispersion limitations of the MOVE statement are handled quite easily by the STRING and UNSTRING statements. The following sections (3.6, 3.7, and 3.8) discuss these three statements in detail.

3.6 THE MOVE STATEMENT

The MOVE statement moves the contents of one field into another. The following illustration shows the two formats of the MOVE statement.

Format 1

```
MOVE FIELD1 TO FIELD2
```

Format 2

```
MOVE CORRESPONDING FIELD1 TO FIELD2
```

NOTE

Format 2 is discussed in Section 3.6.6.

FIELD1 is the name of the sending field and FIELD2 is the name of the receiving field. The statement causes the software to move the contents of FIELD1 into FIELD2. The two fields need not be the same size, class, or usage; and they may be either group or elementary items. If the two fields are not the same length, the software will align them on one end or the other -- and will truncate or pad (with spaces) the other end. The movement of group items and non-numeric elementary items is discussed below.

A point to remember when using the MOVE statement is that it will alter the contents of every character position in the receiving field.

3.6.1 Group Moves

If either the sending or receiving field is a group item, the software considers the move to be a group move. It treats both the sending and receiving fields in a group move as if they were alphanumeric class fields. If the sending field is a group item and the receiving field is an elementary item, the software ignores the receiving field description (except for the size description, in bytes, and any JUSTIFIED clause); therefore, the software conducts no conversion or editing on the receiving field.

3.6.2 Elementary Moves

If both fields of a MOVE statement are elementary items, their data description clauses control their data movement. (If the receiving field was described as numeric or numeric edited, the rules for numeric moves -- see Chapter 4, Numeric Character Handling -- control the data movement.)

The following table shows the legal (and illegal) non-numeric elementary moves.

Table 3-1
Legal Non-Numeric Elementary Moves

SENDING FIELD CATEGORY	RECEIVING FIELD CATEGORY	
	ALPHABETIC	ALPHANUMERIC ALPHANUMERIC EDITED
ALPHABETIC	Legal	Legal
ALPHANUMERIC	Legal	Legal
ALPHANUMERIC EDITED	Legal	Legal
NUMERIC INTEGER (DISPLAY ONLY)	Illegal	Legal
NUMERIC EDITED	Illegal	Legal

In all of the legal moves shown above, the software treats the sending field as though it had been described as PIC X(). If the sending field description contains a JUSTIFIED clause, the clause will have no effect on the move. If the sending field picture-string contains editing characters, the software uses them only to determine the field's size.

Numeric class data must be in DISPLAY (byte) format and must be an integer.

If the description of the numeric data item indicates the presence of an operational sign (either as a character or an overpunch) or if there are P characters in the picture-string of the numeric data item, the software first moves the item to a temporary location. During this move, it removes the sign and fills out any P character positions with zero digits. It then uses the temporary value (which may be shorter than the original if a separate sign were removed, or longer if P character positions were filled in with zeroes) as the sending field as if it had been described as PIC X(), that is, as if its category were alphanumeric.

If the sending item is an unsigned numeric class field with no P characters in its picture-string, the software does not move the item to a temporary location.

A numeric integer data item sending field has no effect on the justification of the receiving field. If the numeric sending field is shorter than the receiving field, the software fills the receiving field with spaces.

In legal, non-numeric elementary moves, the receiving field actually controls the movement of data. All of the following items, in the receiving field, affect the move: (1) the size, (2) the presence of editing characters in its description, and (3) the presence of the JUSTIFIED RIGHT clause in its description. The JUSTIFIED clause and editing characters are mutually exclusive; therefore, the two classes are discussed separately below.

When a field that contains no editing characters or JUSTIFIED clause in its description is used as the receiving field of a non-numeric elementary MOVE statement, the statement moves the characters by starting at the left-hand end of the fields and scanning across, character-by-character to the right. If the sending item is shorter

than the receiving item, the software fills the remaining character positions with spaces.

3.6.2.1 **Edited Moves** - Alphabetic or alphanumeric fields may contain editing characters. Consider the following insertion editing characters. Alphabetic fields will accept only the B character; however, alphanumeric fields will accept all three characters.

B -- blank insertion position

0 -- zero insertion position

/ -- slash insertion position.

When a field that contains an insertion editing character in its picture-string is used as the receiving field of a non-numeric elementary MOVE statement, each receiving character position that corresponds to an editing character receives the insertion byte value. Figure 3-7 illustrates the use of such symbols with the statement, MOVE FIELD1 TO FIELD2. (Assume that FIELD1 was described as PIC X(7).)

	FIELD2	
FIELD1	PICTURE-STRING	CONTENTS AFTER MOVE
070476	XX/99/XX	07/04/76
04JUL76	99BAAAB99	04 JUL 76
2351212	XXXBXXXX/XX/	235 1212/ /
123456	0XB0XB0XB0X	01 02 03 04

Figure 3-7
Data Movement with Editing Symbols

Data movement always begins at the left end of the sending field, and moves only to the byte positions described as A, 9, or X in the receiving field picture-string. When the sending field is exhausted, the software supplies space characters to fill any remaining character positions (not insertion positions) in the receiving field. If the receiving field becomes exhausted before the last character is moved from the sending field, the software ignores the remaining sending field characters.

3.6.2.2 **Justified Moves** - A JUSTIFIED RIGHT clause in the data description of the receiving field causes the software to reverse its usual data movement conventions. (It starts with the right-hand characters of both fields and proceeds from right to left.) If the sending field is shorter than the receiving field, the software fills the remaining left-hand character positions with spaces. Figure 3-8 illustrates various data description situations for the statement, MOVE FIELD1 TO FIELD2, with no editing.

FIELD1		FIELD2	
PICTURE-STRING	CONTENTS	PICTURE-STRING (AND JUST CLAUSE)	CONTENTS AFTER MOVE
XXX	ABC	XX	AB
		XXXXX	ABC
		XX JUST	BC
		XXXXX JUST	ABC

Figure 3-8
Data Movement with No Editing

3.6.3 Multiple Receiving Fields

If a MOVE statement is written with more than one receiving field, it moves the same sending field value to each of the receiving fields. It has essentially the same effect as a series of separate MOVE statements that all have the same sending field. (For information on subscripted fields, see section 3.6.4.)

The receiving fields need have no relationship to each other. The software checks the legality of each one independently, and performs an independent move operation on each one.

Multiple receiving fields on MOVE statements provide a convenient way to set many fields equal to the same value, such as during initialization code at the beginning of a section of processing. For example:

```
MOVE SPACES TO LIST-LINE, EXCEPTION-LINE, NAME-FLD.

MOVE ZEROES TO EOL-FLAG, EXCEPT-FLAG, NAME-FLAG.

MOVE 1 TO COUNT-1, CHAR-PTR, CURSOR.
```

3.6.4 Subscripted Moves

Any field of a MOVE statement may be subscripted and the referenced field may also be used to subscript another name in the same statement.

When more than one receiving field is named in the same MOVE statement, the order in which the software evaluates the subscripts affects the results of the move. Consider the following two situations:

```
Situation 1  MOVE FIELD1(FIELD2) TO FIELD2 FIELD3.

Situation 2  MOVE FIELD1 TO FIELD2 FIELD3(FIELD2).
```

Figure 3-9
Subscripted MOVE Statements

In situation 1, the software evaluates FIELD1(FIELD2) only once, before it moves any data to the receiving fields. In effect it is as if the statement were replaced with the following statements:

```
MOVE FIELD1(FIELD2) TO TEMP.

MOVE TEMP TO FIELD2.

MOVE TEMP TO FIELD3.
```

In situation 2, the software evaluates FIELD3(FIELD2) immediately before moving the data into it (but after moving the data from FIELD1 to FIELD2). Thus, it uses the newly stored value of FIELD2 as the subscript value. In effect, it is as if the statement were replaced with the following statements:

```
MOVE FIELD1 TO FIELD2.

MOVE FIELD1 TO FIELD3(FIELD2).
```

3.6.5 Common Errors, MOVE Statement

A most important thing to remember when writing MOVE statements is that the compiler considers any MOVE statement that contains a group item to be a group move. It is easy to forget this fact when moving a group item to an elementary item, and the elementary item contains editing characters, or a numeric integer. These attributes of the receiving field (which would determine the action of an elementary move) have no effect on the action of a group move.

3.6.6 Format 2 - MOVE CORRESPONDING

Format 2 of the MOVE statement allows the programmer to move multiple elementary items from one group item to another, by using a single MOVE statement. When the corresponding phrase is used, selected elementary items in the sending field are moved to those elementary items in the receiving field whose data-names are identical. For example:

```
01 A-GROUP                  01 B-GROUP

   02 FIELD1                   02 FIELD2

      03 A PIC x                  03 A PIC x

      03 B PIC 9                  03 C PIC xx

      03 C PIC xx                 03 E PIC xxx

      03 D PIC 99

      03 E PIC xxx

MOVE CORRESPONDING A-GROUP TO B-GROUP

                OR

MOVE CORRESPONDING FIELD1 TO FIELD2
```

The above examples are equivalent to the following series of MOVE statements:

```
MOVE A OF FIELD1 TO A OF FIELD2

MOVE C OF FIELD1 TO C OF FIELD 2

MOVE E OF FIELD1 TO E OF FIELD2
```

3.7 THE STRING STATEMENT

The STRING statement concatenates the contents of two or more sending fields into a single field.

The statement has many forms; the simplest is equivalent, in function, to a non-numeric MOVE statement. Consider the following illustration; if the two fields are the same size, or if the sending field (FIELD1) is larger, the statement is equivalent to the statement, MOVE FIELD1 TO FIELD2.

```
STRING1 FIELD1 DELIMITED BY SIZE INTO FIELD2.
```

Figure 3-10
Sample STRING Statement

If the sending field is shorter than the receiving field, an important difference between the STRING and MOVE statements emerges: the software does not fill the receiving field with spaces. Thus, the STRING statement may leave some portion of the receiving field unchanged.

Additionally, the receiving field must be an elementary alphanumeric field with no JUSTIFIED clause or editing characters in its description. Thus, the data movement of the STRING statement always fills the receiving field from left-to-right with no editing insertions.

3.7.1 Multiple Sending Fields

An important characteristic of the STRING statement is its ability to concatenate a series of sending fields into one receiving field. Consider the following example of the STRING statement:

```
STRING FIELD1A FIELD1B FIELD1C DELIMITED BY SIZE
                    INTO FIELD2.
```

Figure 3-11
Concatenation with the STRING Statement

In this sample STRING statement, FIELD1A, FIELD1B, and FIELD1C are all sending fields. The software moves them to the receiving field (FIELD2) in the order in which they appear in the statement, from left to right, resulting in the concatenation of their values.

If FIELD2 is not large enough to hold all three items, the operation stops when it is full. If this occurs while moving one of the sending fields, the software ignores the remaining characters of that field and any other sending fields not yet processed. For example, if FIELD2 became full while receiving FIELD1B, the software would ignore the rest of FIELD1B and all of FIELD1C.

If the sending fields do not fill the receiving field, the operation stops with the movement of the last character of the last sending item (FIELD1C in Figure 3-11). The software does not alter the contents nor space-fill the remaining character positions of the receiving field.

The sending fields may be non-numeric literals and figurative constants (except for ALL literal). For example, the following statement sets up an address label with the literal period and space between the STATE and ZIP fields:

```
STRING CITY SPACE STATE ".  " ZIP
        DELIMITED BY SIZE INTO ADDRESS-LINE.
```

Figure 3-12
Literals as Sending Fields

Sending fields may also be subscripted. For example, the following statement uses subscripts to concatenate the elements of a table (A-TABLE) into a single field (A-FOUR). (I, of course, must be a subscript or an index-name.)

```
STRING A-TABLE(I) A-TABLE(I+1) A-TABLE(I+2) A-TABLE(I+3)
        DELIMITED BY SIZE INTO A-FOUR.
```

Figure 3-13
Indexed Sending Fields

3.7.2 The POINTER Phrase

Although the STRING statement normally starts at the left-hand end of the receiving field, with the POINTER phrase it is possible to start it scanning at another point within the field. (The scanning, however, remains left-to-right.)

```
MOVE 5 TO P.
STRING FIELD1A FIELD1B DELIMITED BY SIZE
        INTO FIELD2 WITH POINTER P.
```

Figure 3-14
Sample POINTER Phrase

When the POINTER phrase is used, the value of P determines the starting character position in the receiving field. In Figure 3-14, the 5 in P causes the software to move the first character of FIELD1A into character position 5 of FIELD2 (the left-most character position of the receiving field is character position 1) and leave positions 1 through 4 unchanged.

When the STRING operation is complete, the software leaves P pointing to one character position beyond the last character replaced in the receiving field. If FIELD1A and FIELD1B in Figure 3-14 are both four characters long, P will contain a value of 13 (5+4+4) when the operation is complete (assuming that FIELD2 is at least 12 characters long).

3.7.3 The DELIMITED BY Phrase

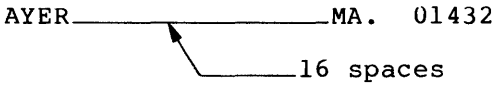
Although the sending fields of the STRING statement are fixed in size at compile time, they frequently contain variable-length items that are padded with spaces. For example, a 20-character city field may contain only the word MAYNARD and 13 spaces. A valuable feature of the STRING statement is that it may be used to move only the useful data from the left-hand end of the sending field. The DELIMITED BY phrase, written with a data-name or literal, instead of the word SIZE, performs this operation. (The delimiter may be a literal, a data item, a figurative constant, or the word SIZE. It may not be ALL literal since ALL literal has an indefinite length. When the phrase contains the word SIZE, the software moves each sending field, in total, until it either exhausts the sending field, or fills the receiving field.)

Consider the following example:

```
STRING CITY SPACE STATE ".  " ZIP
          DELIMITED BY SIZE INTO ADDRESS-LINE.
```

Figure 3-15
Delimiting with the Word SIZE

If CITY is a 20-character field, the result of the STRING operation shown in Figure 3-15 might look like the following:



A far more attractive printout can be produced by having the STRING operation produce the following:

```
AYER, MA.  01432
```

To accomplish this, use the figurative constant SPACE as a delimiter on the sending field; thus,

```
MOVE 1 TO P.
STRING CITY DELIMITED BY SPACE
          INTO ADDRESS-LINE WITH POINTER P.
STRING ", " STATE ".  " ZIP
          DELIMITED BY SIZE
          INTO ADDRESS-LINE WITH POINTER P.
```

Figure 3-16
SPACE as a Delimiter

This sample coding uses the pointer's characteristic of pointing to one character position beyond the last character replaced in the receiving field to enable the second STRING statement to begin at a position one character past where the first STRING statement stopped. (The first STRING statement moves data characters until it encounters a space character -- a match of the delimiter SPACE. The second STRING statement adds the literal, the 2-character STATE field, another literal, and the 5-character ZIP field.)

The delimiter can be varied for each field within a single STRING statement by repeating the DELIMITED BY phrase after the sending field names to which it applies. Thus, the following shorter statement has the same effect as the preceding example. (Placing the operands on separate source lines, as shown in this example, has no effect on the operation of the statement, but improves program readability and simplifies debugging.)

```
STRING CITY DELIMITED BY SPACE
            ", " STATE ". "
            ZIP DELIMITED BY SIZE
                INTO ADDRESS-LINE.
```

Figure 3-17
Repeating the DELIMITED BY Phrase

The sample STRING statement in Figure 3-17 cannot handle 2-word city names, such as New York, since the software would consider the space between the two words as a match for the delimiter SPACE. A longer delimiter, such as two or three spaces (non-numeric literal), can solve this problem. Only when a sequence of characters matches the delimiter will the movement stop for that data item. With a 2-byte delimiter, the same statement can be rewritten in a simpler form:

```
STRING CITY ", " STATE ". " ZIP
            DELIMITED BY "  " INTO ADDRESS-LINE.
```

Figure 3-18
Delimiting with More Than One Space Character

Since only the CITY field may contain two consecutive spaces (the entire STATE field is only two bytes long), the delimiter's search of the other fields will always be unsuccessful and the effect is the same as moving the full field (delimiting by SIZE).

Data movement under control of a data-name or literal is generally slower in execution speed than movement delimited by SIZE.

The example in Figure 3-18 illustrates a frequent source of error in the use of STRING statements to concatenate fields. The remainder of the receiving field is not space-filled as with a MOVE statement. If ADDRESS-LINE is to be printed on a mailing label, for example, the STRING statement should be preceded by the statement, MOVE SPACES TO ADDRESS-LINE. This guarantees a space fill to the right of the concatenated result. Alternatively, the last field concatenated by the STRING statement can be a field previously set to SPACES. (This sending field must be moved under control of a delimiter other than SPACE, of course.)

3.7.4 The OVERFLOW Phrase

When the SIZE option of the DELIMITED BY phrase controls the STRING operation and the pointer value is either known or the POINTER phrase is not used, the programmer can tell, by simple addition, if the receiving field is large enough to hold the sending fields. However, if the DELIMITED BY phrase contains a literal or an identifier, or if the pointer value is not predictable, it may be difficult to tell whether the size of the receiving field is adequate, and an overflow may occur.

Overflow occurs when the receiving field is full and the software is either about to move a character from a sending field or is considering a new sending field. Overflow may also occur if, during the initialization of the statement, the pointer contains a value that is either less than 1 or greater than the length of the receiving field. In this case, the software moves no data to the receiving field and terminates the operation immediately.

The ON OVERFLOW phrase at the end of the STRING statement tests for an overflow condition:

```
STRING FIELD1A FIELD1B DELIMITED BY "C"
                INTO FIELD2 WITH POINTER PNTR
                ON OVERFLOW GO TO PN57.
```

Figure 3-19
The ON OVERFLOW Phrase

The ON OVERFLOW phrase cannot distinguish the overflow caused by a bad initial value in pointer PNTR from the overflow caused by a receiving field that is too short. Only a separate test, preceding the STRING statement, can distinguish between the two.

The following examples illustrate the overflow condition:

```
DATA DIVISION.

  ...
  01 FIELD1A PIC XXX VALUE "ABC".
  01 FIELD2 PIC XXXX.


PROCEDURE DIVISION.

  ...
1.  STRING FIELD1A QUOTE DELIMITED BY SIZE INTO FIELD2.
2.  STRING FIELD1A FIELD1A DELIMITED BY SIZE INTO FIELD2.
3.  STRING FIELD1A FIELD1A DELIMITED BY "C" INTO FIELD2.
4.  STRING FIELD1A FIELD1A FIELD1A FIELD1A
        DELIMITED BY "B" INTO FIELD2.
5.  STRING FIELD1A FIELD1A "C" DELIMITED BY "C"
        INTO FIELD2.
6.  MOVE 2 TO P.
    STRING FIELD1A "AC" DELIMITED BY "C"
        INTO FIELD2 WITH POINTER P.
```

Figure 3-20
Various STRING Statements
Illustrating the Overflow Condition

The results of executing the numbered statements follow:

Table 3-2
Results of the
Preceding Sample Statements

Value of FIELD2 after the STRING operation	Overflow?
1. ABC"	NO
2. ABCA	YES
3. ABAB	NO
4. AAAA	NO
5. ABAB	YES
6. AABA	NO

3.7.5 Subscripted Fields in STRING Statements

All data-names used in the STRING statement may be subscripted, and the pointer value may be used as a subscript.

Since the pointer value might be used as a subscript on one or more of the fields in the statement, it is important to understand the order in which the software evaluates the subscripts and exactly when it updates the pointer. (The use of the pointer as a subscript is not specified by ANS-74 COBOL. Before using it, read the note at the end of this subsection.)

The software updates the pointer after it moves the last character out of each sending field. Consider the following sample coding:

```
MOVE 1 TO P.
STRING "ABC"
     SPACE
     "DEF" DELIMITED BY SIZE
     INTO R WITH POINTER P.
```

Figure 3-21
STRING Statement with Pointer

During the movement of "ABC" into the receiving field (R), the pointer value remains at 1. After the move, the software increases the pointer value by 3 (the size of the sending field literal "ABC") and it takes on the value 4. The software then moves the figurative constant SPACE and increases the pointer value by 1 and it takes on the value 5. "DEF" is then moved and, on completion of the move, the software increases the pointer to its final value for this operation, 8.

Now, consider the updating characteristics of the pointer when applied to subscripting:

```
MOVE 1 TO P.
STRING CHAR(P)
       CHAR(P)
       CHAR(P)
       CHAR(P) DELIMITED BY SIZE
       INTO R WITH POINTER P.
```

Figure 3-22
Subscripting with the Pointer

If CHAR is a 1-character field in a table, the pointer increases by one after each field has been moved and the software will move them into R as if they had been subscripted as CHAR(1), CHAR(2), CHAR(3), and CHAR(4). If CHAR is a 2-character field, the pointer increases by two after each field has been moved and the fields will move into R as if they had been subscripted as CHAR(1), CHAR(3), CHAR(5), and CHAR(7).

Thus, the software evaluates the subscript of a sending item once, immediately before it considers the item as a sending item.

The software evaluates the subscript of a receiving item only once, at the start of the STRING operation. Therefore, if the pointer is used as a subscript on the receiving field, changes occurring to the pointer during the execution of the STRING statement will not alter the choice of which receiving string is altered.

Even the delimiter field can be subscripted, and it too can be subscripted with the pointer. The software re-evaluates the delimiter subscript once for each sending field, immediately before it compares the delimiter to the field. Thus, by subscripting it with the pointer value, the delimiter can be changed for each sending field. This has the peculiar effect of choosing the next sending field's delimiter based on the position, in the receiving field, into which its first character will fall. For example, consider the following sample coding:

```
01 DTABLE.
   03 D PIC X OCCURS 7 TIMES.
      (                 )
      (                 )
   MOVE 1  TO P.
   STRING  "ABC"
           "ABC"
           "ABC" DELIMITED BY D(P)
           INTO R WITH POINTER P.
```

Figure 3-23
Subscripting the Delimiter

The following table shows the value that will arrive in the receiving field (R) from the three "ABC" literals if DTABLE contains the values shown in the left-hand column:

Table 3-3
Results of the
Preceding Sample Statements

DTABLE Value	R Value
ABCDEFG	(Unchanged)
BCDEFGH	AABABC
CDEFGHI	ABABCABC
CCCCCCCC	ABABAB

NOTE

The rules in this section, concerning subscripts in the STRING statement, are rules that are not specified by 1974 American National Standard COBOL. Dependence on these rules, particularly those involving the use of the pointer field as a subscript, may produce programs that will not perform the same way on other COBOL compilers.

If the pointer field is not used as a subscript on any of the fields in the statement, the point at which the software evaluates the subscripts is immaterial to the execution of the statement. Thus, by avoiding the use of the pointer as a subscript, uniform results can be expected from all COBOL compilers that adhere to 1974 ANS COBOL.

3.7.6 Common Errors, STRING Statement

The most common errors made when writing STRING statements are:

- using the word "TO" instead of "INTO"
- forgetting to write "DELIMITED BY SIZE";
- forgetting to initialize the pointer;
- initializing the pointer to 0 instead of 1;
- forgetting to provide for space fill of the receiving field when it is desirable.

3.8 THE UNSTRING STATEMENT

The UNSTRING statement disperses the contents of a single sending field into multiple receiving fields.

The statement has many forms; the simplest is equivalent in function to a non-numeric MOVE statement. Consider the following illustration; the sample statement is equivalent to MOVE FIELD1 TO FIELD2, regardless of the relative sizes of the two fields.

```
UNSTRING FIELD1 INTO FIELD2.
```

Figure 3-24
Sample UNSTRING Statement

The sending field (FIELD1) may be either a group item or an alphanumeric, or alphanumeric edited elementary item. The receiving field (FIELD2) may be alphabetic, alphanumeric, or numeric, but it cannot specify any type of editing.

If the receiving field is numeric, it must be DISPLAY usage. The picture-string of a numeric receiving field may contain any of the legal numeric description characters except for P and, of course, the editing characters. The UNSTRING statement moves the sending field to numeric receiving fields as if the sending field had been described as an unsigned integer; further, it automatically truncates or zero fills as required.

If the receiving field is not numeric, the software follows the rules for elementary non-numeric MOVE statements. It left-justifies the data in the receiving field, truncating or space-filling as required. (If the data-description of the receiving field contains a JUSTIFIED clause, the software right-justifies the data, truncating or space-filling to the left as required.)

3.8.1 Multiple Receiving Fields

An important characteristic of the UNSTRING statement is its ability to disperse one sending field into several receiving fields. Consider the following example of the UNSTRING statement written with multiple receiving fields:

```
UNSTRING FIELD1 INTO
         FIELD2A FIELD2B FIELD2C.
```

Figure 3-25
Multiple Receiving Fields

In this sample statement, FIELD1 is the sending field. The software performs the UNSTRING operation by scanning across FIELD1 from left to right. When the number of characters scanned is equal to the number of characters in the receiving field, the software moves the scanned characters into the receiving field and begins scanning the next group of characters for the next receiving field.

Assume that each of the receiving fields in the preceding illustration (FIELD2A, FIELD2B, and FIELD2C) is five characters long, and that FIELD1 is 15 characters long. The size of FIELD2A determines the number of characters for the first move. The software scans across FIELD1 until the number of characters scanned equals the size of FIELD2A (5). It then moves those first five characters to FIELD2A, and sets the scanner to the next (sixth) character position in FIELD1. The size of FIELD2B determines the size of the next move. The software begins this move by scanning across FIELD1 from character position six, until the number of scanned characters equals the size of FIELD2B (5). It then moves the sixth through the tenth characters to FIELD2B, and sets the scanner to the next (eleventh) character position in FIELD1. FIELD2C determines the size of the last move (for this example) and causes characters 11 through 15 of FIELD1 to be moved into FIELD2C, thus terminating this UNSTRING operation.

Each data movement acts as an individual MOVE statement, the sending field of which is an alphanumeric field equal in size to the receiving field. If the receiving field is numeric, the move operation will convert the data to the numeric form. For example, consider what would happen if the fields under discussion had the data descriptions and were manipulating the values shown in the following table:

Table 3-4
Values Moved Into the Receiving Fields
Based on the Value in the Sending Field

FIELD1 PIC X(15). VALUE IS:	FIELD2A PIC X(5)	FIELD2B PIC S9(5) LEADING SEPARATE	FIELD2C PIC S999V99
ABCDE1234512345	ABCDE	+12345	3450
XXXXX0000100123	XXXXX	+00001	1230

FIELD2A is an alphanumeric field and, therefore, the software simply conducts an elementary non-numeric move with the first five characters.

FIELD2B, however, has a leading separate sign that is not included in its size. Thus, the software moves only five numeric characters and generates a positive sign in the separate sign position.

FIELD2C has an implied decimal point with two character positions to the right of it, plus an overpunched sign on the low-order digit. The sending field should supply five numeric digits; but, since the sending field is alphanumeric, the software treats it as an unsigned integer; it truncates the two high-order digits and supplies two zero digits for the decimal positions. Further, it supplies a positive overpunch sign, making the low-order digit a +0 (or the ASCII character, {). (There is no simple way to have UNSTRING recognize a sign character or a decimal point in the sending field.)

If the sending field is shorter than the sum of the sizes of the receiving fields, the software ignores the remaining receiving fields. If it reaches the end of the sending field before it reaches the end of one of the receiving fields, the software moves the scanned characters into that receiving field. It left-justifies and fills the remaining character positions with spaces for alphanumeric data, or decimal point aligns and zero fills the remaining character positions

for numeric data. Consider the following examples of a sending field that is too short. (The statement is UNSTRING FIELD1 INTO FIELD2A FIELD2B. FIELD2A is a 3-character alphanumeric field, and receives the first three characters of FIELD1 (ABC) in every operation. FIELD2B, however, runs out of characters every time before filling. Since FIELD2A always contains the characters ABC, it is not shown.)

Table 3-5
Handling a Sending Field that is Too Short

FIELD1 PIC X(6) VALUE IS:	FIELD2B PICTURE IS:	FIELD2B Value after UNSTRING Operation
ABCDEF	XXXXX	DEF
ABC246	S99999	0024F
	S9V999	600
	S9999	+0246
	LEADING SEPARATE	

3.8.2 The DELIMITED BY Phrase

The size of the data to be moved can be controlled by a delimiter, rather than by the size of the receiving field. The DELIMITED BY phrase supplies the delimiter characters.

UNSTRING delimiters are quite flexible; they can be literals, figurative constants (including ALL literal), or identifiers (identifiers may even be subscripted data-names). This sub-section discusses the use of these three types of delimiters. Subsequent sections cover multiple delimiters, the COUNT phrase, and the DELIMITER phrase. Subscripting delimiters is discussed at the end of this section under Subscripted Fields in UNSTRING Statements.

Consider the following sample UNSTRING statement; it uses the figurative constant, SPACE, as a delimiter:

```
UNSTRING FIELD1 DELIMITED BY SPACE INTO FIELD2.
```

Figure 3-26
Delimiting with a Space Character

In this example, the software scans the sending field (FIELD1), searching for a space character. If it encounters a space, it moves all of the scanned (non-space) characters that precede that space to the receiving field (FIELD2). If it finds no space character, it moves the entire sending field. When it has determined the size of the sending field, the software moves the contents of that field following the rules for the MOVE Statement, truncating or zero filling as required.

The following table shows the results of an UNSTRING operation that delimits with a literal asterisk (UNSTRING FIELD1 DELIMITED BY "*" INTO FIELD2).

Table 3-6
Results of Delimiting with an Asterisk

FIELD1 PIC X(6) VALUE IS:	FIELD2 PICTURE IS:	FIELD2 VALUE AFTER UNSTRING
ABCDEF	XXX	ABC
	X(7)	ABCDEF
	XXX JUSTIFIED	DEF
******	XXX	ΔΔΔ
*ABCDE	XXX	ΔΔΔ
A*****	XXX JUSTIFIED	ΔΔA
246***	S9999	024F
12345*	S9999 SEPARATE TRAILING	2345+
2468**	S999V9 SEPARATE LEADING	+4680
*246**	9999	0000

If the delimiter matches the first character in the sending field, the software considers the size of the sending field to be zero. The movement operation still takes place, however, and fills the receiving field with spaces or zeroes depending on its class.

A delimiter may also be applied to an UNSTRING statement that has multiple receiving fields:

```
UNSTRING FIELD1 DELIMITED BY SPACE
         INTO FIELD2A FIELD2B.
```

Figure 3-27
Delimiting with Multiple Receiving Fields

The sample instruction in Figure 3-27 causes the software to scan FIELD1 searching for a character that matches the delimiter. If it finds a match, it moves the scanned characters to FIELD2A and sets the scanner to the next character position to the right of the character that matched. It then resumes scanning FIELD1 for a character that matches the delimiter. If it finds a match, it moves all of the characters that lie between the character that first matched the delimiter and the character that matched on the second scan, and sets the scanner to the next character position to the right of the character that matched. (The DELIMITED BY phrase could handle additional receiving fields in the same manner as it handled FIELD2B.)

The following table shows the results of an UNSTRING operation that applies a delimiter to multiple receiving fields (UNSTRING FIELD1 DELIMITED BY "*" INTO FIELD2A FIELD2B).

Table 3-7
Results of Delimiting
Multiple Receiving Fields

FIELD1 PIC X(8) VALUE IS:	VALUES AFTER UNSTRING OPERATION	
	FIELD2A PIC X(3)	FIELD2B PIC X(3)
ABC*DEF*	ABC	DEF
ABCDE*FG	ABC	FGΔ
A*B*****	AΔΔ	BΔΔ
*AB*CD**	ΔΔΔ	ABΔ
**ABCDEF	ΔΔΔ	ΔΔΔ
A*BCDEFG	AΔΔ	BCD
ABC**DEF	ABC	ΔΔΔ
A******B	AΔΔ	ΔΔΔ

The last two examples illustrate the limitations of a single character delimiter. Accordingly, the delimiter may be longer than one character and it may be preceded by the word ALL.

The following table shows the results of an UNSTRING operation that uses a 2-character delimiter (UNSTRING FIELD1 DELIMITED BY "**" INTO FIELD2A FIELD2B):

Table 3-8
Results of Delimiting
with Two Asterisks

FIELD1 PIC X(8) VALUE IS:	VALUES AFTER UNSTRING OPERATION	
	FIELD2A PIC XXX	FIELD2B PIC XXX JUSTIFIED
ABC**DEF	ABC	DEF
A*B*C*D*	A*B	ΔΔΔ
AB***C*D	ABΔ	C*D
AB**C*D*	ABΔ	*D*
AB**CD**	ABΔ	ΔCD
AB***CD*	ABΔ	CD*
AB*****CD	ABΔ	ΔΔΔ

Unlike the STRING statement, the UNSTRING statement accepts the ALL literal as a delimiter. When the word ALL precedes the delimiter, the action of the UNSTRING statement remains essentially the same as with one delimiter until the scanning operation finds a match. At this point, the software scans farther, looking for additional consecutive strings of characters that also match the delimiter item. It considers the "ALL delimiter" to be one, two, three, or more adjacent repetitions of the delimiter item.

The following table illustrates the results of an UNSTRING operation that uses an ALL delimiter (UNSTRING FIELD1 DELIMITED BY ALL "*" INTO FIELD2A FIELD2B).

Table 3-9
Results of Delimiting
with ALL Asterisks

FIELD1 PIC X(8) VALUE IS:	VALUES AFTER UNSTRING OPERATION	
	FIELD2A PIC XXX	FIELD2B PIC XXX JUSTIFIED
ABC*DEF*	ABC	DEF
ABC**DEF	ABC	DEF
A******F	AΔΔ	ΔΔF
A*F*****	AΔΔ	ΔΔF
A*CDEFG	AΔΔ	EFG

The next table illustrates the results of an UNSTRING operation that combines ALL with a 2-character delimiter (UNSTRING FIELD1 DELIMITED BY ALL "**" INTO FIELD2A FIELD2B).

Table 3-10
Results of Delimiting with
ALL Double Asterisks

FIELD1 PIC X(8) VALUE IS:	VALUES AFTER UNSTRING OPERATION	
	PIC XXX	PIC XXX JUSTIFIED
ABC**DEF	ABC	DEF
AB**DE**	ABΔ	ΔDE
A***D***	AΔΔ	Δ*D
A*******	AΔΔ	ΔΔ*

In addition to unchangeable delimiters, such as literals and figurative constants, delimiters may be designated by identifiers. Identifiers (which may even be subscripted data-names) permit variable delimiting. Consider the following sample statement:

```
UNSTRING FIELD1 DELIMITED BY DEL1
         INTO FIELD2A FIELD2B.
```

Figure 3-28
Delimiting with an Identifier

The data-name, DEL1, must be alphanumeric. It may be a group or elementary item, and it may be edited. (Since the delimiter is not a receiving field, any editing characters will not effect its use, other than contributing to the size of the item.)

If the delimiter contains a subscript, the subscript may be varied as a side effect of the UNSTRING operation. The evaluation of subscripts is discussed later in this section.

3.8.2.1 **Multiple Delimiters** - The UNSTRING statement has the ability to scan a sending field, searching for a match from a list of delimiters. This list may contain ALL delimiters and delimiters of various sizes. The only requirement of the list is that delimiters must be connected by the word OR.

The following sample statement separates a sending field into three receiving fields. The sending field consists of three strings separated by the following: (1) any number of spaces, or (2) a comma followed by a single space, or (3) a single comma, or (4) a tab character, or (5) a carriage return character. (The ", " must precede the "," in the list if it is ever to be recognized.)

```
UNSTRING FIELD1 DELIMITED BY
         ALL SPACE OR
         ", " OR
         "," OR
         TAB OR
         CR
         INTO FIELD2A FIELD2B FIELD2C.
```

Figure 3-29
Multiple Delimiters

The following table illustrates the potential of this statement. The tab (represented by the letter t) and carriage return (represented by the letter r) characters represent single character fields containing the ASCII horizontal tab and carriage return characters.

Table 3-11
Results of the Multiple Delimiters
Shown in Figure 3-29

FIELD1 PIC X(12)	FIELD2A PIC XXX	FIELD2B PIC 9999	FIELD2C PIC XXX
A,0,Cr	AΔΔ	0000	CΔΔ
At456,ΔE	AΔΔ	0456	EΔΔ
AΔΔΔ 3ΔΔΔ9	AΔΔ	0003	9ΔΔ
AttBr	AΔΔ	0000	BΔΔ
A,,C	AΔΔ	0000	CΔΔ
ABCD,Δ4321,Z	ABC	4321	ZΔΔ

t--tab character, r--carriage return character

3.8.3 The COUNT Phrase

The COUNT phrase keeps track of the size of the sending string and stores the length in a user-supplied data area.

The length of a delimited sending field may vary widely (from zero to the full length of the field) and some programs may require knowledge of this length. For example, if it exceeds the size of the receiving field (which is fixed in size) some data may be truncated and the program's logic may require this information.

To use the phrase, simply follow the receiving field name with the words COUNT IN and an identifier. Consider the following sample statement:

```
UNSTRING FIELD1 DELIMITED BY ALL "*"
         INTO FIELD2A COUNT IN COUNT2A
         FIELD2B COUNT IN COUNT2B
         FIELD2C.
```

Figure 3-30
The COUNT Phrase

In this sample statement, the software will count the number of characters between the left-hand end of FIELD1 and the first asterisk in FIELD1 and place that value into COUNT2A; thus, COUNT2A contains the size of the first sending string. The software does not include the delimiter in the count (as it is not a part of the string).

The software then counts the number of characters in the second sending field and places that value into COUNT2B.

The phrase should be used only where needed; in this example the length of the string moved to FIELD2C is not needed, so no COUNT phrase follows it.

If the receiving field is shorter than the value placed in the count field, the software truncates the sending string. (If the number of integer positions in a numeric field is smaller than the value placed into the count field, high-order numeric digits have been lost.)

If the software finds a delimiter match on the first character it examines, it places a zero in the count field.

The count field must be described as a numeric integer, either COMP or DISPLAY usage, with no editing symbols nor the character P in its picture-string. The software moves the count value into the count field according to the rules for an elementary numeric MOVE statement

The COUNT phrase may be used only in conjunction with the DELIMITED BY phrase.

3.8.4 The DELIMITER Phrase

The DELIMITER phrase causes the actual character or characters that delimited the sending field to be stored in a user-supplied data area. This phrase is most useful when: (1) the statement contains a delimiter list, (2) any one of the items in the list might have delimited the field, and (3) program logic flow depends on which one found a match. In fact, the DELIMITER and COUNT phrases could be used together and program logic flow could depend on both the size of the sending string and the delimiter character that terminated it.

To use the DELIMITER phrase, simply follow the receiving field name with the words DELIMITER IN and an identifier. (The software places the delimiter character in the area named by the identifier.) Consider the following sample UNSTRING statement:

```
UNSTRING FIELDl DELIMITED BY "," OR TAB OR
         ALL SPACE OR CR
         INTO FIELD2A DELIMITER IN DELIMA
         FIELD2B DELIMITER IN DELIMB
         FIELD2C.
```

Figure 3-31
The DELIMITER Phrase

After moving the first sending string to FIELD2A, the software takes the character (or characters) that delimited that string and places it in DELIMA. DELIMA, then, contains a comma, or a tab, or a carriage return, or any number of spaces. Since the delimiter string is moved under the rules of the elementary non-numeric MOVE statement, the software truncates or space fills with left or right justification (depending on its data description).

The software then moves the second sending string to FIELD2B and places its delimiting character into DELIMB.

When a sending string is delimited by the end of the sending field (rather than a match on a delimiter) the delimiter string is of zero length. This causes the DELIMITER item to be space filled. The phrase should be used only where needed; in this example, the character that delimits the last sending string is not needed, so no DELIMITER phrase follows FIELD2C.

The data item named in the DELIMITER phrase must be described as an alphanumeric item. It may contain editing characters and it may even be a group item.

When the DELIMITER and COUNT phrases are used together, they must appear in the correct order (DELIMITER phrase preceding the COUNT phrase). Both of the data items named in these phrases may be subscripted or indexed. If they are subscripted, the subscript may be varied as a side effect of the UNSTRING operation. (The evaluation of subscripts is discussed in section 3.8.8.)

3.8.5 The POINTER Phrase

Although the UNSTRING statement normally starts at the left-hand end of the sending field, the POINTER phrase permits the user to select a character position in the sending field for the software to begin scanning. (The scanning, however, remains left-to-right.)

When a sending field is to be dispersed into multiple receiving fields, it often happens that the choice of delimiters, the size of subsequent receiving fields, etc. depend on the value in the first sending string or the character that delimited that string. Thus, the program may need to move the first field, hold its place in the sending field, and examine the results of the operation to determine how to handle the sending items that follow. This is done by using an UNSTRING statement with a POINTER phrase that fills only the first receiving field. When the first string has been moved to a receiving item, the software updates the pointer data item with a new position (one character beyond the delimiter that caused the interruption) to begin the next scanning operation. The program may then examine the new position, the receiving field, the delimiter value, the sending string size, and resume the scanning operation by executing another UNSTRING statement with the same sending field and pointer data item. Thus, the UNSTRING statement can move one sending string at a time, with the form of each move being dependent on the context of the preceding string of data.

The POINTER phrase must follow the last receiving item in the statement. Consider the following two UNSTRING statements with their accompanying POINTER phrases and tests:

```
MOVE 1 TO P.
UNSTRING FIELD1 DELIMITED BY
         ":" OR TAB OR CR OR ALL SPACE
         INTO FIELD2A
         DELIMITER IN DELIMA
         COUNT IN LSIZEA
         WITH POINTER PNTR.
IF LSIZEA = 0 GO TO NO-LABEL-PROCESS.
IF DELIMA =  ":"
         IF PNTR > 8 GO TO BIG-LABEL-PROCESS
         ELSE GO TO LABEL-PROCESS.
IF DELIMA = TAB GO TO BAD-LABEL PROCESS.

     ...

UNSTRING FIELD1 DELIMITED BY ...  WITH POINTER PNTR.
```

Figure 3-32
The POINTER Phrase

PNTR contains the current position of the scanner in the sending field. The second UNSTRING statement uses PNTR to begin scanning the additional sending strings in FIELD1.

Since the software considers the left-most character to be character position one, the value returned by PNTR may be used to examine the next character. To do this, simply use PNTR as a subscript on the sending field (providing that the sending field is also described as a table of characters). For example, consider the following sample coding:

```
01 FIELD1.
   02 FIELD1-CHAR OCCURS 40 TIMES.

     ...

   UNSTRING FIELD1
         ...
         WITH POINTER PNTR.
   IF FIELD1-CHAR(PNTR) = "X" ...
```

Figure 3-33
Examining the Next Character
By Using the Pointer Data
Item as a Subscript

Another way to examine the next character of the sending field is to use the UNSTRING statement to move it to a 1-character receiving field. Consider the following sample coding:

```
UNSTRING FIELD1
         ...
         WITH POINTER PNTR.
UNSTRING FIELD1 INTO CHAR1 WITH POINTER PNTR.
SUBTRACT 1 FROM PNTR.
IF CHAR1 = "X" ...
```

Figure 3-34
Examining the Next Character
By Placing It Into a 1-Character Field

The program must decrement PNTR in order for this case to work like the one illustrated in Figure 3-33, since the second UNSTRING statement will increment the pointer value by 1.

The program must initialize the POINTER phrase data item before the UNSTRING statement uses it. The software will terminate the UNSTRING operation if the initial value of the pointer is less than one or greater than the length of the sending field. (A pointer value that is less than one or greater than the length of the sending field causes an overflow condition. Overflow conditions are discussed in section 3.8.7.)

The POINTER and TALLYING phrases may be used together in the same UNSTRING statement; but, when both are used, the POINTER phrase must precede the TALLYING phrase.

3.8.6 The TALLYING Phrase

The TALLYING phrase counts the number of receiving fields that received data from the sending field.

When an UNSTRING statement contains several receiving fields, the possibility exists that there may not always be as many sending strings as there are receiving fields. The TALLYING phrase provides a convenient method for keeping a count of how many fields were acted upon.

```
MOVE 0 TO RCOUNT.
UNSTRING FIELD1 DELIMITED BY "," OR ALL SPACE
         INTO FIELD2A
              FIELD2B
              FIELD2C
              FIELD2D
              FIELD2E
              TALLYING IN RCOUNT.
```

Figure 3-35
The TALLYING Phrase

If the software has moved only three sending strings when it reaches the end of FIELD1, it adds 3 to RCOUNT. The first three fields (FIELD2A, FIELD2B, and FIELD2C) contain data from the operation, and the last two (FIELD2D and FIELD2E) do not.

The TALLYING data item always contains the sum of its initial contents plus the number of sending strings acted upon by the UNSTRING command just executed. Thus, the programmer may want to initialize the tally count before each use.

When used in the same statement with a POINTER phrase, the TALLYING phrase must follow the POINTER phrase and both phrases must follow all of the field names, the DELIMITER and COUNT phrases. The data items for both phrases must contain numeric integers, that is, be without editing characters or the letter P in their picture-strings; both data items may be either COMP or DISPLAY usage. They may be signed or unsigned and, if they are DISPLAY usage, they may contain any desired sign option.

The data items for both phrases may be subscripted or indexed, or they may be used as subscripts on other fields in the statement. (The evaluation of subscripts is discussed in section 3.8.8.) A convenient use of the TALLYING phrase data item is as a subscript of a receiving field. Consider the following sample coding, which causes program control to execute the UNSTRING statement repeatedly until it exhausts the sending field.

```
        MOVE 1 TO PNTR, TLY.
PAR1.   UNSTRING FIELD1 DELIMITED BY "," OR CR
                 INTO FIELD2(TLY)
                 DELIMITER IN DEL2
                 WITH POINTER PNTR
                 TALLYING IN TLY.
        IF DEL2 = "," GO TO PAR1.
```

Figure 3-36
The POINTER and TALLYING Phrases
Used Together

This sample coding causes program control to loop through the UNSTRING statement, using the pointer, PNTR, to scan across FIELD1 with successive executions. Each comma isolates a sending string until control reaches either a carriage return character or the end of FIELD1. If it reaches the end of the field without encountering a carriage return character, the software places a space into the delimiter field, DEL2, and control falls through the IF statement and out of the loop.

Since the TALLYING data item, TLY, is increased by 1 after each data movement, it serves as a subscript on the receiving field. In effect this causes the software to unpack the value in FIELD1 into an array of fixed-size fields. Further, an array of COUNT data items can be supplied and loaded by the UNSTRING/TALLYING statement by adding the following phrase to the coding in Figure 3-36:

```
COUNT IN C(TLY)
```

Figure 3-37
Subscripting the COUNT Phrase
With the TALLYING Data Item

The TALLYING data item, in the above example, is one greater than the number of receiving fields acted upon by the UNSTRING operation. This is because the data item must be initialized to a value of one in order to be used as a subscript for the first receiving item.

3.8.7 The OVERFLOW Phrase

The OVERFLOW phrase detects the overflow condition and provides an imperative statement to be executed when it detects the condition. An overflow condition exists when either of the following two situations occurs:

1. The UNSTRING statement is about to be executed and its pointer data item contains a value of less than one or greater than the size of the sending field. When it detects this situation, the software executes the OVERFLOW phrase before it moves any data. Thus, the values of all of the receiving fields remain unchanged.

2. The UNSTRING statement has filled all of the receiving fields and data still remains in the sending field that has not been matched as a delimiter or included in a sending string. When it detects this situation, the software executes the OVERFLOW phrase after it has executed the UNSTRING statement. Thus, the values of all of the receiving fields are updated, but some data has not been moved.

If the UNSTRING operation causes the scanner to move off the end of the sending field (thus exhausting it), the software will not execute the OVERFLOW phrase.

Consider the following set of instructions, which cause program control to execute the UNSTRING statement repeatedly until it exhausts the sending field. The TALLYING data item is a subscript indexing the receiving field. (Compare this loop with the one in Figure 3-36, which accomplishes the same thing.)

```
        MOVE 1 TO TLY PNTR.
PAR1.   UNSTRING FIELD1 DELIMITED BY "," OR CR
                 INTO FIELD2(TLY)
                 WITH POINTER PNTR
                 TALLYING IN TLY
                 ON OVERFLOW GO TO PAR1.
```

Figure 3-38
Using the OVERFLOW Phrase

NOTE

The overflow condition also occurs if the value of a pointer data item lies outside the sending field at the start of execution of the UNSTRING statement. (The pointer value must not be less than 1, nor greater than the length of the sending field.) This type of overflow is not distinguishable from the overflow condition described at the start of this section, except that this condition causes the UNSTRING statement to terminate before any data movement takes place. Then, the values of all receiving fields remain unchanged.

3.8.8 Subscripted Fields in UNSTRING Statements

Since the flexibility of the UNSTRING statement is enhanced by subscripting and indexing and particularly by subscripting with other fields within the statement (such as subscripting the receiving field with the TALLYING data item as discussed above), it is important to understand how often and exactly when the software evaluates these subscripts and indexes. This sub-section discusses the frequency and times of subscript evaluation.

The software evaluates subscripts and indexes on the following items only once, at the initiation of the UNSTRING statement; thus, any change in subscript values during the execution of the statement has no effect on these fields:

1. Sending field,
2. POINTER data item,
3. TALLYING data item.

The software evaluates subscripts and indexes on the following items immediately before it moves data into the item. It moves the data to these items in the order in which they are listed in the statement (which is the same order as below):

1. Receiving field,
2. DELIMITER data item,
3. COUNT data item.

The software evaluates any subscripts and indexes on the data-names in the DELIMITED BY phrase (delimiters) immediately before it scans each sending string looking for a delimiter match. Thus, it re-evaluates these data-names once for each receiving field in the statement.

If any of the following items are used as subscripts on any receiving fields, the programmer must be aware of the point at which these items are updated:

- POINTER data-item,
- TALLYING data-item,
- COUNT data-item,
- Another receiving field.

Figure 3-39 illustrates, with a flow chart, the sequence of evaluation operations:

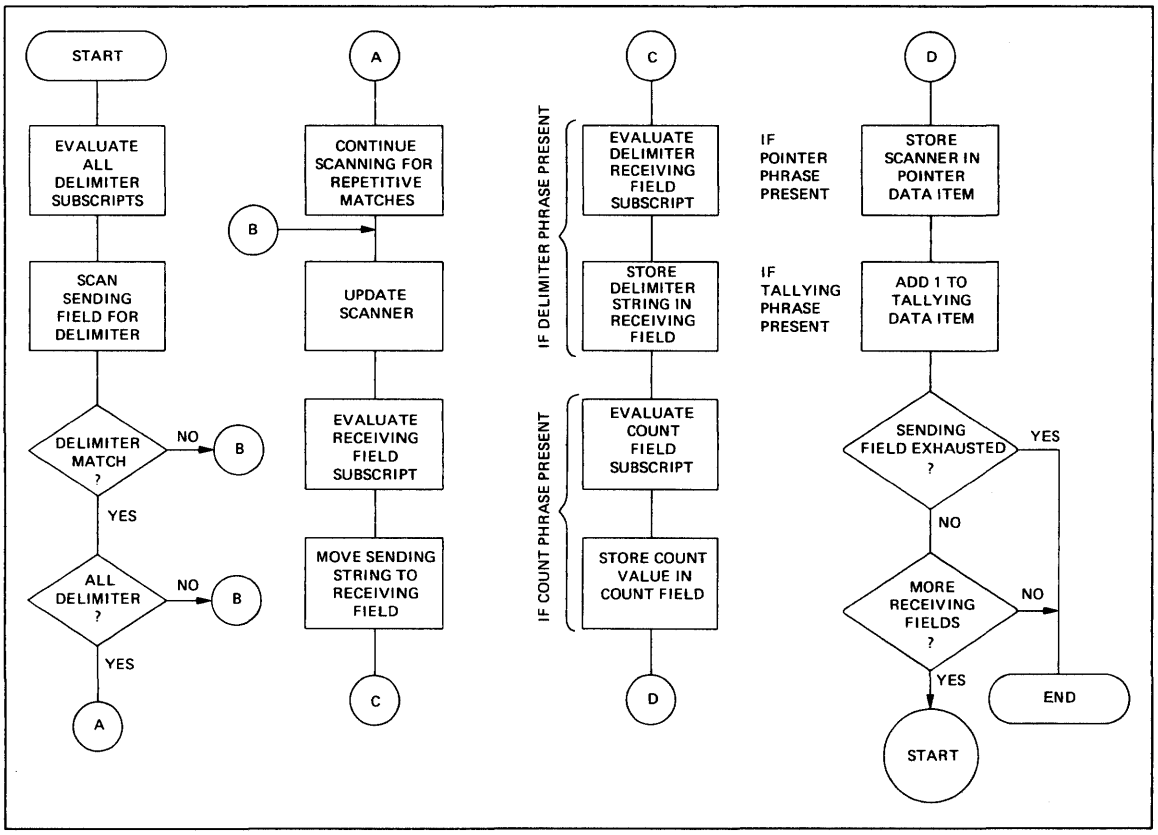


Figure 3-39
Sequence of Subscript Evaluation

NOTE

The rules in this section concerning the exact point at which the software evaluates the identifiers in the DELIMITED BY phrase and the point at which it updates the POINTER and TALLYING data items, are rules that are specified by 1974 American National Standard COBOL, as opposed to the STRING statement where these are not so specified.

3.8.9 Common Errors, UNSTRING Statement

The most common errors made when writing UNSTRING statements are:

- Leaving the OR connector out of a delimiter list;
- Misspelling or interchanging the words, DELIMITED and DELIMITER;
- Writing the DELIMITER and COUNT phrases in the wrong order when both are present (DELIMITER must precede COUNT);
- Leaving out the word INTO or writing it as TO;
- Repeating the word INTO where it is not needed; thus:

```
UNSTRING FIELD1 DELIMITED BY SPACE OR TAB
         INTO FIELD2A DELIMITER IN DELIMA
         INTO FIELD2B DELIMITER IN DELIMB
         INTO FIELD2C DELIMITER IN DELIMC.
```

Figure 3-40
Erroneously Repeating the Word INTO

- Writing the POINTER and TALLYING phrases in the wrong order (POINTER must precede TALLYING).

3.9 THE INSPECT STATEMENT

The INSPECT statement examines the character positions in a field and counts or replaces certain characters (or groups of characters) in that field.

Like the STRING and UNSTRING operations, INSPECT operations scan across the field from left to right; further, like those two statements, the INSPECT statement features a phrase which allows it to begin or terminate the scanning operation with a delimiter match. (Thus, the operation can begin within the field instead of at the left-hand end, or it may begin at the left-hand end and terminate within the field.)

The TALLYING operation (which counts certain characters in the field) and the REPLACING operation (which replaces certain characters in the field) are quite versatile and may be applied to all of the characters in the delimited area of the field being inspected, or they may be applied only to those characters that match a given character string

under stated conditions. Consider the following sample statements, which both cause a scan of the complete field:

```
INSPECT FIELD1 TALLYING TLY FOR ALL "B".
```

Figure 3-41
Sample INSPECT...TALLYING Statement

This statement scans FIELD1 looking for the character B. Each time it finds a B, it increments TLY by 1.

```
INSPECT FIELD1 REPLACING ALL SPACE BY ZERO.
```

Figure 3-42
Sample INSPECT...REPLACING Statement

This statement scans FIELD1 looking for space characters. Wherever it finds a space character, it replaces it with zero.

One INSPECT statement can contain both a TALLYING phrase and a REPLACING phrase. However, when used together, the TALLYING phrase must precede the REPLACING phrase. An INSPECT statement with both phrases is equivalent to two separate INSPECT statements and, in fact, the software compiles such a statement into two distinct INSPECT statements. (To simplify debugging, therefore, it is best to initially write the two phrases in separate INSPECT statements.)

3.9.1 The BEFORE/AFTER Phrase

The BEFORE/AFTER phrase acts as a delimiter and (possibly) restricts the area of the field being inspected.

The following sample statement would count only the zeroes that precede the percent sign (%) in FIELD1.

```
INSPECT FIELD1 TALLYING TLY
        FOR ALL ZEROES BEFORE "%".
```

Figure 3-43
Sample INSPECT...BEFORE Statement

The delimiter (the percent sign in the preceding sample statement) can be a single character, a string of characters, or any figurative constant. Further, it can be either an identifier or a literal.

- If the delimiter is an identifier, it must be an elementary data item of DISPLAY usage. It may be alphabetic, alphanumeric, or numeric, and, it may contain editing characters. The compiler always treats the item as if it had been described as an alphanumeric string. (It does this by implicit redefinition of the item, as described in Section 3.9.2.)

- If the delimiter is a literal, it must be non-numeric.

The software repeatedly compares the delimiter characters against an equal number of characters in the field being inspected. If none of the characters matches the delimiter, or if insufficient characters remain in the field for a full comparison (at the right-hand end), the software considers the comparison to be unequal.

The examples of the INSPECT statement in Figure 3-44, illustrate the way the delimiter character finds a match in the field being inspected. (The portion of the field the statement ignores as a result of the BEFORE/AFTER phrase delimiters is crossed out with a slash, and the portion it inspects is underlined.)

INSTRUCTION	FIELD1 VALUE
INSPECT FIELD1...BEFORE "E". INSPECT FIELD1...AFTER "E".	ABCD/E/F/G/H/I /A/B/C/D/E/FGHI
INSPECT FIELD1...BEFORE "K". INSPECT FIELD1...AFTER "K".	ABCDEFGHI /A/B/C/D/E/F/G/H/I
INSPECT FIELD1...BEFORE "AB". INSPECT FIELD1...AFTER "AB".	/A/B/C/D/E/F/G/H/I /A/BCDEFGHI
INSPECT FIELD1...BEFORE "HI". INSPECT FIELD1...AFTER "HI".	ABCDEFG/H/I /A/B/C/D/E/F/G/H/I
INSPECT FIELD1...BEFORE "IΔ". INSPECT FIELD1...AFTER "IΔ".	ABCDEFGHI /A/B/C/D/E/F/G/H/I
The ellipsis represents the position of the TALLYING or REPLACING phrase.	

Figure 3-44
Matching the Delimiter Characters
to the Characters in a Field

The software scans the field for a delimiter match before it scans for the inspection operation (TALLYING or REPLACING), thus establishing the limits of the operation before beginning the actual inspection. The importance of the separate scan is discussed further in Section 3.9.3.

3.9.2 Implicit Redefinition

The software requires that certain fields referred to by the INSPECT statement be alphanumeric fields. If one of these fields was described as another data class, the compiler redefines that field so the INSPECT statement can handle it as a simple alphanumeric string. This implicit redefinition is conducted as follows:

- If the field was described as alphabetic, alphanumeric edited, or unsigned numeric, the compiler simply redefines it as alphanumeric. This is a compile-time operation; no data movement occurs at object-time.

- If the field was described as signed numeric, the compiler first removes the sign and then redefines the field as alphanumeric. If the sign is a separate character, the compiler ignores that character, essentially shortening the

field, and that character does not participate in the implicit redefinition. If the sign is an "overpunch" on the leading or trailing digit, the compiler actually removes the sign value and leaves the character with only the numeric value that was stored in it. The compiler alters the digit position containing the sign before beginning the INSPECT operation and restores it to its former value after the operation. If the sign's digit position does not contain a valid ASCII signed numeric digit, the action of the redefinition causes the value to change. Table 3-12 shows these original, altered, and restored values.

The compiler never moves an implicitly redefined item from its storage position. All redefinition occurs in place.

The position of an implied decimal point on numeric quantities does not affect implicit redefinition.

Table 3-12
Original, Altered, and Restored Values Resulting from Implicit Redefinition

ORIGINAL VALUE	ALTERED VALUE	RESTORED VALUE
} (173)	0 (60)	} (173)
A (101)	1 (61)	A (101)
B (102)	2 (62)	B (102)
C (103)	3 (63)	C (103)
D (104)	4 (64)	D (104)
E (105)	5 (65)	E (105)
F (106)	6 (66)	F (106)
G (107)	7 (67)	G (107)
H (110)	8 (70)	H (110)
I (111)	9 (71)	I (111)
{ (175)	0 (60)	{ (175)
J (112)	1 (61)	J (112)
K (113)	2 (62)	K (113)
L (114)	3 (63)	L (114)
M (115)	4 (64)	M (115)
N (116)	5 (65)	N (116)
O (117)	6 (66)	O (117)
P (120)	7 (67)	P (120)
Q (121)	8 (70)	Q (121)
R (122)	9 (71)	R (122)
0 (60)	0 (60)	} (173)
1 (61)	1 (61)	A (101)
2 (62)	2 (62)	B (102)
3 (63)	3 (63)	C (103)
4 (64)	4 (64)	D (104)
5 (65)	5 (65)	E (105)
6 (66)	6 (66)	F (106)
7 (67)	7 (67)	G (107)
8 (70)	8 (70)	H (110)
9 (71)	9 (71)	I (111)
All other values	0 (60)	} (173)

3.9.3 The INSPECT Operation

Regardless of the type of inspection (TALLYING or REPLACING), the INSPECT statement has only one method for inspecting the characters in the field. This section describes this method.

However, before discussing how the inspection operation is conducted, let's analyze the INSPECT statement itself:

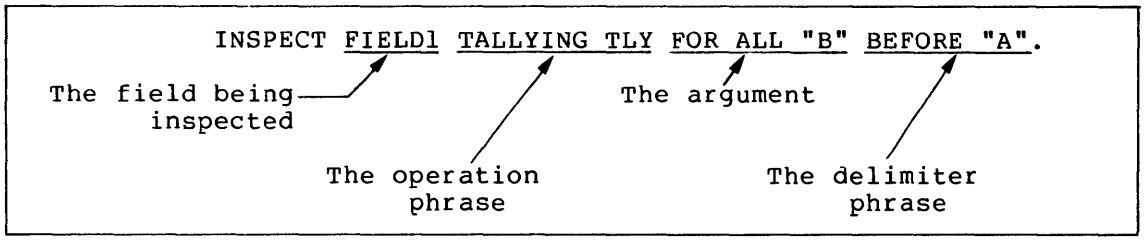


Figure 3-45
Sample INSPECT Statement

The format of the INSPECT statement requires that a field be named which is to be inspected (FIELD1 above); the field name must be followed by an operation phrase (TALLYING TLY above); and, that phrase must be followed by one or more identifiers or literals ("B" above). These identifiers or literals comprise the "arguments" (items to be compared to the field being inspected). More than one argument makes up the "argument list".

- TALLYING Arguments

  Each argument in an argument list can have other fields associated with it. Thus, each argument that is used in a TALLYING operation must have a tally counter (TLY above) associated with it. The software increments the tally counter each time it matches the argument with a character or group of characters in the field being inspected.

- REPLACING Arguments

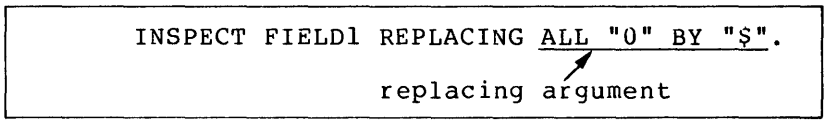


Figure 3-46
Sample REPLACING Argument

  Each argument in an argument list that is used in a REPLACING operation must have a replacement item ($ above) associated with it. The software uses the replacement item to replace each string of characters in the field that matches the argument.

Each argument in an argument list (that is used with either a TALLYING or REPLACING operation) may have a delimiter field (BEFORE/AFTER phrase) associated with it. If the delimiter field is not present, the software applies the argument to the entire field. If the delimiter field is present, the software applies the argument only to that portion of the field specified by the BEFORE/AFTER phrase.

3.9.3.1 **Setting the Scanner** - The INSPECT operation begins by setting the scanner to the leftmost character position of the field being inspected. It remains on this character until an argument has been matched with a character (or characters) or until all arguments have failed to find a match at that position.

3.9.3.2 **Active/Inactive Arguments** - When an argument has a BEFORE/AFTER phrase associated with it, that argument has a delimiter and may not be eligible to participate in a comparison at every position of the scanner. Thus, each argument in the argument list has an active/inactive status at any given setting of the scanner.

For example, an argument that has an AFTER phrase associated with it starts the INSPECT operation in an inactive state. The delimiter of the AFTER phrase must find a match before the argument can participate in the comparison. When the delimiter finds a match, the software retains the character position beyond the matched character string; then, when the scanner reaches or passes this position, the argument becomes active.

```
INSPECT FIELD1 TALLYING TLY
        FOR ALL "B" AFTER "X".
```

Figure 3-47
Sample AFTER Delimiter Phrase

If FIELD1 in Figure 3-47 has a value of "ABABXZBA", the argument B remains inactive until the scanner finds a match for the delimiter X. Thus, argument B remains inactive while the software scans character positions 1 through 5. At character position 5, the delimiter X finds a match, and since the character position beyond the matched delimiter character is the point at which the argument becomes active, argument B is compared for the first time at character position 6. It finds a successful match at character position 7 and this causes TLY to be incremented by 1.

The examples in Figure 3-48 illustrate other situations where the arguments and/or the delimiters are longer than one character. (Consider the sample statement to be an INSPECT...TALLYING statement that is scanning FIELD1, tallying in TLY, and looking for the arguments and delimiters in the left-hand column. Assume that TLY is initialized to 0.)

ARGUMENT AND DELIMITER	FIELD1 VALUE	ARGUMENT ACTIVE AT POSITION	CONTENTS OF TLY AFTER SCAN
"B" AFTER "XX"	BXBXXXXBB	6	2
	XXXXXXXX	3	0
	BXBXBBBBXX	never	0
"X" AFTER "XX"	BXBXXBXXB	6	2
	XXXXXXXX	3	6
	BBBBBBXX	never	0
"B" AFTER "XB"	BXYBXBXX	7	0
	XBXBXBXB	3	3
	BBBBBBXB	never	0
"BX" AFTER "XB"	XXXXBXXXX	6	0
	XXXXBBXXX	6	1
	XXBXXXXBX	4	1

Figure 3-48
Where Arguments Become Active in a Field

When an argument has an associated BEFORE delimiter, the inactive/active states reverse roles: the argument is in an active state when the scanning begins, and becomes inactive at the character position that matches the delimiter. Additionally, regardless of the presence of the BEFORE delimiter, an argument becomes inactive when the scanner approaches the right-hand end of the field and the remaining characters are fewer in number than the characters in the argument. (In such a case, the argument cannot possibly find a match in the field so it becomes inactive.)

Since the BEFORE/AFTER delimiters are found on a separate scan of the field, the software recognizes and sets up the delimiter boundaries before it scans for an argument match; therefore, the same characters can be used as arguments and delimiters in the same phrase.

3.9.3.3 **Finding an Argument Match** - The software selects arguments from the argument list in the order in which they appear in the list. If the first one it selects is an active argument and the conditions stated in the INSPECT statement allow a comparison, the software compares it to the character at the position of the scanner. If the active argument does not find a match, the software takes the next active argument from the list and compares that to the same character. If none of the active arguments finds a match, the scanner moves one position to the right and begins the inspection operation again with the first active argument in the list. The inspection operation terminates at the right-hand end of the field.

When an active argument does find a match, the software ignores any remaining arguments in the list and conducts the TALLYING or REPLACING operation on the character. The scanner moves to a new position and the next inspection operation begins with the first argument in the list. (The INSPECT statement may contain additional conditions, which are described later in this section; this discussion, however, assumes that the argument match is allowed to take place and that inspection is allowed to continue following the match.)

The software updates the scanner by adding the size of the matching argument to it. This moves the scanner to the next character beyond the string of characters that matched the argument. Thus, once an active argument matches a string of characters, the statement does not inspect those character positions again unless program control executes the entire statement again.

3.9.4 Subscripted Fields in INSPECT Statements

Any identifier named in an INSPECT statement may be subscripted or indexed.

The software evaluates all subscripts in an INSPECT statement once, before the inspection begins; therefore, if the action of the INSPECT statement alters one of the subscripts, the new subscript value has no effect on the selection of operands during that inspection operation. For example, consider the following illustration:

```
MOVE 1 TO TLY.
INSPECT FIELD1 TALLYING TLY
        FOR ALL X(TLY).
```

Figure 3-49
Sample Subscripted Argument

In this sample statement, the software evaluates the address of X(TLY) only once, before it begins inspecting the field; hence, it will evaluate X(TLY) as X(1). The alteration of TLY by the action of inspecting and tallying has no effect on the choice of the X operand. (X(1) will be used throughout the operation.)

NOTE

When subscripting an INSPECT statement that contains both a TALLYING and a REPLACING phrase, keep in mind that the statement will be compiled into two separate INSPECT statements. Therefore, any field that is altered by the action of the INSPECT...TALLYING statement will be in its altered state if used as a subscript by the INSPECT...REPLACING statement.

3.9.5 The TALLYING Phrase

An INSPECT statement that contains a TALLYING phrase counts the occurrence of various character strings under certain stated conditions. It keeps the count in a user-designated field called, here, a tally counter.

3.9.5.1 **The Tally Counter** - The identifier that follows the word TALLYING designates the tally counter. The identifier may be subscripted or indexed. The data item must be a numeric integer with no editing or P characters; it may be COMP or DISPLAY usage, and it may be signed (separate or overpunched).

Each time the tally argument matches the delimited string being inspected, the software adds 1 to the tally counter.

The programmer can initialize the tally counter to any numeric value. (The INSPECT statement does not initialize it.)

3.9.5.2 **The Tally Argument** - The tally argument specifies a character-string and a condition under which that string should be compared to the delimited string being inspected. The following figure shows the format of the tally argument:

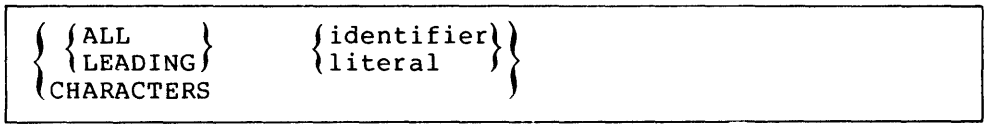


Figure 3-50
Format of the Tally Argument

The CHARACTERS form of the tally argument specifies that every character in the delimited string being inspected should be considered to match an imaginary character that serves as the tally argument. This increments the tally counter by a value that equals the size of the delimited string. For example, the statement in the following illustration causes TLY to be incremented by the number of characters that precede the first comma, regardless of what those characters might be.

```
INSPECT FIELD1 TALLYING TLY FOR
        CHARACTERS BEFORE ",".
```

Figure 3-51
CHARACTERS Form of the Tally Argument

The ALL and LEADING forms of the tally argument specify a particular character string, which may be represented by either a literal or an identifier. The tally argument character string may be any length; however, each character of the argument must match a character in the delimited string before the software considers the argument matched.

- A literal character string must be either non-numeric or a figurative constant (other than ALL literal). A figurative constant, such as SPACE, ZERO, etc., represents a single character and can be written as " ", or "0", etc., with the same effect.

- An identifier must be an elementary item of DISPLAY usage. It may be any data class. However, if it is other than alphanumeric, the software performs an implicit redefinition of the item. (This redefinition is identical to the BEFORE/AFTER delimiter redefinition discussed earlier in Section 3.9.1.)

The words ALL and LEADING supply conditions that further delimit the inspection operation.

- The word ALL specifies that every match that the search argument finds in the delimited character string be counted in the tally counter. When a literal follows the word ALL, it does not have the same meaning as the figurative constant, ALL literal. (The ALL literal meaning of ALL "," is a string of consecutive commas, as many as the context of the statement requires.) ALL "," used as a tally argument means, "count each comma without regard to adjacent characters."

- The word LEADING specifies that only adjacent matches of the TALLY argument at the left-hand end of the delimited character string be counted. At the first failure to match the tally argument, the software terminates counting and causes the argument to become inactive. Consider the examples in Figure 3-52. (The sample statement is an INSPECT...TALLYING statement, scanning FIELD1, tallying in TLY, and looking for the arguments and delimiters in the left-hand column. Assume that the program initializes TLY to 0.)

ARGUMENT AND DELIMITER	FIELD1 VALUE	CONTENTS OF TLY AFTER SCAN
LEADING "*" AFTER "0".	F***0**F	2
	F**0F**	0
	F**F**0	0
	0***F**	3
LEADING "**" AFTER "0".	F**0**F***	1
	F**F0***FF**	1
	F**F0****F**	2
	F**F**0*	0

Figure 3-52
Results of Counting with the
LEADING Condition

3.9.5.3 **The Tally Argument List** - One INSPECT...TALLYING statement can contain more than one tally argument, and each argument can have a separate BEFORE/AFTER phrase and tally counter associated with it. These tally arguments with their associated tally counters and BEFORE/AFTER phrases form an argument list. The manner in which this list is processed affects the action of any given tally argument.

The following sample statements show INSPECT statements with argument lists. The text following each one tells how that list will be processed.

```
INSPECT FIELD1 TALLYING T FOR
        ALL ","
        ALL "."
        ALL ";".
```

Figure 3-53
Argument List Adding Into
One Tally Counter

These three tally arguments have the same tally counter, T, and are active over the entire field being inspected. Thus, this statement adds the total number of commas, periods, and semicolons in FIELD1 to the initial value of T.

```
INSPECT FIELD1 TALLYING
        T1 FOR ALL ","
        T2 FOR ALL "."
        T3 FOR ALL ";".
```

Figure 3-54
Argument List Adding Into
Separate Tally Counters

Each tally argument in this statement has its own tally counter, and is active over the entire field being inspected. Thus, the action of this statement is to add the total number of commas in FIELD1 to the initial value of T1, the total number of periods to the initial value of T2, and the number of semicolons to T3.

```
INSPECT FIELD1 TALLYING
        T1 FOR ALL "," AFTER "A"
        T2 FOR ALL "." BEFORE "B"
        T3 FOR ALL ";".
```

Figure 3-55
Argument List (with Delimiters) Adding
into Separate Tally Counters

Each tally argument in this statement has its own tally counter; the first two arguments have delimiter phrases, and the last one is active over the entire field being inspected. Thus, the first argument is initially inactive and becomes active only after the scanner encounters an A; the second argument begins the scan in the active state but becomes inactive after a B has been encountered; and the third argument is active during the entire scan of FIELD1.

Figure 3-56 shows various values of FIELD1 and the contents of the three tally counters after the scan. Assume that the counters are initialized to 0 before the INSPECT statement.

FIELD1 VALUE	CONTENTS OF TALLY COUNTERS AFTER SCAN		
	T1	T2	T3
A.C;D.E,F	1	2	1
A.B.C.D	0	1	0
A,B,C,D	3	0	0
A;B;C;D	0	0	3
*,B,C,D	0	0	0

Figure 3-56
Results of the Scan in Figure 3-55

The BEFORE/AFTER phrase applies only to the argument that precedes it, and delimits the field for that argument only. Each BEFORE/AFTER phrase causes a separate scan of the field to determine the limits of the field for its corresponding argument.

3.9.5.4 Interference in Tally Argument Lists - When several tally arguments contain one or more identical characters that are active at the same time, they may interfere with each other (i.e., when one of the arguments finds a match, the scanner is stepped past the matching character(s) which prevents those character(s) from being considered for any other match).

The example in Figure 3-57 illustrates two identical tally arguments that do not interfere with each other since they are not active at the same time. (The first A in FIELD1 causes the first argument to become inactive and the second argument to become active.)

```
MOVE 0 TO T1 T2.
INSPECT FIELD1 TALLYING
        T1 FOR ALL "," BEFORE "A"
        T2 FOR ALL "," AFTER "A".
```

Figure 3-57
Two Tallying Arguments that
Do Not Interfere with Each Other

The two identical tally arguments in Figure 3-58 will interfere with each other since both are active at the same time. (For any given position of the scanner, the arguments are applied to FIELD1 in the order in which they appear in the statement. When one of them finds a match, the scanner moves to the next position and ignores the remaining arguments in the argument list.) Each comma in FIELD1 causes T1 to be incremented by 1 and the second argument to be ignored. Thus, T1 will always contain an accurate count of all of the commas in FIELD1, and T2 will always be unchanged.

```
INSPECT FIELD1 TALLYING
        T1 FOR ALL ","
        T2 FOR ALL "," AFTER "A".
```

Figure 3-58
Two Tallying Arguments that
Do Interfere with Each Other

The following statement achieves the same results as the statement in Figure 3-57. The first argument does not become active until the scanner encounters an A. The second argument tallies all commas that precede the A. After the A, the first argument counts all commas and causes the second argument to be ignored. Thus, T1 contains the number of commas that precede the first A and T2 contains the number of commas that follow the first A. This statement works well as written, but could be more confusing to debug than the one in Figure 3-57.

```
INSPECT FIELD1 TALLYING
        T2 FOR ALL "," AFTER "A"
        T1 FOR ALL ",".
```

Figure 3-59
Two Tallying Arguments that,
Because of their Positioning,
Only Partially Interfere with
Each Other

The preceding three examples show that one INSPECT statement cannot count any character more than once. Thus, when using the same character in more than one argument of an argument list, consider the nature of the interference and choose the order of the arguments very carefully. The solution to the problem may require two or more INSPECT statements. Consider the following problem:

```
INSPECT FIELD1 TALLYING
        T1 FOR ALL "AB"
        T2 FOR ALL "BC".
```

Figure 3-60
An Attempt to Tally the Character B
with Two Arguments

If FIELD1 contains "ABCABC", after the scan T1 will be incremented by a 2 and T2 will be unaltered. The successful matching of the argument includes each B in the field. Each match resets the scanner to the character position to the right of the B, and causes the second argument to never be successfully matched. Reversing the order of the arguments has no effect, the results remain the same. Only separate INSPECT statements can develop the desired counts.

Sometimes the programmer can use the interference characteristics of the INSPECT statement to good advantage. Consider the following sample argument list:

```
MOVE 0 TO T4 T3 T2 T1.
INSPECT FIELD1 TALLYING
        T4 FOR ALL "****"
        T3 FOR ALL "***"
        T2 FOR ALL "**"
        T1 FOR ALL "*".
```

Figure 3-61
Tallying Asterisk Groupings

The argument list in Figure 3-61 counts all of the asterisks in FIELD1 but in four different tally counters. T4 counts the number of times that four asterisks occur together; T3 counts the number of times three asterisks appear together; T2 counts double asterisks; and T1 counts singles.

If FIELD1 contains a string of more than four consecutive asterisks, the argument list breaks the string into groups of four, and counts them in T4. It then counts the less-than-four remainder in T3, T2, or T1.

Reversing the order of the arguments in this list causes T1 to count all of the asterisks and T2, T3, and T4 to remain unchanged.

When the LEADING condition is used with an argument in the argument list, that argument becomes inactive as soon as it fails to be matched in the field being inspected. Therefore, when two arguments in an argument list contain one or more identical characters and one of the arguments has a LEADING condition, the argument with the LEADING condition should appear first. Consider the following sample statement:

```
MOVE 0 TO T1 T2.
INSPECT FIELD1 TALLYING
        T1 FOR LEADING "*"
        T2 FOR ALL "*".
```

Figure 3-62
Placing the LEADING Condition
in the Argument List

The placement of the LEADING condition in this sample statement causes T1 to count only leading asterisks in FIELD1; the occurrence of any other character stops this counting and causes the first tally argument to become inactive. T2 keeps a count of any remaining asterisks in FIELD1.

Reversing the order of the arguments in this statement results in an argument list that can never increment T1.

```
INSPECT FIELD1 TALLYING
        T2 FOR ALL "*"
        T1 FOR LEADING "*".
```

Figure 3-63
Reversing the Argument
List in Figure 3-62

If the first character in FIELD1 is not an asterisk, neither argument can match it and the second argument becomes inactive. If the first character in FIELD1 is an asterisk, the first argument matches and causes the second argument to be ignored. The first non-asterisk character in FIELD1 will fail to match the first argument and the second argument will become inactive. (The second argument becomes inactive because it has not found a match in all of the preceding characters.)

An argument with both a LEADING condition and a BEFORE phrase can sometimes sucessfully "delimit" the field being inspected:

```
MOVE 0 TO T1 T2.
INSPECT FIELD1 TALLYING
     T1 FOR LEADING SPACES
     T2 FOR ALL "   " BEFORE "."
     T2 FOR ALL "  " BEFORE "."
     T2 FOR ALL " " BEFORE ".".
IF T2 > 0 ADD 1 TO T2.
```

Figure 3-64
An Argument List that Counts
Words in a Statement

The statements in Figure 3-64 count the number of "words" in the English statement in FIELD1. (This assumes that no more than three spaces separate the words in the sentence and that the sentence ends with a period.) When FIELD1 has been scanned, T2 contains the number of gaps between the words. Since a count of the gaps renders a number that is one less than the number of words, the conditional statement adds one to the count.

The first argument removes any leading spaces, counting them in a different tally counter. This shortens FIELD1 by preventing the application of the second through the fourth arguments until the scanner finds a non-space character. The BEFORE phrase on each of the other arguments causes them to become inactive when the scanner reaches the period at the end of the sentence. Thus, the BEFORE phrases "shorten" FIELD1 by making the second through the fourth arguments inactive before the scanner reaches the right-hand end of FIELD1. If the sentence in FIELD1 is indented with tab characters instead of spaces, a second LEADING argument can count the tab characters. The following sample statement illustrates this technique:

```
INSPECT FIELD1 TALLYING
        T1 FOR LEADING SPACES
        T1 FOR LEADING TAB
        T2 FOR ALL "    " etc.
```

Figure 3-65
Counting Leading Tab or Space Characters

When an argument list contains a CHARACTERS argument, it should be the last argument in the list. Since the CHARACTERS argument always matches the field, it prevents the application of any of the following arguments in the list. However, as the last argument in an argument list, it can count the remaining characters in the field being inspected. Consider the following illustration.

```
MOVE 0 TO T1 T2 T3 T4 T5.
INSPECT FIELD1 TALLYING
        T1 FOR LEADING SPACES
        T2 FOR ALL "." BEFORE ","
        T3 FOR ALL "+" BEFORE ","
        T4 FOR ALL "-" BEFORE ","
        T5 FOR CHARACTERS BEFORE ",".
```

Figure 3-66
Counting the Remaining Characters
With the CHARACTERS Argument

If FIELD1 is known to contain a number in the form frequently used to input data, it may contain a plus or minus sign, and a decimal point; further, the number may possibly be preceded by spaces and terminated by a comma. If this statement were compiled and executed, it would deliver the following results:

T1 would contain the number of leading spaces,

T2 would contain the number of periods,

T3 would contain the number of plus signs,

T4 would contain the number of minus signs,

T5 would contain the number of remaining characters (assumed to be numeric), and

the sum of T1 through T5 (plus 1) gives the character position occupied by the terminating comma.

3.9.6 The REPLACING Phrase

When an INSPECT statement contains a REPLACING phrase, that statement selectively replaces characters or groups of characters in the designated field.

The REPLACING phrase names a search argument consisting of a character string of one or more characters and a condition under which the string may be applied to the field being inspected. Associated with the search argument is the replacement value, which must be the same length as the search argument. Each time the search argument finds a match in the field being inspected, under the condition stated, the replacement value replaces the matched characters.

A BEFORE/AFTER phrase may be used to delimit the area of the field being inspected. A search argument applies only to the delimited area of the field.

3.9.6.1 The Search Argument - The search argument of the REPLACING phrase names a character string and a condition under which the character string should be compared to the delimited string being inspected. Figure 3-67 shows the format of the search argument:

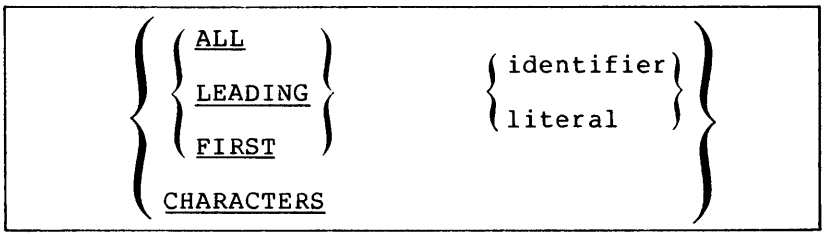


Figure 3-67
Format of the Search Argument

The CHARACTERS form of the search argument specifies that every character in the delimited string being inspected should be considered to match an imaginary character that serves as the search argument. Thus, the replacement value replaces each character in the delimited string. (The replacement value, in this case, must be one character long.)

The ALL, LEADING, and FIRST forms of the search argument specify a particular character string, which may be represented by a literal or an identifier. The search argument character string may be any length. However, each character of the argument must match a character in the delimited string before the software considers the argument matched.

- A literal character string must be either non-numeric or a figurative constant (other than ALL literal). A figurative constant, such as SPACE, ZERO, etc., represents a single character and can be written as " ", "0", etc. with the same effect. Since a figurative constant represents a single character, the replacement value must be one character long.

- An identifier must represent an elementary item of DISPLAY usage. It may be any class. However, if it is other than alphabetic, the software performs an implicit redefinition of the item. (This redefinition is identical to the BEFORE/AFTER delimiter redefinition discussed in Section 3.9.1.)

The words ALL, LEADING, and FIRST supply conditions which further delimit the inspection operation:

- The word ALL specifies that each match that the search argument finds in the delimited string is to be replaced by the replacement value. When a literal follows the word ALL, it does not have the same meaning as the figurative constant, ALL literal. (The figurative constant meaning of ALL "," is a string of consecutive commas, as many as the context of the statement requires.) ALL "," as a search argument of the REPLACING phrase means, "replace each comma without regard to adjacent characters."

- The word LEADING specifies that only adjacent matches of the search argument at the left-hand end of the delimited character string be replaced. At the first failure to match the search argument, the software terminates the replacement operation and causes the argument to become inactive.

- The word FIRST specifies that only the leftmost character string that matches the search argument is to be replaced. After the replacement operation, the search argument containing this condition becomes inactive.

3.9.6.2 **The Replacement Value** - Whenever the search argument finds a match in the field being inspected, the matched characters are replaced by the replacement value. The word BY followed by an identifier or literal specifies the replacement value.

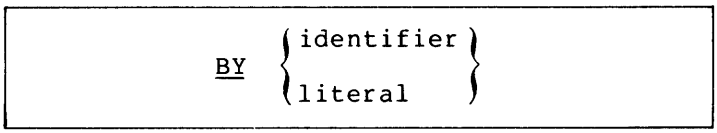


Figure 3-68
Format of the Replacement Value

The replacement value must always be the same size as its associated search argument.

If the replacement value is a literal character string, it must be either a non-numeric literal or a figurative constant (other than ALL literal). A figurative constant represents as many characters as the length that the search argument requires.

If the replacement value is an identifier, it must be an elementary item of DISPLAY usage. It may be any class. However, if it is other than alphanumeric, the software conducts an implicit redefinition of the item. (This redefinition is the same as the BEFORE/AFTER redefinition discussed in Section 3.9.1.)

3.9.6.3 **The Replacement Argument** - The replacement argument consists of the search argument (with its condition and character string), the replacement value, and an optional BEFORE/AFTER phrase.

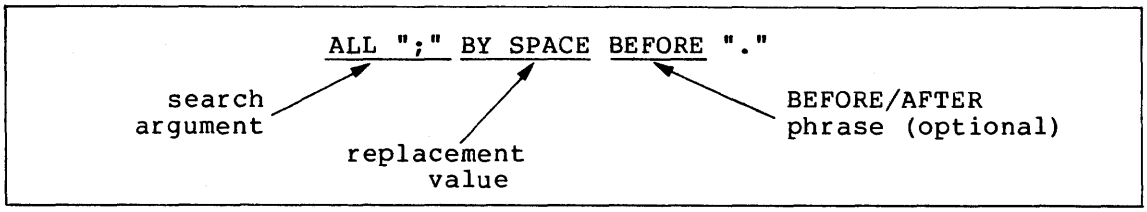


Figure 3-69
The Replacement Argument

3.9.6.4 **The Replacement Argument List** - One INSPECT...REPLACING statement can contain more than one replacement argument. Several replacement arguments form an argument list, and the manner in which the list is processed affects the action of any given replacement argument.

The following examples show INSPECT statements with replacement argument lists. The text following each one tells how that list will be processed.

```
INSPECT FIELD1 REPLACING
        ALL "," BY SPACE
        ALL "." BY SPACE
        ALL ";" BY SPACE.
```

Figure 3-70
Replacement Argument List that is
Active Over the Entire Field

These three replacement arguments all have the same replacement value, SPACE, and are active over the entire field being inspected.

Thus, this statement replaces all commas, periods, and semicolons with space characters; and leaves all other characters unchanged.

```
INSPECT FIELD1 REPLACING
        ALL "0" BY "1"
        ALL "1" BY "0".
```

Figure 3-71
Replacement Argument List that
"Swaps" Ones for Zeroes and Zeroes for Ones

Each of these two replacement arguments has its own replacement value, and is active over the entire field being inspected. This statement exchanges zeros for ones and ones for zeroes, and leaves all other characters unchanged.

NOTE

When a search argument finds a match in the field being inspected, the software replaces that character string and scans to the next position beyond the replaced characters. It ignores the remaining arguments and applies the first argument in the list to the character string in

the new position. Thus, it never inspects the new value that was supplied by the replacement operation. Because of this, the search arguments may have the same values as the replacement arguments with no chance of interference.

```
INSPECT FIELD1 REPLACING
        ALL "0" BY "1" BEFORE SPACE
        ALL "1" BY "0" BEFORE SPACE.
```

Figure 3-72
Replacement Argument List that
Becomes Inactive with the
Occurrence of a Space Character

This sample statement is identical to the statement in Figure 3-71, except that, here, the first occurrence of a space character in FIELD1 causes both arguments to become inactive.

```
INSPECT FIELD1 REPLACING
        ALL "0" BY "1" BEFORE SPACE
        ALL "1" BY "0" BEFORE SPACE
        CHARACTERS BY "*" BEFORE SPACE.
```

Figure 3-73
Argument List with Three Arguments
That Become Inactive with the
Occurrence of a Space

Just as in the argument list in Figure 3-72, the first space character causes all of these replacement arguments to become inactive. This argument list exchanges zeroes for ones, ones for zeroes, and asterisks for all other characters that are in the delimited area.

If the BEFORE phrase is removed from the third argument, that argument will remain active across all of FIELD1. Within the area delimited by the first space character, the third argument replaces all characters except ones and zeroes with asterisks. Beyond this area, it replaces all characters (including the space that delimited FIELD1 for the first two arguments and any zeroes and ones) with asterisks.

3.9.6.5 **Interference in Replacement Argument Lists** - When several search arguments that are active at the same time contain one or more identical characters, they may interfere with each other, and consequently have an effect on the replacement operation. This interference of one search argument with the matching of other search arguments is similar to the interference that occurs between tally arguments.

The action of a search argument is never affected by the BEFORE/AFTER delimiters of other arguments, since the software scans for delimiter matches before it scans for replacement operations.

The action of a search argument is never affected by the characters of any replacement value, since the scanner does not inspect the replaced characters again during execution of the INSPECT statement.

Interference between search arguments, therefore, depends on the order of the arguments, the values of the arguments, and the active-inactive status of the arguments. (The discussion in Section 3.9.5.4 Interference in Tally Argument Lists, applies, generally, to replacement arguments as well.)

The following rules will help minimize interference in replacement argument lists:

1. Place search arguments with LEADING or FIRST conditions at the start of the list;

2. Place several arguments with the CHARACTERS condition at the end of the list;

3. Consider, very carefully, the order of appearance of any search arguments that contain one or more identical characters.

3.9.7 Common Errors, INSPECT Statement

The most common errors made when writing INSPECT statements are:

- Leaving the FOR out of an INSPECT...TALLYING statement.
- Using the word "WITH" instead of "BY" in the REPLACING phrase.
- Failing to initialize the tally counter.
- Omitting the word "ALL" e.g.:

```
INSPECT FIELD1 TALLYING TLY FOR SPACES.
```

CHAPTER 4

NUMERIC CHARACTER HANDLING

4.1 INTRODUCTION

This chapter discusses numeric class data and the COBOL operations that may be performed on numeric class data. It is assumed that the reader has read Chapter 3, and understands the concept of COBOL data classes.

4.2 USAGES, DISPLAY/COMP

The USAGE of a numeric class item specifies the form in which that item's data is held in memory. COBOL has two basic formats for data storage, DISPLAY and COMPUTATIONAL (DISPLAY, DISPLAY-6, and DISPLAY-7 are all equivalent):

- ANS-74 COBOL standards prescribe DISPLAY usage to be a string of characters or bytes in decimal radix, with an assumed decimal point location and various sign conventions.

- The same standards prescribe COMPUTATIONAL (COMP) usage to be a real number with the same range of values as a DISPLAY usage number. However, with COMP usage, the compiler implementor has the liberty of specifying the form in which that number is held in memory.

TRAX COBOL stores COMP usage fields as binary numbers in one, two, three or four words with an assumed decimal scaling position. Consider the following field description:

```
01 GEMINI PIC 99V99 COMP.
```

If this field contains the value 12.34, TRAX COBOL stores it as a 1-word binary number. The word contains the integer value 1234 and another location contains the scaling factor. In this example, the scaling factor records the fact that this integer has two decimal fractional positions associated with it. Thus, the COBOL OTS knows that the stored binary integer is 100 times larger than the programmer intends it to be.

If the compiler encounters the following statement:

```
ADD 1 TO GEMINI.
```

it generates instructions to add a 1 to the 1234 in GEMINI. The OTS, however, scales the literal 1 up by two decimal places and adds the resultant literal, 100, to the number in GEMINI. Thus, after the ADD operation, GEMINI contains the new value 1334 (which is actually 13.34 with the stored decimal scaling position).

Thus, the TRAX COBOL compiler and OTS manipulate the data in both DISPLAY and COMP usage items in much the same way. Both usages have exactly the same accuracy and precision, and can be freely mixed in a program. If a DISPLAY usage number and a COMP usage number are both involved in the same arithmetic statement, the OTS converts them to a common radix, with no loss of information. It also converts the result (if necessary), before storing it, with no loss of significance.

The only effect of specifying the COMP usage is that it reduces the space required for most numbers and speeds up the execution of arithmetic statements.

4.2.1 Sign Conventions

DISPLAY or COMP usage numeric items may be signed or unsigned. Unsigned numbers may contain values that range from zero to the largest positive value allowed by their declared precision. Negative values are not allowed. All TRAX COBOL arithmetic operations yield signed results. When the OTS must store such a result, whether positive or negative, in an unsigned data item, it stores only the absolute value of the result. Thus, unsigned items always contain zero or positive values.

This guide does not recommend unsigned numbers for general use. They are usually a source of programming errors, and are handled less efficiently than signed quantities by the OTS.

Signed quantities always contain a numeric value and an operational sign. The OTS stores the sign with the numeric value in a variety of ways depending on the usage of the item and the presence of the SIGN clause.

NOTE

If numeric data is read into a field described using the picture character S, then that data must include an operational sign of the appropriate format to pass the NUMERIC test.

TRAX COBOL always stores signed COMP items in two's complement binary form. Thus, the high-order bit indicates the sign of the item.

TRAX COBOL always stores signed DISPLAY items as a sequence of byte positions containing numeric ASCII characters. It may include the sign in the high-order byte, the low-order byte, or as a separate, extra, byte on either the high-order or low-order end of the item.

When the OTS stores the sign as part of a byte that also contains a numeric digit, the sign causes a value change in that byte and, hence, changes the value of the numeric digit. Table 4-1 shows the actual ASCII character that results when a numeric value and a sign share the same byte.

Table 4-1
The Resulting ASCII Character From a
Sign and Digit Sharing the Same Byte

		DIGIT VALUE									
		0	1	2	3	4	5	6	7	8	9
SIGN	+	{	A	B	C	D	E	F	G	H	I
	-	}	J	K	L	M	N	O	P	Q	R

A byte containing a +0 stores as an octal 173, which prints as either a { or a [depending on the printing device.

A byte containing a -0 stores as an octal 175, which prints as either a } or a] depending on the printing device.

When the OTS stores the sign as a separate distinct character, the actual ASCII character that it stores is the graphic plus sign (octal 053) or the graphic minus sign (octal 055).

4.2.2 Illegal Values in Numeric Fields

All TRAX COBOL arithmetic operations store legal values in their result fields. However, it is possible, by reading invalid data or through redefinition and group moves, to store data in numeric fields that do not obey the descriptions of those fields. (For example, it is possible to place signed values into unsigned fields, and to place non-numeric or improperly signed data into signed numeric DISPLAY fields.) TRAX COBOL handles this data in the following manner.

NOTE

The following four compiler techniques are not specified by ANS-74 COBOL standards. Dependence on them may yield programs that are not compiler independent.

1. When a quantity described as unsigned enters into an arithmetic operation, the OTS treats it as a signed quantity. If it contains no sign, the OTS either considers the sign to be positive, or ignores the sign if the value of the field is zero. If the field does contain a legally constructed sign, the OTS interprets the sign as if the item had been described as a signed quantity.

   Thus the OTS treats a negative value in an unsigned COMP item as a negative value. Likewise a negative sign, stored as J through R, in the rightmost digit of an unsigned DISPLAY item, causes the OTS to treat that value as a negative value.

   When an arithmetic operation or legal elementary MOVE statement places its result in an unsigned item, that item receives the absolute value only (no sign information is encoded in the result).

For example the following coding results in an unsigned value of 15 in field B:

```
      .
      .
      .
    02 A PIC S99 VALUE IS 5
    02 C PIC XX VALUE IS "2 ".
    02 B REDEFINES C PIC 99.
      .
      .
      .
    ADD A TO B.
```

However, given the same original values in A and B, the following statement would result in a value of -15 in field A. (Field B remains at -20.)

```
ADD B TO A.
```

2. When a signed quantity enters into an arithmetic operation, the OTS interprets the sign as follows:

   a. If the item is COMP usage, the OTS takes the value as a two's complement number;

   b. If the item is DISPLAY usage and the sign is encoded within the leading or trailing digit position, the OTS takes the sign as positive if that position contains either a { (octal 173) or any ASCII byte that collates less than J. Thus, the OTS considers a space, 0 through 9, and A through I, to be positive. Further, it considers any ASCII character that collates equal-to or higher-than J (except { --octal 173) to be negative. (The OTS conducts this sign determination separately from the numeric value determination for the same byte.)

VALUE	SIGN DETERMINATION
000A	+0001
000J	-0001

   c. If the item is DISPLAY usage and the sign is encoded as a separate leading or trailing byte, the OTS takes the sign as negative only if that byte contains the ASCII character - (octal 055). The OTS considers that all other ASCII characters in the separate sign position indicate a positive field.

3. A COMP usage item may receive a value that is larger than the specified range. For example, the OTS stores a field described as PIC S9999 COMP as a 16-bit binary number. The declared range is four decimal digits, but the field has the capability of storing any value from -32,768 to +32,767 (decimal). The OTS stores the results of an arithmetic operation on such a field as a value modulo the declared decimal range. Thus, any value that exceeds 9,999 stores a modulo 10,000 value. (The binary value of 10,000 stores as a zero.)

When a COMP usage field enters an arithmetic operation, however, the OTS uses the full binary number as the binary value of the field. Thus, a value stored in a COMP field by a group move may cause the field to contain a value that exceeds the declared range. Arithmetic operations will use that value as found.

4. A DISPLAY usage item may contain a value in which some or all of the numeric digit positions contain illegal values.

   When a DISPLAY usage numeric item enters an arithmetic operation, the OTS converts each character to a binary value either before or during the operation. This conversion maps certain ASCII characters into the numeric values 0 through 9, and all other ASCII characters into the numeric value 0. Table 4-2 shows these conversion values:

Table 4-2
Conversion Values

ASCII CHARACTERS	BINARY VALUES
A J 1	0001 (1)
B K 2	0010 (2)
C L 3	0011 (3)
D M 4	0100 (4)
E N 5	0101 (5)
F O 6	0110 (6)
G P 7	0111 (7)
H Q 8	1000 (8)
I R 9	1001 (9)
ALL OTHERS	0000 (0)

All arithmetic operations (including the numeric elementary MOVE) deliver the ASCII characters 1 through 9 and 0 into all digit positions of a numeric DISPLAY field. A digit position that also contains a sign value receives a correctly coded sign value as shown in Table 4-1.

4.3 TESTING NUMERIC FIELDS

COBOL provides the following three kinds of tests for evaluating numeric fields:

1. Relation tests, that compare the field's contents to another numeric value;

2. Sign tests, that examine the field's sign to see if it is positive or negative; and,

3. Class tests, that inspect the field's digit positions for legal numeric values.

The following sub-sections explain these tests in detail.

4.3.1 Relation Tests

A relation test compares two numeric quantities and determines if the specified relation between them is true. For example, the following statement compares FIELD1 to FIELD2 and determines if the numeric value of FIELD1 is greater than the numeric value of FIELD2. If so, the relation condition is true and program control takes the True path of the statement.

```
IF FIELD1 > FIELD2 ...
```

Either field in a relation test may be a numeric literal or the figurative constant, ZERO. (The numeric literals 0, 00, 0.0, or ZERO are all equivalent, both in meaning and in execution speed.)

The sizes of the fields in a numeric relation test do not have to be the same (this includes the sizes of numeric literals). The comparison operation aligns both fields on their assumed decimal positions (through actual scaling operations in temporary locations or by accessing the individual digits) and supplies leading or trailing (as required) zeroes to either or both fields.

The comparison operation always compares the signs of non-zero fields and considers positive fields to be greater than negative fields. However, since it does not compare them, positive zeroes and negative zeroes are equal. (A negative zero could arrive in a field through redefinition of the field or a MOVE to a group item.) Further, the operation considers unsigned numeric fields to be positive.

The form of representation of the number (COMP or DISPLAY usage) and the various methods of storing DISPLAY usage signs have no effect on numeric relation tests.

For comparison purposes, the operation converts any illegal characters stored in DISPLAY usage fields to zeroes. It does not, however, alter the actual values in those fields.

4.3.2 Sign Tests

The sign test compares a numeric quantity to zero and determines if it is greater (positive), less (negative), or equal (zero). Both the relation test and the sign test can perform this function. For example, consider the following relation test:

```
IF FIELD1 > 0 ...
```

Now consider the following sign test:

```
IF FIELD1 POSITIVE ...
```

Both of these tests accomplish the same thing and would always arrive at the same result. The sign test, however, shortens the statement and shows, at a glance, that it is testing the sign.

Table 4-3 shows the sign tests and their equivalent relation tests as applied to FIELD1.

Table 4-3
The Sign Tests

SIGN TEST	EQUIVALENT RELATION TEST
IF FIELD1 POSITIVE ...	IF FIELD1 > 0 ...
IF FIELD1 NOT POSITIVE ...	IF FIELD1 NOT > 0 ...
IF FIELD1 NEGATIVE ...	IF FIELD1 < 0 ...
IF FIELD1 NOT NEGATIVE ...	IF FIELD1 NOT < 0 ...
IF FIELD1 ZERO ...	IF FIELD1 = 0 ...
IF FIELD1 NOT ZERO ...	IF FIELD1 NOT = 0 ...

Sign tests have no execution speed advantage over relation tests. The compiler actually substitutes the equivalent relation test for every correctly written sign test. (Sections 4.2.1 and 4.2.2 discuss the acceptable sign values and the treatment of illegal sign values.)

4.3.3 Class Tests

The class test interrogates a numeric field to determine if it contains numeric or alphabetic data, and uses the result to alter the flow of control in a program. For example, the following statement determines if FIELD1 contains numeric data. If so, the test condition is true and program control takes the true path of the statement.

```
IF FIELD1 IS NUMERIC ...
```

When reading in newly prepared data, it is often desirable to check certain fields for valid values. Relation tests and sign tests can only determine if the field's contents are within a certain range, and these tests both treat illegal characters in DISPLAY usage items as zeroes. Thus, some data preparation errors could pass both of these tests.

The NUMERIC class test checks numeric (or alphanumeric) DISPLAY usage fields for valid numeric digits.

If the field being tested contains a sign (whether carried as an overpunch or as a separate character), the test checks it for a valid sign value. If the character position carrying the sign contains an illegal sign value, the NUMERIC class test rejects the item and program control takes the false path of the IF statement. If the character position contains a valid sign and all digit positions in the field contain valid numeric digits, the NUMERIC class test passes the item and program control takes the true path of the IF statement.

The ALPHABETIC class test checks alphabetic (or alphanumeric) fields for valid alphabetic characters and the space character. If all of the character positions of the field contain ASCII characters (A-Z or space), the item passes the ALPHABETIC class test and causes program control to take the true path of the IF statement. (For further information concerning the ALPHABETIC class test, see Chapter 3, Section 3.3.2.)

4.4 THE MOVE STATEMENT

The MOVE statement moves the contents of one field into another. The following sample MOVE statement moves the contents of FIELD1 into FIELD2.

```
MOVE FIELD1 TO FIELD2.
```

Section 3.5 discusses the basic MOVE statement. This section considers MOVE statements as applied to numeric fields. These MOVE statements can be grouped into the following three categories:

1. Group moves,
2. Elementary moves with numeric receiving fields, and
3. Elementary moves with numeric edited receiving fields.

The following three sub-sections (4.4.1, 4.4.2, and 4.4.3) discuss each of these categories separately.

4.4.1 Group Moves

The software considers a move to be a group move if either the sending field or the receiving field is a group item. It treats both fields in a group move as alphanumeric class fields and performs the move as an alphanumeric to alphanumeric elementary move.

If either field in a group move is a numeric elementary item, the OTS treats the storage area occupied by that item as a field of alphanumeric bytes; thus, it ignores the USAGE, sign, and decimal point location characteristics of the numeric item.

Only the item's allocated size, in bytes, affects the move operation. The OTS considers a separate sign character to be part of the item and moves it with the numeric digit positions.

4.4.2 Elementary Numeric Moves

If both fields of a MOVE statement are elementary items and the receiving field is numeric, the OTS considers the move to be an elementary numeric move. (The sending field may be either numeric or alphanumeric.) The numeric receiving field may be either DISPLAY or COMP usage. The elementary numeric move converts the data format of the sending field to the data format of the receiving field.

An alphanumeric sending field may be either an elementary data item or any alphanumeric literal other than the figurative constants SPACE, QUOTE, LOW-VALUE, HIGH-VALUE, or ALL "literal". The elementary numeric move accepts the figurative constant ZERO and considers it to be equivalent to the numeric literal 0. It treats alphanumeric sending fields as unsigned integers of DISPLAY usage.

If necessary, the numeric move operation converts the sending field to the data format of the receiving field and aligns the sending field's decimal point on that of the receiving field. It then moves the sending field digits to their corresponding receiving field digits.

If the sending field has more digit positions than the receiving field, the decimal point alignment operation truncates the sending field, with the resultant loss of digits. The end truncated (high-order or low-order) depends upon the number of sending field digit positions that find matches on each side of the receiving field's decimal point. If the receiving field has fewer digit positions on both sides of the decimal point, the operation truncates both ends of the sending field. Thus, if a field described as PIC 999V999 is moved to a field described as PIC 99V99, it loses one digit from the left end and one from the right end. Figure 4-1 illustrates this alignment operation (the carat (^) indicates the stored decimal scaling position):

```
      01 GANDALF PIC 99V99.

         ...

         MOVE 123.321 TO GANDALF.

Before execution   00^00

After execution    23^32
```

Figure 4-1
Truncation Caused By Decimal Point Alignment

If the sending field has fewer digit positions than the receiving field, the move operation supplies zeroes for all unfilled digit positions. Figure 4-2 illustrates this alignment (the carat (^) indicates the stored decimal scaling position):

```
      01 RIVENDELL PIC 999V99.

         ...

         MOVE 1 TO RIVENDELL.

Before execution   000^00

After execution    001^00
```

Figure 4-2
Zero Filling Caused By Decimal Point Alignment

The following statement produces the same results:

```
MOVE 001.00 TO RIVENDELL.
```

Consider the following two MOVE statements and their resultant truncating and zero-filling effects:

STATEMENT	RIVENDELL AFTER EXECUTION
MOVE 00100 TO RIVENDELL	100 00
MOVE "00100" TO RIVENDELL	100 00

Literals with leading or trailing zeroes have no significant advantage in space or execution speed with TRAX COBOL, and the zeroes are often lost by decimal point alignment.

The MOVE statement's receiving field dictates how the sign will be moved. A signed DISPLAY usage receiving field causes the sign to be moved as a separate quantity. An unsigned DISPLAY usage receiving field causes no sign movement. A COMP usage receiving field, whether signed or unsigned, causes the sign to be moved; however, if the receiving field is unsigned, the OTS sets its value to absolute.

4.4.3 Elementary Numeric Edited Moves

The TRAX COBOL object time system considers an elementary numeric move to a receiving field of the numeric edited category to be an elementary numeric edited move. The sending field of an elementary numeric edited move may be either numeric or alphanumeric and, if numeric, it can be either DISPLAY usage or COMP usage. The OTS treats alphanumeric sending fields in numeric edited moves as unsigned DISPLAY usage integers.

The OTS considers the receiving field to be numeric edited category if it is described with a BLANK WHEN ZERO clause, or a combination of the following symbols:

- **B** Space insertion position;
- **P** Decimal scaling position;
- **V** Location of assumed decimal point;
- **Z** Leading numeric character position to be replaced by a space if the position contains a zero;
- **0** Zero insertion position;
- **9** Position contains a numeric character;
- **/** Slash insertion position;
- **,** Comma insertion position;
- **.** Decimal point insertion position;
- ***** Leading numeric character position to be replaced by an asterisk if the position contains a zero;
- **+** Positive editing sign control symbol;
- **-** Negative editing sign control symbol;
- **CR** Credit editing sign control symbol;

DB Debit editing sign control symbol;

cs Currency symbol ($) insertion position.

A numeric edited field may contain 9, V, and P, but combinations of those symbols without an editing character do not make the field numeric edited.

The numeric edited move operation first converts the sending field to DISPLAY usage and aligns both fields on their decimal point locations, truncating or padding (with zeroes) the sending field until it contains the same number of digit positions on both sides of the decimal point as the receiving field. It then moves the resulting digit values to the receiving field digit positions following the COBOL editing rules.

The COBOL editing rules allow the numeric edited move operation to perform any of the following editing functions:

- Suppress leading zeroes with either spaces or asterisks;
- Float a currency sign and a plus or minus sign through suppressed zeroes, inserting the sign at either end of the field;
- Insert zeroes and spaces;
- Insert commas and a decimal point.

Figure 4-3 illustrates several of these functions with the statement, MOVE FRODO TO RIVENDELL. (Assume that FRODO is described as S9999V99.)

FRODO	RIVENDELL	
	PICTURE STRING	CONTENTS AFTER MOVE
0023^00	ZZZZ.99	Δ Δ23.00
0085^9O	++++.99	Δ -85.96
1234^00	Z,ZZZ.99	1,234.00
0012^34	$,$$$.99	Δ $12.34
0000^34	$,$$9.99	Δ Δ$0.34
1234^00	$$,$$$.99	$1,234.00
0012^34	$$9,999.99	$0,012.34
0012^34	$$$$,$$$.99	ΔΔΔΔ $12.34
0000^00	$$$,$$$.$$	ΔΔΔΔΔΔΔΔΔΔ
0012^3M	++++.99	-12.34
0012^34	$***,***.99	$**1,234.00
0012^34	$***,***.99	$*****12.34

Figure 4-3
Numeric Editing

The currency symbol ($) and the editing sign control symbols (+ -) are the only floating symbols. To float them, enter a string of two or more occurrences of the symbol.

4.4.4 Common Errors, Numeric MOVE Statements

The most common errors made when writing numeric MOVE statements are:

- Placing an incorrect number of replacement characters in a numeric edited item.
- Moving non-numeric data into numeric fields with group moves.
- Trying to float the $ or + insertion characters past the decimal point to force zero values to appear as .00 instead of spaces. (Use $$.99 or ++.99.)
- Forgetting that the $ or + insertion characters require an additional position on the leftmost end that cannot be replaced by a digit (unlike the * insertion character which can be completely replaced).

4.5 THE ARITHMETIC STATEMENTS

The COBOL arithmetic statements, ADD, SUBTRACT, MULTIPLY, DIVIDE, and COMPUTE allow COBOL programs to perform simple arithmetic operations on numeric data.

This section covers the use of the COBOL arithmetic statements. The first five sub-sections (4.5.1 through 4.5.5) discuss the common features of the statements and the last five (4.5.6 through 4.5.10) discuss the individual arithmetic statements themselves.

4.5.1 Intermediate Results

Most forms of the arithmetic statements perform their operations in temporary work locations, then move the results to the receiving fields, aligning the decimal points and truncating or zero filling the resultant values.

This temporary work field, called the intermediate result field, has a maximum size of 18 numeric digits. The actual size of the intermediate result field varies for each statement, and is determined at compile time based on the sizes of the operands used by the statement.

When the compiler determines that the size of the intermediate result field exceeds 18 digits, it truncates the excess high-order digits. Thus, a program that requests a multiplication operation between the following two fields,

```
PIC 9(18) and PIC V99.
```

(which would otherwise cause the compiler to set up a 20-digit intermediate result field -- 9(18)V99) actually causes the following intermediate result field

```
PIC 9(16)V99.
```

PDP-11 COBOL truncates high-order digits or low-order digits to the right of the decimal point, based on the assumption that most large data declarations are larger than ever need be, so zeroes occupy most of their high-order digit positions. Numeric data may be declared as PIC 9(12) or PIC 9(15) but the values that are placed in these fields will probably not exceed nine digits of range (1 billion) in most applications.

When using large numbers (or numbers with many decimal places) that are close to 18 digits long, examine all of the arithmetic operations that manipulate those numbers to determine if truncation will occur.

If truncation is a possibility, reduce the size of the number by dividing it by a power of 10 prior to the arithmetic operation. (This scaling down operation causes the low-order end to lose digits, but these are probably less critical.) Then, after the arithmetic operation, multiply the result by the same power of 10.

To save the low-order digits in such an operation, move the field to a temporary location before the scaling DIVIDE, perform separate, identical arithmetic operations on both the original and the temporary fields, then, after the scaling MULTIPLY, combine their results.

4.5.2 The ROUNDED Phrase

Rounding-off is an important tool with most arithmetic operations. The ROUNDED phrase causes the OTS to round-off the results of COBOL arithmetic operations.

The phrase may be used on any COBOL arithmetic statement. Rounding-off takes place only when the ROUNDED phrase requests it, and then only if the intermediate result has more low-order digits than the result field.

TRAX COBOL rounds-off by adding a 5 to the leftmost truncated digit of the absolute value of the intermediate result before it stores that result.

Consider the following illustration and assume an intermediate result of 54321.2468:

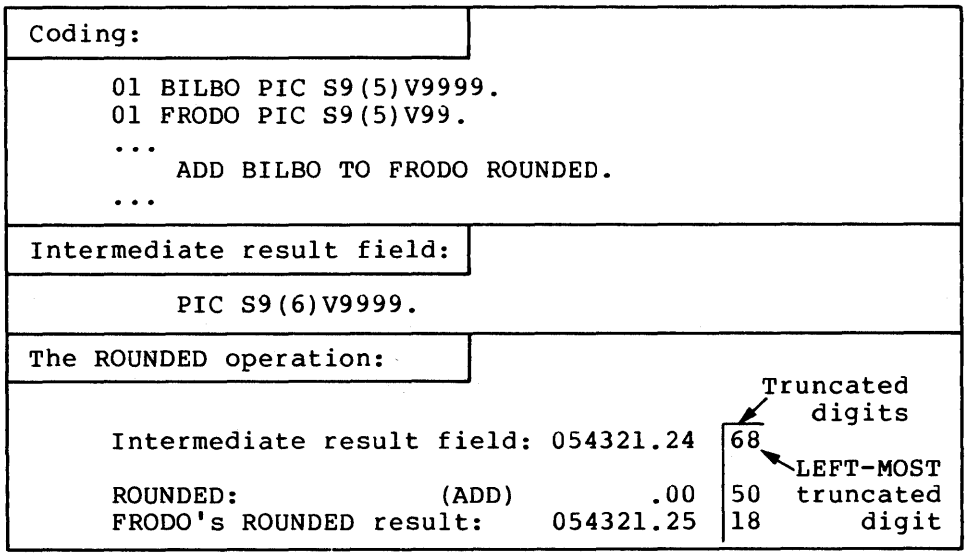


Figure 4-4
Rounding Truncated Decimal Point Positions

The following ROUNDING example rounds-off to the decimal scaling position (P). Assume an intermediate result of 24680. (Section 4.5.4 discusses the GIVING phrase in numeric operations.)

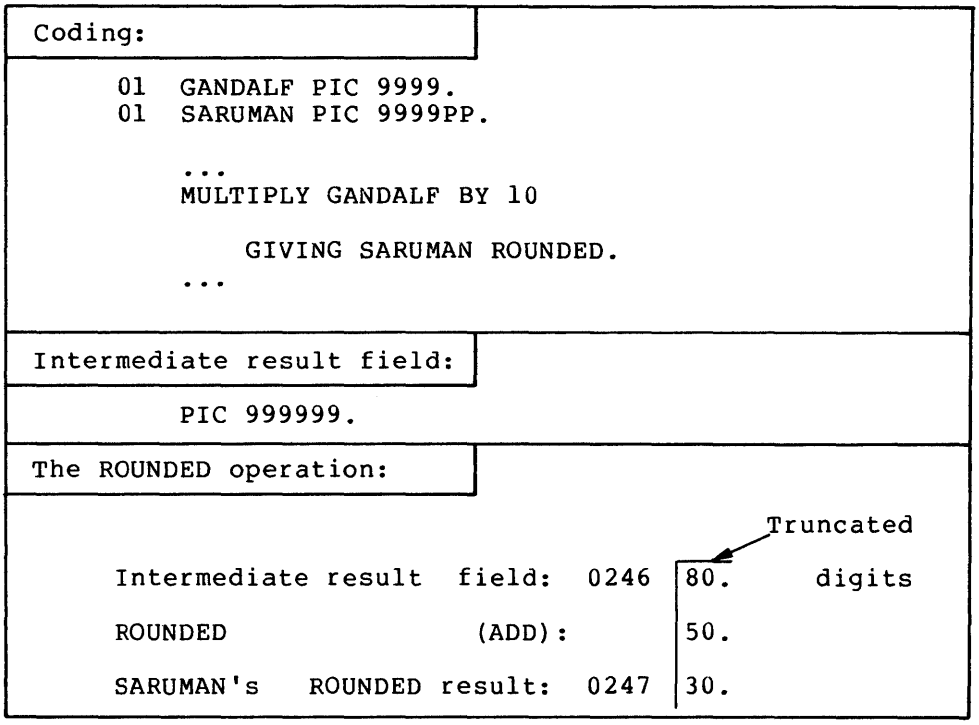


Figure 4-5
Rounding Truncated Decimal Scaling Positions

4.5.3 The SIZE ERROR Phrase

The SIZE ERROR phrase detects the loss of high-order non-zero digits in the results of COBOL arithmetic operations.

The phrase may be used on any COBOL arithmetic statement.

When the execution of a statement with no SIZE ERROR phrase results in a size error, the OTS truncates the high-order digits and stores the result without notifying the user. When the execution of a statement with a SIZE ERROR phrase results in a size error, the OTS discards the entire result (it does not alter the receiving fields in any way) and executes the SIZE-ERROR imperative phrase.

If the statement contains both ROUNDED and SIZE ERROR phrases, the OTS rounds the result before it checks for a size error.

The phrase cannot be used on numeric MOVE statements. Thus, if a program moves a numeric quantity to a smaller numeric field, it may inadvertently lose high-order digits. For example, consider the following MOVE of a field to a smaller field:

```
01 BIGFOOT PIC 9(8)V99.

01 LITTLEFOOT PIC 9(4)V99.

   ...

MOVE BIGFOOT TO LITTLEFOOT.
```

This MOVE operation always loses four of BIGFOOT's high-order digits. Either of the following two statements could determine whether these digits are zero or non-zero, and could be tailored to any size field:

1. IF BIGFOOT NOT > 9999.99
   MOVE BIGFOOT TO LITTLEFOOT
   ELSE ...

2. ADD ZERO TO BIGFOOT GIVING LITTLEFOOT
   ON SIZE ERROR ...

Both of these alternatives allow the MOVE operation to occur only if BIGFOOT loses no significant digits. If the value in BIGFOOT is too large, both alternatives avoid altering LITTLEFOOT and take the alternative execution path.

4.5.4 The GIVING Phrase

The GIVING phrase moves the intermediate result field of an arithmetic operation to a receiving field. (The phrase acts exactly like a MOVE statement with the intermediate result serving as a sending field and the data item following the word GIVING (in the statement) serving as a receiving field.)

The phrase may be used on the ADD, SUBTRACT, MULTIPLY, and DIVIDE statements.

If the data item following the word GIVING is a numeric edited field, the OTS performs the editing the same way it does for MOVE statements.

4.5.5 Multiple Operands in ADD and SUBTRACT Statements

Both the ADD and SUBTRACT statements may contain a string of more than one operand preceding the word TO, FROM, or GIVING.

Multiple operands in either of these statements cause the OTS to add the string of operands together and use the intermediate result of that operation as a single operand to be added to or subtracted from, the receiving field.

The following three equivalent coding groups illustrate how the software executes the multiple operand statements:

1. Statement:

```
ADD A B C D TO E F G H.
```

   Equivalent coding:

```
ADD A B, GIVING TEMP.
ADD TEMP, C, GIVING TEMP.
ADD TEMP, D, GIVING TEMP.
ADD TEMP, E, GIVING E.
ADD TEMP, F GIVING F.
ADD TEMP, G GIVING G.
ADD TEMP, H GIVING H.
```

2. Statement:

```
SUBTRACT A, B, C, FROM D.
```

   Equivalent coding:

```
ADD A, B, GIVING TEMP.
ADD TEMP, C GIVING TEMP.
SUBTRACT TEMP FROM D GIVING D.
```

3. Statement:

```
ADD A B C D GIVING E.
```

   Equivalent coding:

```
ADD A B GIVING TEMP.
ADD TEMP C GIVING TEMP.
ADD TEMP D GIVING E.
```

(Just as with all COBOL statements, any commas in these statements are optional.)

Only statement 3 may have a numeric edited receiving field, since it is the only statement containing a GIVING phrase.

4.5.6 The ADD Statement

The ADD statement adds two or more operands together and stores the result.

The statement may contain multiple operands (with the exception of Format 3) and the ROUNDED and SIZE ERROR phrases. It may be written in one of the following formats:

```
Format 1.    ADD FIELD1 ...TO FIELD2 FIELD3 ... .

Format 2.    ADD FIELD1 FIELD2 ...GIVING FIELD3 FIELD4 ... .

Format 3.    ADD CORRESPONDING FIELD1 TO FIELD2.
```

In Format 1, the receiving fields (FIELD2, FIELD3) are one of the addends. These must not be in the numeric edited category.

In Format 2, the receiving fields (FIELD3, FIELD4) are not one of the addends. They may either be numeric or numeric edited. When using this format, omit the word TO.

In Format 3, the receiving field (FIELD2) is one of the addends. Both FIELD1 and FIELD2 must be group items. The corresponding elements of FIELD1 are added to the corresponding elements of FIELD2.

4.5.7 The SUBTRACT Statement

The SUBTRACT statement subtracts one, or the sum of two or more, operands from another operand and stores the result.

The statement may contain multiple operands (with the exception of Format 3) and the ROUNDED and SIZE ERROR phrases. It may be written in one of the following formats:

```
Format 1.    SUBTRACT FIELD1 ...  FROM FIELD2 FIELD3 ... .

Format 2.    SUBTRACT FIELD1 ...  FROM FIELD2
             GIVING FIELD3 FIELD4 ... .

Format 3.    SUBTRACT CORRESPONDING FIELD1 FROM FIELD2.
```

In Format 1, the receiving fields (FIELD2, FIELD3) are both the subtrahend and the difference (the result). These must not be in the numeric edited category.

In Format 2, the receiving fields (FIELD3, FIELD4) are used only to store the result. They may be either numeric or numeric edited.

In Format 3, the receiving field (FIELD2) is both the subtrahend and the difference (results). Both FIELD1 and FIELD2 must be group items. The corresponding elements of FIELD2.

4.5.8 The MULTIPLY Statement

The MULTIPLY statement multiplies one operand by another and stores the result.

The statement may contain the ROUNDED and SIZE ERROR phrases. It may contain multiple receiving operands. It may be written in either of the following formats:

Format 1. MULTIPLY FIELD1 BY FIELD2, FIELD3 ... .

Format 2. MULTIPLY FIELD1 BY FIELD2 GIVING FIELD3, FIELD4 ... .

In Format 1, the receiving fields (FIELD2, FIELD3) are also the multipliers. These must not be in the numeric edited category.

In Format 2, the receiving fields (FIELD3, FIELD4) are neither multiplier nor multiplicand. These may be either numeric or numeric edited.

COBOL's "near English" format could cause a problem with the MULTIPLY statement, since it is common to speak of multiplying a number (multiplicand) by another number (multiplier) and to think of the result as a new value for the multiplicand; thus:

```
MULTIPLY EARNINGS BY 0.24.
         ↖        ↖
         |        Multiplier
         Multiplicand
```

This statement is incorrect since the OTS stores the result in the multiplier field, and this multiplier is a literal. The compiler could diagnose this error, but would not diagnose it if the multiplier were a data item. Consider this multiplier written as a data item:

```
MULTIPLY EARNINGS BY TAX-RATE.
```

The compiler would not diagnose this statement's error, and would store the result of the operation in TAX-RATE. A good practice when using MULTIPLY statements is to always write them in Format 2. This ensures that the result is properly stored. The following two statements safely capture their results:

```
MULTIPLY EARNINGS BY 0.24 GIVING EARNINGS.
```

or

```
MULTIPLY EARNINGS BY TAX-RATE GIVING EARNINGS.
```

4.5.9 The DIVIDE Statement

The DIVIDE statement divides one operand into another and stores the result.

The statement may contain the ROUNDED and SIZE ERROR phrases. With the exception of Formats 4 and 5, it may not contain multiple receiving operands. It may be written in any of the following formats:

Format 1.	DIVIDE FIELD1 INTO FIELD2 FIELD3 ... .
Format 2.	DIVIDE FIELD1 INTO FIELD2 GIVING FIELD3 FIELD4 ... .
Format 3.	DIVIDE FIELD2 BY FIELD1 GIVING FIELD3 FIELD4 ... .
Format 4.	DIVIDE FIELD1 INTO FIELD2 GIVING FIELD3 REMAINDER FIELD4.
Format 5.	DIVIDE FIELD1 BY FIELD2 GIVING FIELD3 REMAINDER FIELD4.

In Format 1, the receiving fields (FIELD2, FIELD3) are also the dividends. These must not be in the numeric edited category.

In Formats 2 and 3, the receiving fields (FIELD3, FIELD4 ...) are neither dividends nor divisor. These may be either numeric or numeric edited.

In Formats 4 and 5, the receiving field (FIELD3) is neither a dividend nor a divisor. FIELD4 is the remainder. The receiving field and the remainder may be either numeric or numeric edited.

4.5.10 The COMPUTE Statement

The COMPUTE statement computes the value of an arithmetic expression and stores the value in the result.

The statement may contain the ROUNDED and SIZE ERROR phrases. It may contain multiple receiving operands. The COMPUTE statement has the following format:

```
COMPUTE FIELD1 FIELD2 ... = arithmetic-expression.
```

The receiving fields (FIELD1, FIELD2) may be either numeric or numeric edited.

4.5.11 Common Errors, Arithmetic Statements

The most common errors made when using arithmetic statements are:

- Using an alphanumeric class field in an arithmetic statement. The MOVE statement allows data movement between alphanumeric class fields and certain numeric class fields, but arithmetic statements require that all fields be numeric.
- Writing the ADD or SUBTRACT statements without the GIVING phrase, but attempting to put the result into a numeric edited field.
- Writing a Format 2 ADD statement with the word TO; For example:

```
ADD A TO B GIVING C.
```

- Subtracting a 1 from a numeric counter that was described as an unsigned quantity, and testing for a value of less than zero.

- Forgetting that the MULTIPLY statement, without the GIVING phrase, stores the result back into the second operand (multiplier).

- Performing a series of calculations in such a way as to generate an intermediate result that is larger than 18 digits when the final result will be fewer digits. (The programmer should be careful to intersperse divisions with multiplications or to drop non-significant digits that result from multiplying large numbers (or numbers with many decimal places).

- Performing an operation on a field that contains a value greater than the precision of its data description. This can happen only if the field was disarranged by a group move or redefinition.

- Forgetting that, in an arithmetic statment containing multiple receiving fields, the ROUNDED phrase must be specified for each receiving field that is to be rounded.

- Forgetting that, in an arithmetic statement containing multiple receiving fields, the ON SIZE ERROR phrase, if specified, applies to all receiving fields. Only those receiving operands for which a size error condition is raised are left unaltered. The ON SIZE ERROR imperative statement is executed after all the receiving fields are processed by the OTS.

4.6 ARITHMETIC EXPRESSION PROCESSING

4.6.1 Motivation for Intermediate Results

COBOL provides language facilities for manipulating user-defined data arithmetically. In particular, the language provides the arithmetic statements ADD, SUBTRACT, MULTIPLY, and DIVIDE and the facilities of arithmetic expressions using the +, -, *, /, and ** operators. In simple terms, a given arithmetic functionality may be expressed in one of several ways. For example, consider a COBOL application in which the total yearly sales of a salesman are to be computed as the sum of the four individual sales quarters. Figure 4-6 illustrates one method of expressing a solution to this problem in COBOL:

```
.
.
.
MOVE 0 TO TEMP.
ADD 1ST-SALES TO TEMP.
ADD 2ND-SALES TO TEMP.
ADD 3RD-SALES TO TEMP.
ADD 4TH-SALES TO TEMP GIVING TOTAL-SALES.
.
.
.
```

Figure 4-6 Explicit Programmer-Defined Temporary Work Area

In figure 4-6, the COBOL programmer chooses to use a series of single ADD statements to develop the final value for TOTAL-SALES. In the process of computing TOTAL-SALES, a COBOL data-name, called TEMP, is used to develop the partial sums (i.e., intermediate results). The important point here is that the programmer explicitly defines and declares the temporary work area TEMP in the data division of the COBOL program. That is, the attributes (i.e., class, USAGE, number of integer and decimal places to be maintained) are specified explicitly by the COBOL programmer.

Figure 4-7 below illustrates another way of expressing a solution to the problem:

```
.
.
.
ADD 1ST-SALES, 2ND-SALES, 3RD-SALES, 4TH-SALES
    GIVING TOTAL-SALES.
.
.
.
```

Figure 4-7
Arithmetic Statement Intermediate Result Field Attributes
Determined from Composite of Operands

In this example, the programmer chooses to compute TOTAL-SALES with a single ADD statement. Analogous to the previous example, an intermediate result field is required to develop the partial sums of the four quarterly sales quantities. In Figures 4-6, the programmer is cognizant of this requirement, but chose to define the intermediate result area TEMP explicitly in the data division of his COBOL program. However, for the example in Figure 4-7, the software defines the intermediate result field in a manner transparent to the COBOL source program. That is, the software allocates storage for and assigns various attributes to this "transparent" intermediate result field according to a well-defined set of rules defined by the COBOL language specification. In particular, the attributes of number-of-integer-places, number-of-decimal-places, and USAGE assigned by the software to the intermediate result field are a function of the composite of source operands in the ADD statement. (The reader should read the TRAX COBOL Language Reference Manual for details concerning the composite of operands for the arithmetic statements.) The important point here is that the ANS-74 COBOL language standard prescribes rules for determining the attributes of intermediate result fields for the arithmetic statements and the associated language processor (e.g., TRAX COBOL compiler) must implement those rules.

As a final example, consider the following solution to our problem:

```
.
.
.
COMPUTE TOTAL-SALES = 1ST-SALES + 2ND-SALES + 3RD-SALES
        + 4TH-SALES.
.
.
.
```

Figure 4-8
Arithmetic Expression Intermediate Result Field
Attributes Determined by Implementor-Defined Rules

In Figure 4-8, the programmer solves the problem by using a single COMPUTE statement with an embedded arithmetic expression. Again, an intermediate result field is required and, as in Figure 4-7, is defined by the software. However, in defining the attributes of intermediate result fields for COBOL arithmetic expressions, the ANS-74 COBOL language standard is not as helpful to the user as it could be. In fact, the COBOL language standard gives almost complete freedom to the implementor in defining the attributes of the arithmetic expression intermediate result fields. The only rules imposed by the ANS-74 COBOL language specifications are:

1. Arithmetic operations are to be combined without restrictions on the composite of operands and/or receiving fields.

2. Each implementor will indicate techniques used in handling arithmetic expressions.

Thus, the user can and should expect differences between various implementations of ANS-74 COBOL. The purpose of the remainder of this section is to specify the conceptual algorithms used by the software to compute the attributes for the arithmetic expression intermediate result field; i.e., the number-of-integer-places and number-of-decimal-places to be maintained (for a given intermediate result field) as a function of a particular arithmetic operator and its associated operands.

4.6.2 Intermediate Results for Arithmetic Expressions

In the compile-time and object-time processing of arithmetic expressions, the software maintains a maximum precision of 18 decimal digits for intermediate result fields. One of the major compile-time functions in processing an arithmetic expression operator x is to determine the following attributes for the associated object-time intermediate result field IR(x):

1. USAGE type,

2. number of integer places, I(IR(x)), to be maintained, and

3. number of decimal places, D(IR(x)), to be maintained.

All arithmetic expression intermediate result fields are treated as signed data. The software must determine the USAGE type for an intermediate result in order to determine the form of its internal representation; the number of integer places and decimal places are determined to know how much object-time storage is required for the intermediate result.

With the exception of the exponentiation operator (**), all infix arithmetic operators yield an intermediate result field whose USAGE type is determined as a function of the USAGE types of its two source operands. That is, if both source operands are DISPLAY, the USAGE type for the intermediate result field is also DISPLAY. If one of the operands associated with an infix operator has a USAGE IS COMPUTATIONAL declaration, the USAGE type of the intermediate result field is also COMPUTATIONAL (i.e., the intermediate result is represented as COMPUTATIONAL data at object-time). The USAGE type of an intermediate result for the exponentiation operator is the same USAGE type as its first operand. Moreover, the only unary operator which requires an intermediate result field is the unary negate operator. In this case, the USAGE type of its intermediate result is the same as its singular operand. The unary plus operator is essentially a "no-op" operator and, thus, is ignored at compile-time and has no impact at object-time.

The process of determining the final number of integer places I(IR(x)) and the final number of decimal places D(IR(x)) to be maintained for an intermediate result field IR(x) resulting from an arithmetic expression operator x is conceptually the five step procedure outlined in Figure 4-9 below. In computing the final values for I(IR(x)) and D(IR(x)), remember that these values are subject to the following criterion:

$$1 <= I(IR(x)) + D(IR(x)) <= 18.$$

That is, a maximum precision of 18 decimal digits is maintained for an intermediate result field.

1. Record the largest number of integer places, IMAX, declared for any source operand in an entire COBOL expression.

2. Record the largest number of decimal places, DMAX, declared for any source operand in an entire COBOL expression.

3. Compute the number of integer places, I(x), and number of decimal places, D(x), for an arithmetic expression operator x as a function of the operands associated with operator x.

4. Using IMAX, DMAX, I(x), and D(x) computed above, apply the following criterion and redefinition:

   a. If IMAX > I(x) then redefine I(x) = IMAX.

   b. If DMAX > D(x) then redefine D(x) = DMAX.

5. Using the (possible redefined) values of I(x) and D(x) from step 4, apply truncation criterion to determine the final values I(IR(x)) and D(IR(x).

Figure 4-9 Procedure to Determine I(IR(x)) and D(IR(x)) for an Arithmetic Expression Result Field IR

Before pursuing the procedure outlined in Figure 4-9 in more depth, the following notational conventions are adopted to facilitate the subsequent discussion:

x	-	a COBOL expression operator from the set +,-,*,/,**, and unary -.
IR(x)	-	Intermediate result field obtained from the execution of an arithmetic operation x.
OP1(x)	-	First operand in arithmetic operation x.
OP2(x)	-	Second operand in arithmetic operation x.
I(OP1(x)	-	Number of integer places declared for OP1 in arithmetic operation x.
D(OP1(x))	-	Number of decimal places declared for OP1 in arithmetic operation x.
I(OP2(x))	-	Number of integer places declared for OP2 in arithmetic operation x.
D(OP2(x))	-	Number of decimal places declared for OP2 in arithmetic operation x.
IMAX	-	Maximum of number of integer places for any source operand (except for exponents) in a COBOL expression.
DMAX	-	Maximum number of decimal places for any source operand (except for exponents) in a COBOL expression.
I(x)	-	Number of integer places for an arithmetic expression operator x computed as a function of the operator's source operands.

D(x) - Number of decimal places for an arithmetic expression operator x computed as a function of the operator's source operand(s).

I(IR(x)) - Final number of integer places to be maintained for an intermediate result IR obtained by the execution of operator x.

D(IR(x)) - Final number of decimal places to be maintained for an intermediate result IR obtained by the execution of operator x.

To determine the values for IMAX and DMAX (i.e., steps 1 and 2, Figure 4-9), the compile-time software inspects the operands of arithmetic operators and all data-name references which are compared to an arithmetic expression in relation conditions. In the process of inspecting the operands of arithmetic expressions, the software ignores OP2 of the exponentiate (**) operator. Moreover, since the software essentially "forgets" the presence of an unary plus operator, its singular operand has no role in the determination of IMAX and DMAX. Having determined the values of IMAX and DMAX, the software then iteratively applies steps 3 through 5 of the procedure to each arithmetic operator in an arithmetic expression. The algorithms for computing I(x) and D(x) are summarized below:

Unary Negate (x = "-")

I(unary -) = I(OP1(unary -))

D(unary -) = D(OP1(unary -))

Addition (x = "+")

I(+) = MAX(I(OP1(+)), I(OP2(+))) + 1

D(+) = MAX(D(OP1(+)), D(OP2(+)))

Subtraction (x = "-")

I(-) = MAX(I(OP1(+)), I(OP1(-))) + 1

D(-) = MAX(D(OP1(-)), D(OP1(-)))

Multiplication (x = "*")

I(*) = I(OP1(*)) + I(OP2(*))

D(*) = D(OP1(*)) + D(OP2(*))

Division (x = "/")

I(/) = I(OP1(/)) + D(OP2(/))

D(/) = MAX(D(OP1(/)), D(OP2(/))) + 1

Exponentiation (x = "**")

Case 1: OP2(**) is a data-name exponent:

I(**) = I(OP1(**)) * F(I(OP2(**)))

where:	I(OP2(**))	F(I(OP2(**)))
	0 OR 1	9
	> 1	18

D(**) = DMAX

Case 2: OP2(**) is a numeric integer literal exponent

I(**) = I(OP1(**)) * OP2(**)

D(**) = D(OP1(**)) * OP2(**)

With the values of I(x), D(x) IMAX, and DMAX known, the software applies step 4 of Figure 4-9 to possibly redefine the values of I(x) and D(x) in light of the known values of IMAX and DMAX. The purpose of step 4 is to ensure that the object-time software will maintain sufficient precision for intermediate field IR resulting from an arithmetic operation in the context in which that arithmetic operation occurs. Finally, step 5 applies the truncation criterion specified in Figure 4-9 to determine the final values of I(IR(x)) and D(IR(x)).

I(x) + D(x)	D(x)	I(x) + DMAX	Compiler Action
<18 =18	Any Value	Any Value	I(IR(x)) = I(x) D(IR(x)) = D(x)
>18	< DMAX	Any	I(IR(x) = 18 - D(x)[High order trunc]
	= DMAX	Value	D(IR(x)) = D(x)
	>DMAX	<18	I(IR(x) = I(x)
		=18	D(IR(x)) = 18 - I(x)[low order trunc]
		>18	I(IR(x)) = 18 - DMAX [high order trunc] D(IR(x)) = DMAX[Low order trunc]

Figure 4-10
Truncation Criterion and I(IR(x))and D(IR(x)) Computation

4.6.3 Example of Intermediate Result Fields

Figure 4-11 illustrates the application of the conceptual algorithms for computing the attributes of intermediate result fields.

```
.
.
.
01    A    PIC    999V99      USAGE IS DISPLAY.
01    B    PIC      99V9      USAGE IS COMPUTATIONAL.
01    C    PIC    99V999      USAGE IS DISPLAY.
.
.
.
      IF A + 2 * B = C GO TO TAG-1.
.
.
.
```

Figure 4-11
Example of Intermediate Results

The IF statement given in Figure 4-11 contains a relation condition which specifies the comparison of an arithmetic expression to a data-name. The arithmetic expression "A + 2 * B" gives rise to the creation of the following intermediate result fields:

```
IR'(*) = 2 * B
IR"(+) = A + IR'(+)
```

where the "primes" indicate the order in which the intermediate result fields are created. The major problem here is to determine the USAGE types of IR' and IR", respectively, and to determine the values of I(IR'(*)), D(IR'(*)), I(IR''(+)), and D(IR''(+)).

To begin the development of solution, we observe that the USAGE of IR'(*) is COMPUTATIONAL since OP2(*) = B has a COMPUTATIONAL USAGE. Then, it follows that the USAGE of IR"(+) is COMPUTATIONAL since OP2(+) = IR'(*) has a COMPUTATIONAL USAGE type. Now, before applying the five step procedure in Figure 4-9, the following conditions are obtained from the declarations of A,B,C, and the specification of the IF statement in Figure 4-11:

I(OP1(*)) = 1 and D(OP1(*)) = 0 for OP1(*) =2,

I(OP2(*)) = 2 and D(OP2(*)) = 1 for OP2(*) = B,

I(OP1(+)) = 3 and D(OP1(+) = 2 for OP1(+) = A,

I(C) = 2 and C(C) = 3 for the C dataname reference.

It should be noted, that since OP2(+) = "2 * B" is not a data name or literal reference, OP2(+) does not enter into the specification of the initial conditions, and therefore into the computation of the values for IMAX and DMAX. Further, we note the values of I(C) and D(C) for the dataname C reference since the relation condition involves the comparison of an arithmetic expression to a data name reference. The values of I(C) and D(C) are needed for the subsequent calculation of IMAX and DMAX for the COBOL expression "A + 2 * B = C".

Given these initial conditions, now apply step 1 and 2 of Figure 4-3 to calculate the values of IMAX and DMAX:

```
IMAX = MAX(I(OP1(+)), I(OP1(*)), I(OP2(*)), I(C))

IMAX = MAX(3,1,2,2)

IMAX = 3

DMAX = MAX(D(OP1(+)), D(OP1(*)), D(OP2(*)), D(C))

DMAX = MAX(2,0,1,3)

DMAX = 3
```

Therefore, from the application of steps 1 and 2, IMAX = 3 and DMAX = 3 for the COBOL expression "A + 2 * B = C". Next, iteratively apply steps 3-5 to each arithmetic expression operator (in the order in which the expression is evaluated at run time) to determine the values of I(IR'(*)), D(IR'(*)), I(IR''(+)), and D(IR''(+)). Thus, applying step 3 to OP1(*) and OP2(*), we determine the following values for I(*) and D(*):

```
I(*) = I(OP1(*)) + I(OP2(*))

I(*) = 1 + 2

I(*) = 3

D(*) = D(OP1(*)) + D(OP2(*))

D(*) = 0 + 1

D(*) = 1
```

With I(*) = 3 and D(*) = 1 determined from step 3, now apply step 4 to discover that I(*) = 3 and D(*) is redefined to 3 since DMAX > D(*) = 1. Thus, step 4 yields the following values:

```
I(*) =3

D(*) = 3
```

Finally, apply step 5 to the values of I(*) and D(*) to yield

```
I(IR'(*)) = 3

D(IR'(*)) = 3
```

since

```
I(*) + D(*) < 18.
```

Thus, the object-time software will maintain three integer places and three decimal places for IR'(*) resulting from the evaluation of "2 * B".

We wish to apply steps 3-5 to OP1(+) and OP2(+) to determine the values for I(IR''(+)) and D(IR''(+)). Note that, since OP2(+) = IR'(*), we have the following values for I(OP2(+)) and D(OP2(+)):

```
I(OP2(+)) = I(IR'(*))

I(OP2(+)) = 3

D(OP2(+)) = D(IR'(*))

D(OP2(+)) = 3.
```

With I(+) = 4 and D(+) = 3 determined from step 3 of Figure 4-9, now apply step 4 to find that I(+) = 4 and D(+) = 3 remain unchanged since IMAX < I(+) and DMAX = D(+). Finally, apply step 5 to the values of I(+) and D(+) to yield:

```
I(IR''(+)) = 4

D(IR''(+)) = 3
```

since

```
I(+) + D(+) < 18.
```

Hence, the object-time software will maintain four integer places and three decimal places for IR''(+) resulting from the evaluation of "A + 2 * B = C".

CHAPTER 5

TABLE HANDLING

5.1 INTRODUCTION

With COBOL, as with any other language, any data item to which the program refers must be uniquely identified. This unique identification of data items is usually accomplished by assigning a unique name to each item. However, in many applications this is tedious and inconvenient; often programs require too many names for items that have different names but contain the same type of information. Tables provide a simple solution to this problem. TRAX COBOL includes full table handling capabilities as outlined for standard COBOL in the 1974 ANSI Standards.

A table is a repetition of one item (element) in memory. This repetition is accomplished by the use of the OCCURS clause in the data description entry. The literal value in the OCCURS clause causes the software to duplicate the data description entry as many times as indicated by that value, thus creating a matrix or table.

The elements may be initialized with the VALUE clause or with a procedural instruction. They may contain synchronized or unsynchronized data. They may be accessed only with subscripted procedural instructions. A subscript is a parenthesized integer or data name (with an integer value). The integer value represents the desired occurrence of the element.

This chapter discusses how to set up tables and access them accurately and efficiently. It attempts to cover any problems that may be encountered while handling tables. Read it through carefully before setting up tables with TRAX COBOL. Sections 4 and 5 of the TRAX COBOL Language Reference Manual contains reference information on the individual table handling instructions (OCCURS, USAGE IS INDEX, SET, and SEARCH).

5.2 DEFINING TABLES

To define a table with TRAX COBOL, simply complete a standard data description for one element of the table and follow it with an OCCURS clause. The OCCURS clause contains an integer which dictates the number of times that element will be repeated in memory, thus creating a table.

The OCCURS phrase has two formats:

Format 1

```
OCCURS integer-2 TIMES

[ {ASCENDING } KEY IS data-name-2  [, data-name-3] ... ] ...
  {DESCENDING}

    [ INDEXED BY index-name-1  [, index-name-2] ... ]
```

Format 2

```
OCCURS integer-1 TO integer-2 TIMES DEPENDING ON data-name-1

[ {ASCENDING } KEY IS data-name-2  [, data-name-3] ... ] ...
  {DESCENDING}

    [ INDEXED BY index-name-1  [, index-name-2] ... ]
```

In either format, the system generates a buffer large enough to accommodate integer-2 occurrences of the data description. Therefore, the amount of storage allocated in either case is equal to the amount of storage required to repeat the data entry integer-2 times.

The software will automatically map the elements into memory. When mapping a table into memory, the software follows the rules for mapping which depend on whether the element contains synchronized items or not. If they do not contain synchronized items, the software maps them into adjacent memory locations and the size of the table can be easily calculated by multiplying the size of the element times the number of occurrences (5X10 for the table illustrated in Figure 5-1, or 50 bytes of memory).

```
01 A-TABLE
   03 A-GROUP PIC X(5) OCCURS 10 TIMES.
```

Figure 5-1
Defining a Table

5.2.1 The OCCURS Phrase - Format 1

When Format 1 is used, a fixed length table is generated, whose length (number of occurrences) is equal to the value specified by integer-2. This format is useful for storing large amounts of frequently used reference data whose size never changes. Tax tables, used in payroll deduction programs, are an excellent example of where a Format 1 (fixed length) table might be used.

5.2.2 The OCCURS Phrase - Format 2

Format 2 is used to generate variable length tables. When used, a table whose length (number of occurrences) is equal to the value specified by data-name-1 is generated.

NOTE

Data-name-1 must always be a positive integer whose value is equal to or greater than integer-1 but not greater than integer-2.

Unlike format 1 tables, the number of occurrences of data items in format 2 tables can be dynamically expanded or reduced to satisfy user needs.

By generating a variable length table, the user is, in effect, saying; "build me a table that can contain at least integer-1 occurrences, but no more than integer-2 occurrences, and set its number of occurrences equal to the value specified by data-name-1".

Data-name-1 always reflects the number of occurrences available for user access. To expand the size (number of occurrences available for use) of a table, the user need only increase the value of data-name-1 accordingly.

Likewise, reducing the value in data-name-1 will reduce the number of occurrences available for user access.

5.3 MAPPING TABLE ELEMENTS

As mentioned in Section 5.2, when the software detects an OCCURS clause in an unsynchronized item, it maps the table elements into adjacent locations in memory. Consider the following data description of a simple table and the way it is mapped into memory:

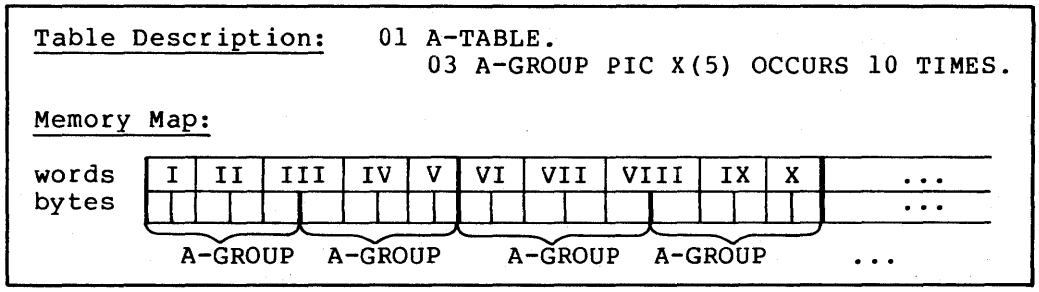


Figure 5-2
Mapping a Table into Memory

The data description in Figure 5-2 causes the software to set up ten items of five bytes each (elements) and place them in adjacent ascending memory locations for a total of 50 character positions, thus creating a table. Since the length of each A-GROUP element is odd (5), the memory addresses of each subsequent element will alternate between odd and even locations.

The SYNCHRONIZED clause causes the software to add a fill byte to items that contain an odd number of bytes, thereby making the number of bytes in that item even. This ensures that each subsequent occurrence of the element will not alternate between odd and even addresses, but will map the same (odd or even) as the first repetition of that element.

If the data description of A-GROUP contained a SYNCHRONIZED clause, the software would map it quite differently. If A-GROUP were synchronized, it would expand its length to three words. The item will, by default, be synchronized to the left occupying the first five characters of the three words. The software supplies a padding character to fill out the third word. This padding character is not a part of the A-GROUP element and table instructions referring to A-TABLE will not detect the presence or absence of the character.

The padding character does, however, affect the overall length of the group item and, hence, the table. Without the SYNCHRONIZED clause, A-TABLE required only 50 character positions; now, with the clause, it requires 60 character positions. (This length includes the last padding character -- following the tenth element in the table.)

Although the SYNCHRONIZED clause has little value when used with alphanumeric fields, an understanding of the concept is essential before attempting to use COMP and INDEX data items in tables. The software automatically synchronizes all COMP and INDEX usage data items, and will most probably alter the size of any table (often drastically) that contains these data types. Consider the following illustration of a synchronized data item being mapped by the software:

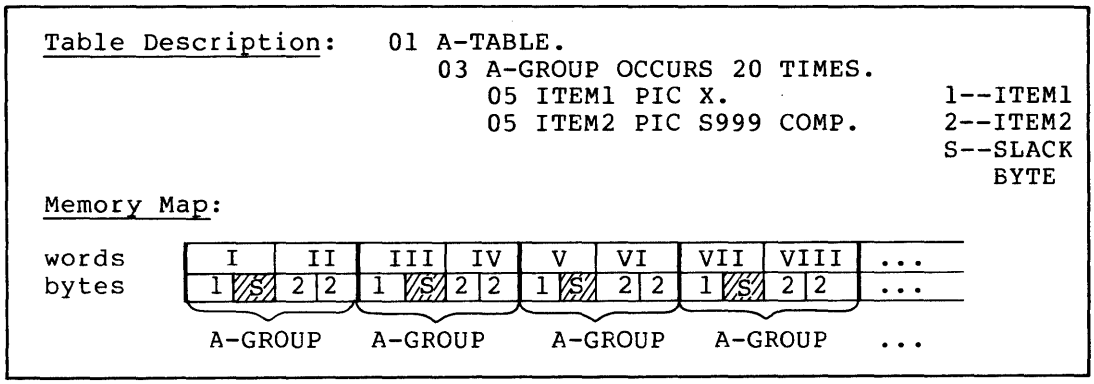


Figure 5-3
Synchronized COMP Item in a Table

Since the software synchronizes the ITEM2 fields (COMP), these fields each occupy a single word in memory; thus, a slack byte follows each occurrence of ITEM1. Each repetition of A-GROUP consumes four bytes of memory -- one byte for ITEM1, one byte for the slack byte, and two bytes for ITEM2. A-TABLE, then, requires 80 bytes of memory (20 elements of four bytes each).

Now, consider the effect of adding a 1-byte field to A-TABLE. If we place the field between ITEM1 and ITEM2, it will take the space formerly occupied by the slack byte. This has the effect of adding a data byte but leaving the size of the table unchanged. Consider the following illustration:

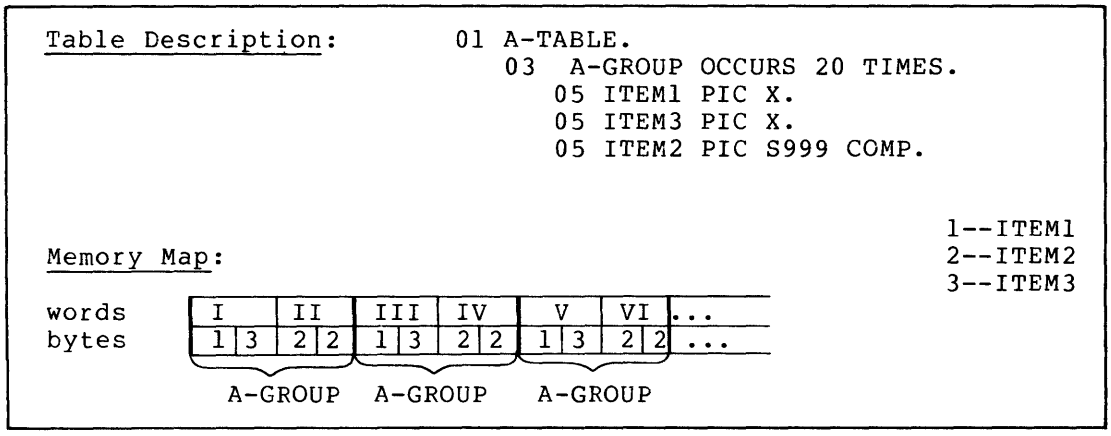


Figure 5-4
Adding a Field without Altering the Table Size

If, however, we place the 1-byte field after ITEM2, it has the effect of adding its own length plus another slack byte. Now, each element requires six full bytes and the complete table consumes 120 bytes of memory (6X20)! This is due to the fact that the first repetition of ITEM1 falls on an even byte and, in order to keep the mapping of each A-GROUP element the same, the software allocates each successive repetition of ITEM1 to an even byte address. Thus, it assigns ITEM3 to the even byte of the third word and adds a slack byte to guarantee that the next element begins on an even byte. Consider the following illustration:

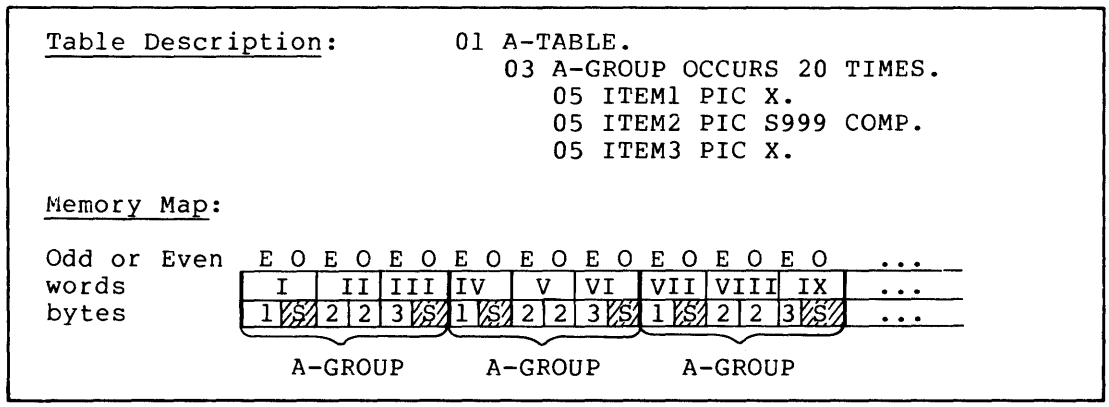


Figure 5-5
Adding One Byte which Adds Two Bytes
to the Element Length

NOTE

The illustrations in this section show each byte with an even address (E) as the leftmost byte, and each byte with an odd address (O) as the rightmost byte. (The two bytes, odd and even, are reversed in actual memory.)

If, however, we use a FILLER byte to force the first allocation of ITEM1 to occur on an odd byte, A-GROUP again requires only four bytes and no slack bytes. Figure 5-6 illustrates this. Since the FILLER item occupies the even byte of the first word, ITEM1 falls on an odd byte. The software requires that each repetition of ITEM1 must be an even number of bytes in length in order to guarantee that the synchronized item(s) will map onto word boundaries. No slack bytes are needed and A-GROUP elements are again only four bytes long, and A-TABLE requires only 81 bytes.

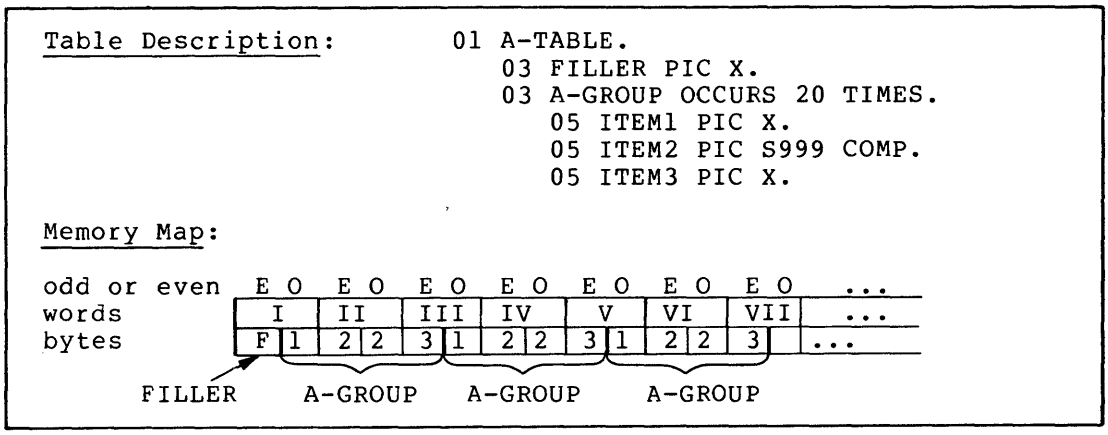


Figure 5-6
Forcing an Odd Address By Adding a 1-Byte FILLER Item to the Head of the Table

If we try to force ITEM1 onto an odd byte with a SYNCHRONIZED RIGHT clause, the software maps ITEM1 into the odd byte, but prohibits all repetitions of the element from using the even byte. Thus, the first repetition of A-GROUP has a slack byte at its beginning and, so that the next element can begin (with a slack byte) at an even address, another slack byte (odd) following ITEM3. This expands the element length to six bytes and the table length to 120 bytes.

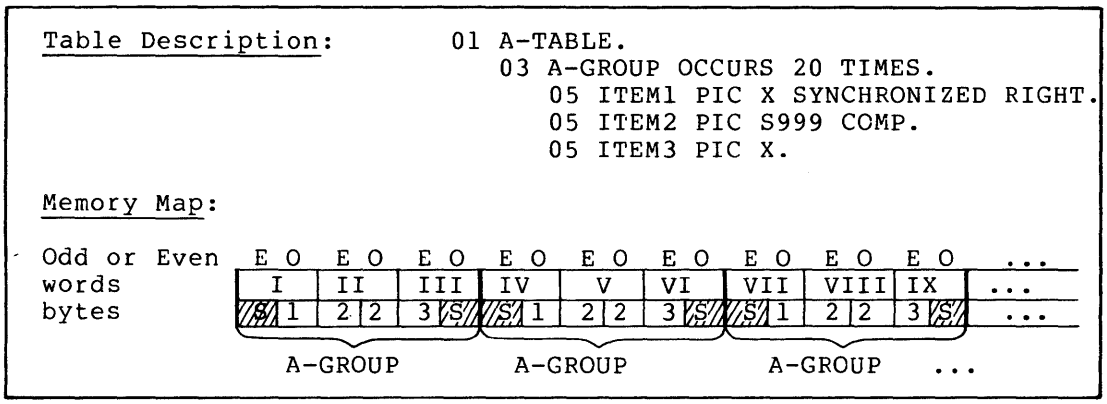


Figure 5-7
The Effect of a SYNCHRONIZED RIGHT Clause Instead of a FILLER Item as shown in Figure 5-6

To determine how the software will map a given table, apply the following two rules:

1. The software maps all items in the first repetition of a table element into memory words as with any item properly defined with a data description, obeying any implicit or explicit synchronization requirements.

2. If the first repetition contains any elementary items with implicit or explicit synchronization, the software maps each successive repetition of the element into memory words in the same way as the first repetition. It does this by adding one slack byte, if necessary, to make the size of the element even.

5.3.1 Initializing Tables

If a table contains only DISPLAY items, it can be set to any desired initial value (initialized). To initialize a table, simply specify a VALUE phrase on the record level preceding the item containing the OCCURS clause. The sample data definitions, below, will set up initialized tables:

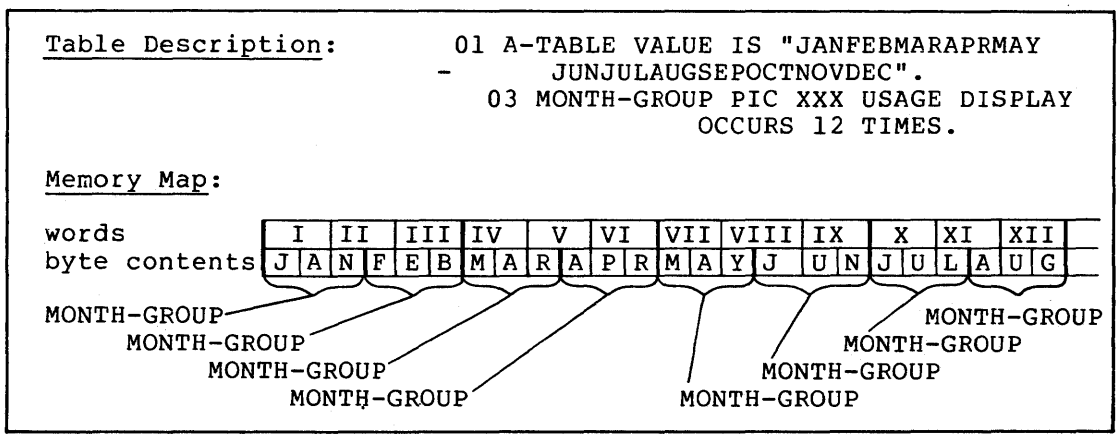


Figure 5-8
Initializing Tables

Often a table is too long to initialize with a single literal, or it contains items that cannot be initialized (numeric, alphanumeric, or COMP). These items can be individually initialized by redefining the group level preceding the level that contains the OCCURS clause. Consider the following sample table descriptions:

Table Description:

```
01 A-RECORD-ALT.
   05 FILLER PIC XX VALUE "AX".
   05 FILLER PIC 99 COMP VALUE 1.
   05 FILLER PIC XX VALUE "BX".
   05 FILLER PIC 99 COMP VALUE 2.
   .
   .
   .
01 A-RECORD REDEFINES A-RECORD-ALT.
   03 A-GROUP OCCURS 26 TIMES.
      05 ITEM1 PIC X.
      05 ITEM2 PIC S99 COMP.
```

Memory Map:

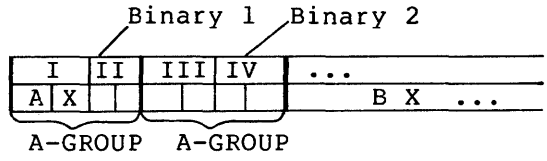


Figure 5-9
Initializing Mixed Usage Fields

In the preceding example, the slack bytes in the alphanumeric fields (ITEM1) are being initialized to X.

Table Description:

```
01 A-RECORD-ALT.
   03 FILLER PIC X(30) VALUE IS
      "AAAAAAAAAABBBBBBBBBBCCCCCCCCCC".
   03 FILLER PIC X(30) VALUE IS
      "DDDDDDDDDDEEEEEEEEEEFFFFFFFFFF".
(etc.)

01 A-RECORD REDEFINES A-RECORD-ALT.
   03 ITEM1 PIX X(10) OCCURS 26 TIMES.
```

Memory Map:

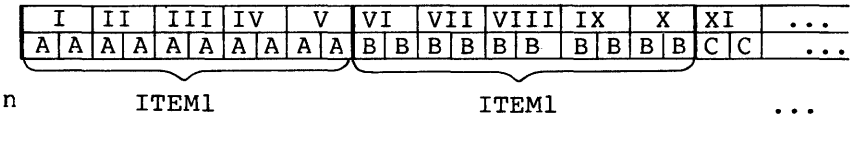


Figure 5-10
Initializing Alphanumeric Fields

In the preceding example, each FILLER item initializes three 10-byte table elements.

When redefining or initializing table elements, allow space for any slack bytes that may be added due to synchronization (implicit or explicit). The slack bytes do not have to be initialized; however, they may be and, if initialized to an uncommon value, they may even serve as a debugging aid for situations such as a statement referring to the record level above the OCCURS clause or another record redefining that level.

Sometimes the length and format of table items are such that they would best be initialized by statements in the Procedure Division. This initialization coding could be executed once and then overlaid (due to the automatic segmentation feature) if the entire Procedure Division is too large to be held in memory at one time.

Once the OCCURS clauses have established the necessary tables, the program must be able to access the elements of those tables individually. Subscripting and indexing are the two methods provided by COBOL for accessing individual elements.

5.4 SUBSCRIPTING AND INDEXING

To refer to a particular element within a table, simply follow the name of the desired element with a parenthesized subscript or index. A subscript is an integer or a data-name that has an integer value; the integer value represents the desired occurrence of the element -- an integer value of 3, for example, refers to the third occurrence of the element. An index is a data-name that has been named in an INDEXED BY phrase in the OCCURS clause.

5.4.1 Subscripting with Literals

A literal subscript is simply a parenthesized integer whose value represents the occurrence number of the desired element. In figure 5-11, the literal subscript in the MOVE instruction (2) causes the software to move the contents of the second element of the table, A-TABLE, to I-RECORD.

Table Description	01 A-TABLE. 03 A-GROUP PIC X(5) OCCURS 10 TIMES.
Procedural Instruction	MOVE A-GROUP(2) TO I-RECORD.

Figure 5-11
Literal Subscripting

If the table has more than one level (or dimension), follow the name of the desired item with a list of subscripts, one for each OCCURS clause to which the item is subordinate. The first subscript in the list applies to the first OCCURS clause to which the item is subordinate. (This is the most encompassing level -- A-GROUP in the following example.) The second subscript in the list applies to the next most encompassing level, and the last subscript applies to the lowest level OCCURS clause being accessed (or the desired occurrence number of the item named in the procedural instruction -- ITEM5 in the following example).

Consider Figure 5-12; the subscripts (2,11,3) in the MOVE instruction cause the software to move the third repetition of ITEM5 in the eleventh repetition of ITEM3 in the second repetition of A-GROUP to I-FIELD5. (For illustration simplicity, I-FIELD5 is not defined.) (ITEM5(1,1,1) would refer to the first occurrence of ITEM5 in the table and ITEM5(5,20,4) would refer to the last occurrence of ITEM5.)

Table Description	01 A-TABLE. 03 A-GROUP OCCURS 5 TIMES. 05 ITEM1 PIC X. 05 ITEM2 PIC 99 COMP OCCURS 20 TIMES. 05 ITEM3 OCCURS 20 TIMES. 07 ITEM4 PIC X. 07 ITEM5 PIC XX OCCURS 4 TIMES.
Procedural Instruction	MOVE ITEM5(2, 11, 3) TO I-FIELD5.

Figure 5-12
Subscripting a Multi-Dimensional Table

NOTE

Since ITEM5 is not subordinate to ITEM2, an occurrence number for ITEM2 is not permitted in the subscript list.

Figure 5-13 summarizes the subscripting rules for each of the above items and shows the size of each field in bytes.

NAME OF FIELD	NUMBER OF SUBSCRIPTS REQUIRED TO REFER TO THE NAMED FIELD	SIZE OF FIELD
A-TABLE	NONE	1110
A-GROUP	ONE	222
ITEM1	ONE	1*
ITEM2	TWO	2
ITEM3	TWO	9
ITEM4	TWO	1
ITEM5	THREE	2
* Plus a slack byte		

Figure 5-13
Subscripting Rules for a
Multi-Dimensional Table

5.4.2 Operations Performed by the Software

When a literal subscript is used to refer to an item in a table, the software performs the following steps to determine the exact address of the item:

1. The compiler converts the literal to a 1-word binary value.

2. The compiler range checks the subscript value (the value must not be less than 1 nor greater than the number of repetitions specified by the OCCURS clause) and prints a diagnostic message if the value is out of range.

3. The compiler decrements the value of the subscript by 1 and multiplies it by the size of the item that contains the OCCURS clause corresponding to this subscript, thus forming an index value; it then stores this value, plus the literal subscript, in the object program.

4. At object execution time for a fixed length table, the run time system adds the index value (from 3 above) to a base address, thus determining the address of the desired item. For a variable length table reference, the procedure for fixed length tables is preceded by the procedure described in Section 5.4.6.

5.4.3 Subscripting with Data-Names

As discussed earlier in this section, subscripts may also be specified using data-names instead of literals. To use a data-name as a subscript, simply define it as a numeric integer (COMP or DISPLAY). It may be signed, but the sign must be positive at the time it is used as a subscript.

The sample subscripts in figure 5-14 refer to the same element accessed in Figure 5-12, (2, 11, 3).

Data Descriptions of Subscript data-names	01 KEY1 PIC 99 USAGE DISPLAY. 01 KEY2 PIC 99 USAGE COMP. 01 KEY3 PIC S99.
Procedural Instructions	MOVE 2 TO KEY1. MOVE 11 TO KEY2. MOVE 3 TO KEY3. GO TO TABLERTN. TABLERTN. MOVE ITEM5(KEY1 KEY2 KEY3) TO I-FIELD5.

Figure 5-14
Subscripting with Data-Names

5.4.4 Operations Performed by the OTS on Data Names

When a data-name subscript is used to refer to an item in a table, the OTS performs the following steps at object execution time:

1. If the data-name's data type is DISPLAY, the software converts it to a 1-word binary value.

2. For fixed length tables, the software range checks the subscript value (the value must not be less than 1 nor greater than the number of repetitions specified by the OCCURS clause) and terminates the object program (with a diagnostic message) if it is out of range. For variable length tables, the procedure described in Section 5.4.6 is followed.

3. The software decrements the value of the subscript by 1 and multiplies it by the size of the item that contains the OCCURS clause corresponding to this subscript, thus forming an index value.

4. The software adds the index value (from 3 above) to a base address, thus determining the address of the desired item.

5.4.5 Subscripting with Indexes

The same rules apply for the specification of indexes as apply to subscripts except that the index must be named in the INDEXED BY phrase of the OCCURS clause.

An index-name item (an item named in the INDEXED BY phrase of the OCCURS clause) has the ability to hold an index value. (The index value is the product formed in step 3 of the operations performed by the software for literal or data-name subscripts -- the relative location, within the table, of the desired item.)

The compiler allocates a 2-part data item for each name that follows an INDEXED BY phrase. These index-name items cannot be accessed as normal data items; they cannot be moved about, redefined, written to a file, etc. However, the SET verb can change their values and relation tests can examine their values. One part of the 2-part index-name item contains a subscript value and the other part contains an index value. Consider the following illustration:

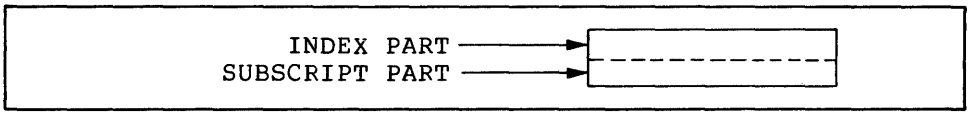


Figure 5-15
Index-Name Item

Whenever a SET statement places a new value in the subscript part, the software performs an index value computation and stores the result in the index part. Only the subscript part of the item acts as a sending or receiving field. The index part is never altered by any other operation and is never moved to another item. It is used only when the index-name is used as an index referring to a table item. The sample MOVE statement in Figure 5-16 would move the contents of the third repetition of A-GROUP to I-FIELD. (For illustration simplicity, once again, I-FIELD is not defined.)

Table Description	01 A-TABLE. 03 A-GROUP OCCURS 5 TIMES INDEXED BY IND-NAME.
Procedural Instructions	SET IND-NAME TO 3. MOVE A-GROUP (IND-NAME) TO I-FIELD.

Figure 5-16
Subscripting With Index-name Items

5.4.6 Operations Performed by the OTS on the SET Statement

The OTS performs the following steps when it executes the SET statement:

1. The OTS converts the contents of the sending field of the SET statement to a 1-word binary value.

2. The OTS range checks the value (the value must not be less than 1 nor greater than the number of repetitions specified in the OCCURS clause) and terminates the object program with a diagnostic message if it is out of range.

3. The OTS decrements the value by 1 and multiplies it by the size of the item that contains the OCCURS clause, thus forming an index value.

For fixed length tables, once the SET statement has been executed and the software has encountered the index-name item as an index, it only has to add the index value (from 3 above) to a base address to determine the address of the desired item. Since this is the only action performed, the execution speed of a procedural statement with an indexed data-name is equivalent to a reference with a literal subscript.

For a variable length table, when the index-name is encountered as an index, the procedure described in Section 5.4.6 is invoked before following the fixed length table logic. However, the SET statement itself is not impacted by the fixed/variable characteristic of the associated table.

TRAX COBOL initializes the value of all index-name items to a subscript value of 1 (index value of 0), hence an attempt to use an index-name item as an index before it has been the receiving field of a SET verb will not result in an out-of-range termination.

NOTE

Initialization of index-name items is an extension to the ANSI COBOL standards. Users concerned with writing TRAX COBOL programs that adhere to standard COBOL should not rely on this feature.

5.4.7 Relative Indexing

To perform relative indexing, when referring to a table item, simply follow the index-name with a plus or minus sign and an integer literal. Relative indexing, albeit easy to use, causes additional overhead to be generated each time a table item is referenced in this fashion. At compile time, the compiler has to compute the index value corresponding to the specified literal; and transfer this index value to the object file. At object run time, the index value for the literal is added to (+) or subtracted from (-) the index value of the index-name. The resulting index value is stored in a temporary location. The OTS adds this temporary index value to the base address of the table to determine the address of the desired table item. At this point, a range check is performed on the temporary index value to insure that the resulting index is within the permissible range for the table.

For fixed length tables, this index manipulation is relatively straightforward. The size of the table is known at compilation time, and this size is passed along to the OTS in the object file. A simple compare against this fixed value is all that is required to determine if a given index value is within the permissable range for the table.

For a variable length table, however, the process is more involved. The current number of occurrences (data-name-1) for the table must be determined and range checked; the index value corresponding to the current number of occurrences must be calculated; then the temporary index value must be range checked using the current number of occurrence's index value.

The object time overhead required for the relative indexing of variable length tables is significantly greater than that required for fixed length tables. In either case, the index portion of the index-name is not altered. If any of the range checks reveals an illegal (out of range) value, execution is terminated with an apropriate error message.

The sample MOVE instruction in Figure 5-17 moves the fourth repetition of A-GROUP to I-FIELD if IND-NAME has not been altered with a SET verb.

```
MOVE A-GROUP(IND-NAME + 3) TO I-FIELD.
```

Figure 5-17
Relative Indexing

The actual operation of accessing a table element is shorter at run time since the compiler has calculated the index value of the literal at compile time and has stored it in the object program ready for use. Relative indexing, therefore, involves two additions and a range check during object execution. It leaves the index-name item unaltered.

5.4.8 Index Data Items

Often a program will require that the value of an index-name item be stored outside of that item. It is for this purpose that TRAX COBOL provides the index data item.

Index data items are 1-word binary integers with implicit synchronization. (The 1-word size corresponds to the subscript part of the index-name item.) They must be declared with a USAGE IS INDEX phrase and they may be modified (explicitly) only by the SET statement.

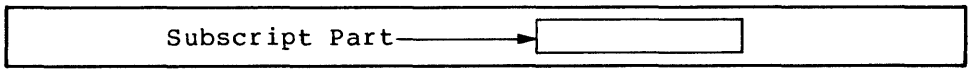


Figure 5-18
Index Data Item

Since index data items are considered to contain only the subscript part of an index-name item, when a SET statement "moves" an index-name item to an index data item, only the subscript part is moved. Likewise, when a SET statement "moves" an index data item to an index-name item, a new index value is computed by the software. This is done to guarantee that an index-name item will always contain a good index value.

The only advantage gained by using index data items over numeric, COMP items is that the data description is shorter, easier to write, and more self-documenting. Further, the restrictions placed on access to index items may be useful in debugging the program.

5.4.9 The SET Statement

The SET statement alters the value of index-name items and copies their value into other items. When used without the UP BY/DOWN BY clause, it functions like a MOVE statement. Figure 5-19 illustrates the legal data movements that the SET statement can perform.

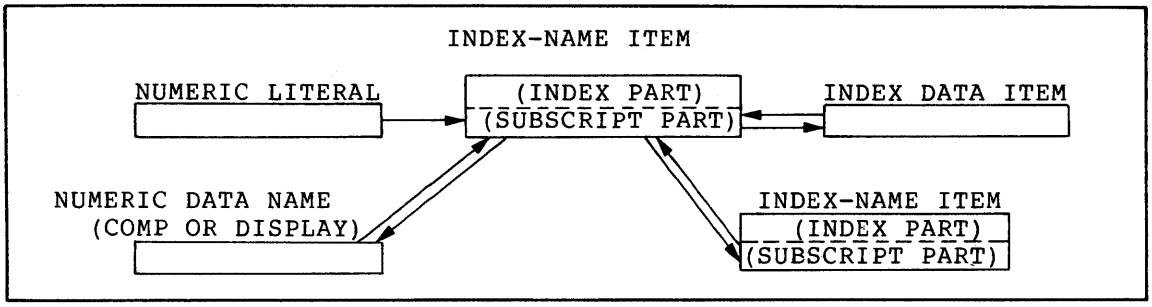


Figure 5-19
Legal Data Movement with the SET Statement

The SET statement may be used with the UP BY/DOWN BY clause to alter the value of an index-name item arithmetically. The numeric literal is added to (UP BY) or subtracted from (DOWN BY) the subscript part, and the index part is recalculated by the software after the appropriate range check against the number of repetitions for the table. The SET statement is not affected by whether the table is fixed or variable length.

5.4.10 Referencing a Variable Length Table Element at OTS Time

At OTS time, when a procedural reference involves an element in a variable length table, the following procedure is used:

1. Determine the number of occurrences in the table (the value contained in data-name-1), and verify its legality.

   (integer-1 <= data-name-1 <= integer-2)

2. Verify that the subscript is within the legal range.

   (subscript <= data-name-1)

If any of the above checks fails, execution is terminated with an appropriate error message.

5.4.11 Referencing a Dynamic Group at OTS Time

A dynamic group is defined as a group item that contains a subordinate item that is a variable length table. At OTS time, when a dynamic group is referenced, the following procedures are followed:

1. The number of occurrences of the subordinate variable length table is determined, and checked for legality; i.e., integer-1<=data-name-1<=integer-2. If this check fails, execution terminates and the appropriate error message is issued.

2. The size of the dynamic group is calculated. The number of occurrences of the variable length table (data-name-1) is multiplied by the size of one table entry. The resulting number is then added to the fixed size of the dynamic group.

NOTE

The fixed size of a dynamic group is the size of the group up to but not including the variable length table.

5.4.12 The SEARCH Verb

The SEARCH verb has two formats: Format 1, which performs a sequential search of the specified table beginning with the current index setting; and Format 2 which performs a selective (binary) search of the specified table, beginning with the middle of the table.

Both formats allow the programmer to specify imperative statements within the SEARCH verb. At OTS time, an imperative statement contained within a search verb is executed only when one of the exit paths (success or failure) is taken.

The failure path is defined either explicitly by the AT END statement, in which case the imperative statement which follows it is executed; or by default, in which case control is passed to the next procedural sentence. In either case (success or failure), after an imperative statement is executed, control is passed to the next procedural sentence.

5.4.13 The SEARCH Verb - Format 1

Format 1 directs the OTS to search the indicated table sequentially. The OCCURS clause for the table being searched must contain the INDEXED by phrase. Unless otherwise specified in the SEARCH statement, the first index is the controlling index for the table search. The search begins with the current index setting, and progresses through the table, augmenting the index by one as each occurrence is interrogated. If any of the specified conditions is true (success), the associated imperative statement is executed; the search exits; and the index remains at the current setting.

If the possible number of occurrences for the table is exhausted before any of the specified conditions are met, the specified failure exit path is taken. That is, either the AT END exit path (if specified) is taken, or control is passed to the next procedural sentence.

Figure 5-20 contains an example of using the SEARCH verb to search a table a serially.

Associated with Format 1 is the optional VARYING phrase. This phrase can be specified by using any of the following methods:

1. default - phrase omitted
2. VARYING index-name-n
3. VARYING identifier-2
4. VARYING index-name-2

NOTE

The following is true regardless of which of the above methods is used.

a. An index name associated with the table is methodically augmented by one, by the OTS, for each cycle of the serial search. This controlling index, when compared to the allowable number of occurrences for the table, dictates the permissible range of search cycles at OTS time. When an exit occurs (success or failure), this index remains at the current setting.

b. The OTS will not initialize the index when the search begins. It is the programmers responsibility to insure that the initial index setting is the appropriate one. The OTS will begin processing the table with the setting it finds when the search is initiated.

When method 1 is used, the first index name (index-name-1) associated with the table is used as the controlling index. Only this index is set to consecutive values by the OTS serial search processor. See Figure 5-20, Example 2, for an example of using method 1.

When method 2 is used, index-name-n is any index that is associated with the table being searched. It becomes the controlling index for the table. It alone is set to consecutive values by the OTS search processor. See Figure 5-20, Example 3, for an example of using method 2.

When method 3 is used, identifier-2 is augmented by one each time the first index (controlling index) for the table is augmented by one. Identifier-2 is not a substitute index. It merely allows the programmer to maintain an additional pointer to elements within a table. See Figure 5-20, Example 4, for an example of method 3.

When method 4 is used, index-name-2 is an index that is associated with a table other than the one being searched. Each time the controlling index (lst index for the table) of the searched table is augmented, index-name-2 is also augmented. See Figure 5-20, Example 5.

5.4.14 The SEARCH Verb - Format 2

Format 2 is used to direct the OTS to search the indicated table selectively. The selective (binary) search is predicated upon the ASCENDING/DESCENDING KEY attributes of the table being searched. Therefore, an ASCENDING and/or DESCENDING KEY(s) must be specified in the OCCURS clause that defines the table, to inform the OTS that the keys are stored within the table in ascending or descending order.

The INDEXED BY phrase must also be specified. When the binary search is executed, the OTS uses the first or only index associated with the table as the controlling index for the search.

The selective (binary) search is implemented in the OTS as follows:

1. The OTS examines the range of permissible values for the index of the table being searched; selects the median value; and assigns this median value to the index.

2. The OTS then proceeds to process the sequence of simple tests for equality, beginning with the first, with the index set to the median value.

3. If all of the tests for equality are true (success), the search is terminated; the associated imperative statement is executed; the search exits; and the index retains its current value.

4. If any of the tests for equality is false, the following results occur.

   a. The OTS determines if all of the possible occurrences for the table have been tested. If the table has been exhausted, the imperative statement which accompanies the AT END statement (if specified) is executed. In either case, control is passed to the next procedural statement.

   b. The OTS will now determine which half of the table is to be eliminated from further consideration. This determination is predicated on whether the key being tested is in ascending or descending order, and whether the test failed because of a greater than or less than comparison. For example, if the key values being tested are stored in ascending order, and the median table element being tested is greater than the value being tested for equality, the OTS will assume that all key elements following the one tested are also greater than the value being tested for equality. Therefore, the lower half of the table, those items which follow the current index setting, are no longer in contention.

   c. Once the direction of search is determined, half of the table is eliminated from further consideration. A new range of permissible index values is computed from the remaining half of the table.

   d. Processing begins all over again from step 1.

See Figure 5-20, Example 6, for an example of searching a table using Format 2 of the SEARCH verb.

```
FED-TAX-TABLES.
02  ALLOWANCE-DATA.
    03  FILLER                     PIC X(70) VALUE
        "0001440
        "0202880
        "0304320
        "0405760
        "0507200
        "0608640
        "0710080
        "0811520
        "0912960
        "1014400".
02  ALLOWANCE-TABLE REDEFINES ALLOWANCE-DATA.
    03  FED-ALLOWANCES OCCURS 10 TIMES
        ASCENDING KEY IS ALLOWANCE-NUMBER
        INDEXED BY IND-1.
        04  ALLOWANCE-NUMBER       PIC XX.
        04  ALLOWANCE              PIC 999V99.
02  SINGLES-DEDUCTION-DATA.
    03  FILLER                     PIC X(112) VALUE
        "025000670000016
        "067001150006722Ø
        "115001830016322Ø
        "183002400031962Ø
        "240002790043932Ø
        "279003460054073Ø
        "346009999741736".
02  SINGLES-DEDUCTION-TABLE REDEFINES SINGLES-DEDUCTION-DATA.
    03  SINGLES-TABLE OCCURS 7 TIMES
        ASCENDING KEY IS S-MIN-RANGE S-MAX-RANGE
        INDEXED BY IND-2, TEMP-INDEX.
        04  S-MIN-RANGE            PIC 999V99.
        04  S-MAX-RANGE            PIC 999V99.
        04  S-TAX                  PIC 99V99.
        04  S-PERCENT              PIC V99.
02  MARRIED-DEDUCTION-DATA.
    03  FILLER                     PIC X(119) VALUE
        "048000960000000017
        "096001730000816Ø0
        "173002640002356Ø7
        "264003460003903Ø5
        "346004330005953Ø8
        "433005000008389Ø2
        "500009999910533Ø6".
02  MARRIED-DEDUCTION-TABLE REDEFINES MARRIED-DEDUCTION-DATA.
    03  MARRIED-TABLE OCCURS 7 TIMES
        ASCENDING KEY IS M-MIN-RANGE M-MAX-RANGE
        INDEXED BY IND-0, IND-3.
        04  M-MIN-RANGE            PIC 999V99.
        04  M-MAX-RANGE            PIC 999V99.
        04  M-TAX                  PIC 999V99.
        04  M-PERCENT              PIC V99.
TEMP-INDEX                          USAGE INDEX.
```

Figure 5-20
Example of Using SEARCH
To Search a Table

Example 1

```
SINGLE.
        IF TAXABLE-INCOME < 02499
                GO TO END-FED-COMP.
        SET IND-2 TO 1.
        SEARCH SINGLES-TABLE VARYING IND-2 AT END
                GO TO TABLE-2-ERROR
          WHEN TAXABLE-INCOME = S-MIN-RANGE(IND-2)
                MOVE S-TAX(IND-2) TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER
                GO TO STORE-FED-TAX
          WHEN TAXABLE-INCOME < S-MAX-RANGE(IND-2)
                SUBTRACT S-MIN-RANGE(IND-2) FROM TAXABLE-INCOME
                MULTIPLY TAXABLE-INCOME BY S-PERCENT(IND-2) ROUNDED
                ADD TAXABLE-INCOME TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER.
```

Example 2

```
SINGLE.
        IF TAXABLE-INCOME < 02499
                GO TO END-FED-COMP.
        SET IND-2 TO 1.
        SEARCH SINGLES-TABLE VARYING IND-2 AT END
                GO TO TABLE-2-ERROR
          WHEN TAXABLE-INCOME = S-MIN-RANGE(IND-2)
                MOVE S-TAX(IND-2) TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER
                GO TO STORE-FED-TAX
          WHEN TAXABLE-INCOME < S-MAX-RANGE(IND-2)
                SUBTRACT S-MIN-RANGE(IND-2) FROM TAXABLE-INCOME
                MULTIPLY TAXABLE-INCOME BY S-PERCENT(IND-2) ROUNDED
                ADD TAXABLE-INCOME TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER.
```

Example 3

```
MARRIED.
        IF TAXABLE-INCOME < 04799
                MOVE ZEROS TO FED-TAX-DEDUCTION OF OUTPUT-MASTER,
                GO TO END-FED-COMP.
        SET IND-3 TO 1.
        SEARCH MARRIED-TABLE VARYING IND-3
                AT END GO TO TABLE-3-ERROR
          WHEN TAXABLE-INCOME = M-MIN-RANGE(IND-3)
        MOVE M-TAX(IND-3) TO FED-TAX-DEDUCTION OF OUTPUT-MASTER,
                GO TO STORE-FED-TAX,
          WHEN TAXABLE-INCOME < M-MAX-RANGE(IND-3)
        MOVE M-TAX(IND-3) TO FED-TAX-DEDUCTION OF OUTPUT-MASTER,
        SUBTRACT M-MIN-RANGE(IND-3) FROM TAXABLE-INCOME ROUNDED,
        MULTIPLY TAXABLE-INCOME BY M-PERCENT(IND-3) ROUNDED,
        ADD TAXABLE-INCOME TO FED-TAX-DEDUCTION
                        OF OUTPUT-MASTER ROUNDED,
                GO TO STORE-FED-TAX.
```

Figure 5-20 (Cont.)
Example of Using SEARCH
To Search a Table

Example 4

```
SINGLE.
        IF TAXABLE-INCOME < 02499
                GO TO END-FED-COMP.
        SET IND-2 TO 1.
        SEARCH SINGLES-TABLE VARYING TEMP-INDEX AT END
                GO TO TABLE-2-ERROR
          WHEN TAXABLE-INCOME = S-MIN-RANGE(IND-2)
                MOVE S-TAX(IND-2) TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER
                GO TO STORE-FED-TAX
          WHEN TAXABLE-INCOME < S-MAX-RANGE(IND-2)
                SUBTRACT S-MIN-RANGE(IND-2) FROM TAXABLE-INCOME
                MULTIPLY TAXABLE-INCOME BY S-PERCENT(IND-2) ROUNDED
                ADD TAXABLE-INCOME TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER.
```

Example 5

```
SINGLE.
        IF TAXABLE-INCOME < 02499
                GO TO END-FED-COMP.
        SET IND-2 TO 1.
        SEARCH SINGLES-TABLE VARYING IND-0 AT END
                GO TO TABLE-2-ERROR
          WHEN TAXABLE-INCOME = S-MIN-RANGE(IND-2)
                MOVE S-TAX(IND-2) TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER
                GO TO STORE-FED-TAX
          WHEN TAXABLE-INCOME < S-MAX-RANGE(IND-2)
                SUBTRACT S-MIN-RANGE(IND-2) FROM TAXABLE-INCOME
                MULTIPLY TAXABLE-INCOME BY S-PERCENT(IND-2) ROUNDED
                ADD TAXABLE-INCOME TO FED-TAX-DEDUCTION OF
                        OUTPUT-MASTER.
```

Example 6

```
FED-DEDUCT-COMPUTATION.
        SET IND-1 TO 1.
        SEARCH ALL FED-ALLOWANCES AT END GO TO TABLE-1-ERROR
          WHEN ALLOWANCE-NUMBER(IND-1) = NR-DEPENDENTS OF
                OUTPUT-MASTER,
          SUBTRACT ALLOWANCE(IND-1) FROM GROSS-WAGE OF OUTPUT-MASTER
                GIVING TAXABLE-INCOME ROUNDED.
        IF MARRITAL-STATUS OF OUTPUT-MASTER = "M"
                GO TO MARRIED.
```

Figure 5-20 (Cont.)
Example of Using SEARCH
To Search a Table

CHAPTER 6

FILE HANDLING

TRAX COBOL provides three ways to arrange the records in its files (file organization): sequential, relative, and indexed. The ORGANIZATION in the Environment Division clause specifies the file organization for COBOL files.

TRAX COBOL provides three ways to process the records in its files (file access): sequential, random, and dynamic. The ACCESS MODE clause specifies the file access mode for each file used by COBOL programs. The following chart shows the three file organizations and the file access methods that apply to each of them:

FILE ORGANIZATION	FILE ACCESS
SEQUENTIAL	SEQUENTIAL
RELATIVE	SEQUENTIAL RANDOM DYNAMIC
INDEXED	SEQUENTIAL RANDOM DYNAMIC

Once a program creates a file, all other programs that access it must describe it with the same file organization. For example, it is not possible to create a sequential file in one program and read it as a relative file with another program. However, programs can use different access methods to process records in the same file as long as the organization of the file supports the access method.

The following table compares the different file organizations with their file manipulation capabilities.

Table 6-1
COBOL File Types

Access Capabilities	File Type (Organization) Sequential	Relative	Indexed
Sequential	Yes	Yes	Yes
Random	No	Yes	Yes
Record Replacement	Limited	Yes	Yes
Record Addition (at end of file)	Yes	Yes	Yes
Record Insertion	No	Limited	Yes
Record Deletion	No	Yes	Yes

COBOL I/O statements allow COBOL programs to communicate with the system devices. These statements differ for sequential, relative, and indexed file organizations. Therefore, the COBOL I/O statements are discussed separately by file organization. Section 6.1 discusses sequential organization, Section 6.2 discusses relative organization, and Section 6.3 discusses indexed organization. All file processing is performed by the COBOL object time system (OTS), regardless of organization.

Table 6-2 shows which statements apply to each file organization methods:

Table 6-2
I/O Statements

Sequential I/O Statements	Relative and Indexed I/O Statements
CLOSE	CLOSE
OPEN	DELETE
READ	OPEN
REWRITE	READ
WRITE	REWRITE
	START
	WRITE

6.1 SEQUENTIAL FILE ORGANIZATION

Sequential file organization arranges the records in a file serially; each record (except the first) has another record preceding it and each record (except the last) has another record following it. The records remain in the order in which they were written. Thus, COBOL statements cannot delete records from the file, insert new records between existing records, or alter the order of the existing records in any way. However, they can replace existing records (providing the length of the replacement record is identical to the original) and add new records onto the end of the file.

The opening operation for reading, writing, or updating sequential files must begin with the first record in the file and proceed by the prescribed order through the file. For example, to read a particular record in the file, say the 15th record, the program must open the file and successfully execute 14 READ statements before the 15th execution can read the desired record. The program can read all of the remaining records (from record 16 on), but it cannot read any record prior to record 16 without opening the file again and beginning with record 1.

Sequential files always contain an end-of-file mark that designates the end of the file. COBOL statements can write over the end-of-file mark and, thus, extend the length of a file. (The software inserts another end-of-file mark after the last record written.) Since the end-of-file mark indicates the end of useful data, TRAX COBOL provides no method for reading beyond the end-of-file mark; even though the amount of space reserved for the file exceeds the amount actually used. See Figure 6-1.

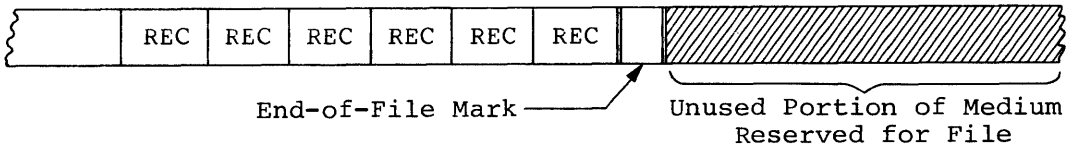


Figure 6-1 Placement of End-of-File Mark

Occasionally a file with sequential organization is so large that it requires more than one volume (such as a multi-reel magnetic tape file). An end-of-volume label marks the end of recorded information on each volume and signals the file system to switch to a new volume. On multi-volume files, the end-of-file mark appears once, at the end of the last record on the last volume. See Figure 6-2.

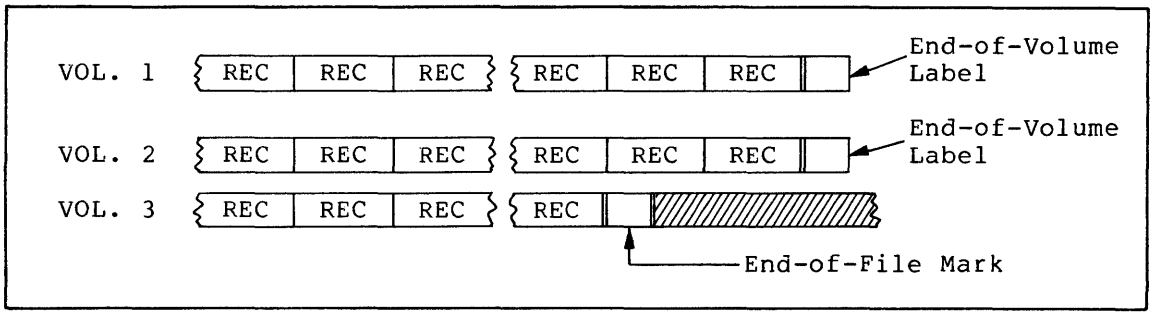
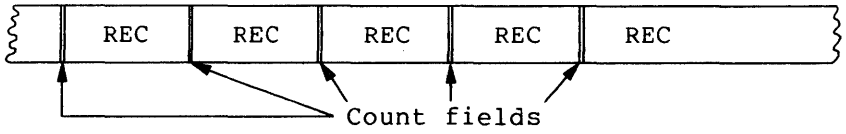


Figure 6-2 Placement of the End-of-Volume Label and End-of-File Mark in a Multi-Volume File

6.1.1 Record Size

If there is only one record description for a file or if there are more than one that describe the same length record, that file contains fixed-length records. If the data descriptions for a sequential file consist of more than one record description, which describe several different-sized records, that file contains variable-length records.

When a program creates a sequential file with variable-length records, the software places a count field in front of each record it writes into the file. This count field contains the number of character positions in the record. When a COBOL statement requests the record, the software releases a record whose length is that specified by the count field. The OTS creates and uses the count field automatically. COBOL statements cannot access it during input operations, and the 01 level record description entries must not describe it.



6.1.2 RECORD CONTAINS Clause

The RECORD CONTAINS clause, when specified without the "integer-1 TO" option, is for documentation purposes only. The compiler determines record size from the data descriptions. When the "integer-1 TO" option is specified, it forces the compiler to generate a variable length record file, even if the data descriptions describe fixed length records.

Conversely, if the data descriptions for a sequential file describe variable-length records, the software sets up variable sized records automatically and ignores this clause.

Even though the software ignores the values in the "integer-1 TO..." phrase, the clause may be used in any program to document record sizes.

6.1.3 SAME RECORD AREA Clause

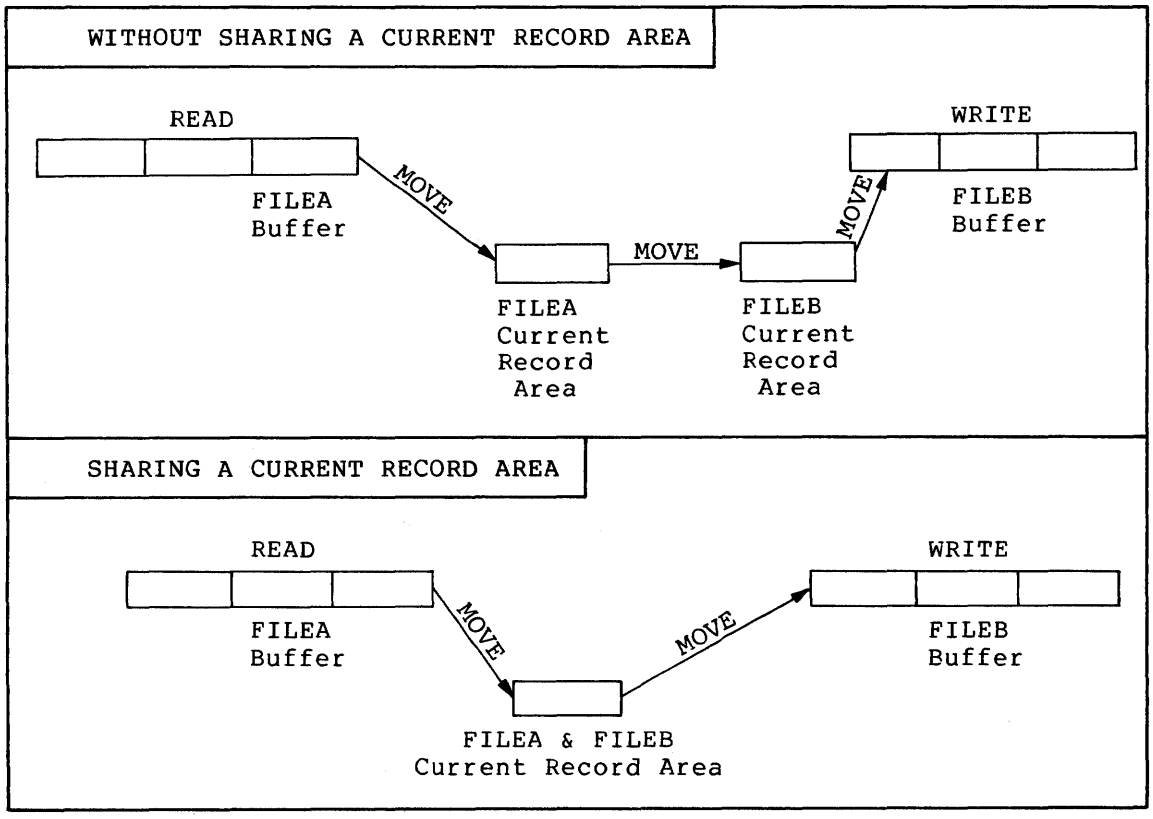
The file system reserves a record processing area in memory for each file. This area is the current record area. The system fixes the location of the current record area when it opens the file. It also reserves a byte preceding and following each current record area for possible print-control characters. The current record area always begins on an even byte boundary. Two or more files may share a current record area if a SAME RECORD AREA clause contains their file-names. This clause causes the system to begin the current record area of each file listed at a common location. (Thus, current record areas that share space are aligned on their leftmost bytes.) The records do not have to be the same size and the current record areas need not have the same maximum size. The following sample statement would cause FILEA and FILEB to share the same current record area:

```
I-O-CONTROL.

    SAME RECORD AREA FOR FILEA FILEB

    ...
```

Since the system places a file's current record area in a separate location from its buffers, each READ, WRITE, and REWRITE operation causes a record to move between the buffers and the current record area. When a program reads a record from a file, modifies it, and writes it into another file, a SAME RECORD AREA clause, containing both file-names, can save an entire move of the record. The following illustration shows these record movements:



Record Movement Caused by
Reading, Processing, and Writing
Records in Two Files

6.1.4 Print-Controlled Records

If a sequential file is described in a LINAGE IS clause, an APPLY PRINT-CONTROL clause, or is referenced in a WRITE statement with the ADVANCING clause specified, and the file is not going directly to a printing device (is going to be spooled), the software designates the file as a print-controlled file. Print-controlled files contain form advancing information with each record. Explicit forms control bytes are placed directly into the file. Therefore, any COBOL program trying to process a print-controlled file may have unpredictable results.

6.1.5 Record Blocking

The manner in which the file system blocks the records of sequential files depends on the device to which the file is assigned and the presence and format of the BLOCK CONTAINS clause.

COBOL programs can assign sequential files to disk which requires fixed-length virtual blocks, and to magnetic tape, which allows variable-length blocks.

The BLOCK CONTAINS clause of a COBOL program refers to a logical block size. For magnetic tape, the logical block size and virtual block size are the same. For disk, however, the logical block size is equal to one or more virtual blocks. (A virtual block on disk is 512 bytes).

For files assigned to disk, the OTS packs records together (end-to-end) until a logical block is filled. The logical block is written to disk, and any portion of the previously processed record that did not fit into the logical block is put into the next logical block. This process is called record spanning because it allows records to span virtual block boundaries.

Record spanning is prohibited for files assigned to magnetic tape. For these files, only complete records (fixed or variable length) are placed end-to-end in a logical block. The OTS writes the logical block out to the file when it determines that the block is full to the extent that the next record will not fit into it.

There are three ways to specify block size in a COBOL program; by default; by using the BLOCK CONTAINS integer RECORDS clause; or by using the BLOCK CONTAINS integer CHARACTERS clause. The default philosophy is to make the logical block size as small as possible; thus minimizing the memory buffer space required. By using the BLOCK CONTAINS (integer RECORDS or integer CHARACTERS) clause, you can increase the memory buffer space required. Increasing the buffer space, allows for faster I/O by decreasing the number of I/O operations required to process a file. Use the BLOCK CONTAINS clause only if you can afford the price of additional memory buffer space for the ability to process your files faster. The following paragraphs further define the three blocking methods:

Default

By default, the logical block size is made equal to the record size (add four bytes for variable length records on magnetic tape or two bytes for variable length records on disk). For disk files, the logical block size is rounded up to the next even multiple of 512 bytes to make the logical block size an integral number of virtual blocks. For example:

If the maximum record size for a disk file is 510 bytes, and the file contains variable length records, then the logical block size is 1024 bytes. (510 plus 4 for variable length records is 514, and 514 rounded up to the next even multiple of 512 is 1024.)

BLOCK CONTAINS integer RECORDS

If this clause is used, the logical block size is equal to the record size (plus four bytes for variable length records on magnetic tape or two bytes for variable length records on disk) times the number of records per block. For disk files, the logical block size is rounded up to the next even multiple of 512 bytes to make the block size an integral number of virtual blocks. For example:

If the record size for a fixed-length disk file is 100 bytes and the clause BLOCK CONTAINS 10 RECORDS is specified, the logical block size is 1024 bytes. (100 times 10 is 1000, and 1000 rounded up to the next even multiple of 512 is 1024).

BLOCK CONTAINS integer CHARACTERS

If this clause is used, the logical block size is equal to the number of characters given in the clause. If the specified number of characters is less than the actual record size (plus four bytes for variable-length records on magnetic tape or two bytes for variable length records on disk) the compiler generates a block size that is equal to the actual record size. For disk files, the specified number of characters must equal an even multiple of 512. If the number you specify is not correct, the OTS will round the logical block size it finds to the next even multiple of 512 bytes.

When a program assigns a file to magnetic tape, all programs that access the file must describe it the same way that the creating program described it in order to guarantee an accurate allocation of buffers.

Note: The previous discussion has used the following format:

$$\left[\underline{\text{BLOCK}}\ \text{CONTAINS integer}\ \left\{\begin{matrix}\underline{\text{RECORDS}}\\ \text{CHARACTERS}\end{matrix}\right\}\right]$$

If the following format is used:

$$\left[\underline{\text{BLOCK}}\ \text{CONTAINS}\left[\text{integer-1}\ \underline{\text{TO}}\right]\text{integer-2}\ \left\{\begin{matrix}\underline{\text{RECORDS}}\\ \text{CHARACTERS}\end{matrix}\right\}\right]$$

the compiler ignores integer-1, and integer-2 is used as the integer.

6.1.6 Buffering

When the system performs an input operation, it reads a block from the medium into the buffer, and moves a record from the buffer to the current record area. Each subsequent read operation moves a record from the buffer to the current record area. When it has exhausted the buffer (has read an entire block), the system reads another block into the buffer.

When performing an output operation, each write operation moves a record from the file's current record area into the file's buffer. Each subsequent write operation moves a record from the current record area into the buffer. The system writes the block to the medium when it has filled the buffer.

The following subsections discuss the size of the buffers, the number of buffers, and the sharing of buffers.

6.1.6.1 **Buffer Size -** Buffer size depends on the size of the largest record in the file and on the blocking factor. For files with sequential organization, the buffer size will be at least 512 bytes.

6.1.6.2 **I-O Buffer Areas -** The RESERVE clause in the Environment Division specifies the number of I-O buffer areas to be allocated for each file. Each I-O area represents the space for one logical block. A minimum of one and a maximum of two are permitted for sequential files. One is the default. Since two I-O areas do not increase the speed of access and take additional memory space, it is recommended that this clause not be used.

6.1.6.3 **Buffer Space -** To calculate the total amount of buffer space required for each sequential file, the following algorithm may be used:

```
Buffer space = record size + (logical blocksize * no. of areas)
   + 234
```

In addition there are 76 bytes of buffer space that are shared among all files.

6.1.6.4 **Sharing Buffer Space Among Files -** The SAME AREA clause provides a simple method of sharing buffer space among several files. Two or more files may share the same buffers if the SAME AREA clause contains their file-names and only one of them is open at any time during program execution. Further, since only one file is open at a time, the files will also share the same current record area. The size of the current record area is set to the size of the largest record description specified in the group.

If only one of these files is open at a time, the following sample statement causes them all to share the same buffer and current record area.

```
I/O-CONTROL.

    SAME AREA FOR FILEA FILEB FILEC.

    ...
```

6.1.7 Sequential I/O Statements

TRAX COBOL provides the following I/O statements for sequential files:

- CLOSE
- OPEN
- READ
- REWRITE
- WRITE

Before a COBOL program can access a file, it must open the file; then, when the program is finished with the file, it must close the file.

A COBOL program may open a sequential file in one of four modes, INPUT, OUTPUT, I-O (input/output), or EXTEND. In INPUT mode, records may be read from the file; in OUTPUT mode the file is created and records can only be written to it; in I-O mode, records can be read from the file and updated; in EXTEND mode, records may be added onto the end of the file. Table 6-3 shows which statements apply to the four different OPEN modes of sequential files. (The table does not include the OPEN and CLOSE statements since they apply to all modes.)

Table 6-3
Sequential OPEN Modes

Statement	Open Mode			
	Input	Output	Input-Output	Extend
READ	X		X	
REWRITE			X	
WRITE		X		X

6.1.7.1 **Opening Sequential Files** - The OPEN statement makes a file available for processing by a COBOL program. A program must execute an OPEN statement for a file before it executes any other I/O statement for that file. Consider the following sample OPEN statement. It opens the file named THOREAU for input/output. The program containing this statement could, after executing it, READ, REWRITE, and CLOSE THOREAU.

```
ENVIRONMENT DIVISION.
INPUT-OUTPUT SECTION.
FILE-CONTROL.
    SELECT THOREAU
    ASSIGN TO "DK1:".
.
.
.
DATA DIVISION.
FILE SECTION.
FD  THOREAU
.
.
.
PROCEDURE DIVISION.
.
.
.
    OPEN I-O THOREAU.
.
.
.
```

The OPEN statement must refer to the file by the file-name appearing in both the SELECT clause in the Environment Division and the FD paragraph in the Data Division.

When the OTS executes an OPEN statement, it performs the following actions for the file named in the statement:

- If the file is already open, the OTS generates an error message and performs the USE procedure section (if specified). (Section 6.9 discusses USE procedures and Section 12.3 discusses error messages.)

- When opening an existing file, the attributes (i.e., record length, block size, etc.) of the file are used for accessing the file. Those specified in the program are ignored. Be sure that the attributes specified in the COBOL program agree with the actual attributes of the file.

- If the SELECT clause of the File-Control paragraph declares the file OPTIONAL, the OTS displays the following message:

  "FILE nnn ... OPTIONAL FILE MOUNTED? Y OR N?"

  (nnn represents the file-name.)

  If the file is available for processing, type a Y. If not, type an N. If the file is not available (N), the OTS disables all I/O processing on the file except READ and CLOSE; a later READ statement causes program control to take the AT END imperative path.

- If a SAME AREA clause contains the name of the file and none of the other files named in the clause is open, the OTS allocates buffer space for the file.

- When the file has passed all of the preceding checks and is ready for opening, the OTS instructs the Record Management Services to open the file. If the Record Management Services fails to open the file, the OTS reports an error condition and performs any applicable USE procedure (if present).

- If the program is creating the file (OPEN OUTPUT) and the file description specifies LINAGE or APPLY PRINT-CONTROL, the OTS initializes the LINAGE counters.

- Finally, depending on which statements apply to the open mode, the OTS enables or disables all of the program's I/O statements that refer to the file (see Table 6-3). For example, if the OPEN mode is INPUT, it enables all READ statements for that file and disables all REWRITE and WRITE statements for that file.

Since the EXTEND mode simply allows the WRITE statement to add records onto the end of the file, files opened in this mode must already exist on disk or tape (only the last file on magnetic tape can be extended). If the file does not exist, the OPEN statement fails and the OTS issues an error message.

6.1.7.2 **Reading Sequential Files** - The READ statement makes the next logical record of an open sequential file available to the program. If the preceding I/O operation was an OPEN, it makes the first record of the file available to the program.

Consider the following example. If the last I/O operation on the file named THOREAU was an OPEN, this statement would provide the program with the first record in the file THOREAU. Every time the statement is executed, it provides the program with the next sequential record in THOREAU. Program control transfers to the paragraph named LIBRARY when an end-of-file mark is encountered during the READ.

```
BEGIN.  OPEN THOREAU.
LOOP.   READ THOREAU AT END GO TO LIBRARY.
.
.
.
        GO TO LOOP.
```

If the file contains variable-length records, the program must determine the length of the record just read. No such information is supplied to the user program.

If the file is open in the I-O mode, the successful execution of a READ statement enables any following REWRITE of the record just read. (For further information on the REWRITE statement, see the next subsection -- 6.1.7.3.)

If the file has more than one record description, the records automatically share the same current record area. The OTS does not clear this area before it executes the READ statement (no blank filling, etc.). Therefore, if the record read by the latest READ statement does not fill the entire current record area, the area not overlaid by the incoming record remains unchanged. For example, if the file's record area contains ten 3's, and a READ operation moves in a 6-character record containing all 1's, the current record area then contains six 1's followed by four 3's. Consider the following example:

Current Record Area with all 3's	3333333333
Next Record in the File	111111
Current Record Area after READ	1111113333

6.1.7.3 **Rewriting Records into Sequential Files** - The REWRITE statement places the record just read from an input-output file back into its file on disk or magnetic tape. (The WRITE statement cannot access I-O files.) The following sample statement writes the record, REC1, back into its file. (REC1, of course, must be a record in the file read by the preceding READ for that file.)

```
REWRITE REC1
```

Before the REWRITE statement can refer to a record, the program containing the statement must meet the following conditions:

- The file containing the record must be open in the I-O mode;
- The last I/O operation on the file containing the record must have been a successful READ;
- The record length of the record to be rewritten must be the same as the record last read from the file.

6.1.7.4 **Writing Sequential Files** - The WRITE statement releases a logical record to an output file, thereby creating an entirely new record in the file.

The following sample WRITE statement releases the record PRINT-LINE to the device assigned to that record's file, then skips three lines. When it reaches the end of a page (as specified by the LINAGE clause), it causes program control to transfer to the subroutine, HEADER-RTN.

```
WRITE PRINT-LINE BEFORE ADVANCING 3 LINES

    AT EOP GO TO HEADER-RTN.
```

Note that this produces two blank lines following every line printed.

The WRITE statement releases records to files that are open in either the output or extend mode. The following text discusses the two modes separately.

- OUTPUT Mode - The WRITE statement can create the following two kinds of files in the OUTPUT mode:

1. Print-files - A print-file produces a listing on a printing device. The LINAGE clause, the APPLY PRINT-CONTROL clause, or a WRITE statement with the ADVANCING option included, designates a file as a print-file. One or more records containing carriage-control characters are written to perform line spacing. The WRITE statement does not have to release print-files directly to a printing device, but may also release them to a storage medium such as disk for printing at a later time.

2. Storage files - A storage file remains on disk or tape for future reference. All files that are not print-files are storage files. A sample storage file WRITE statement follows; this statement writes a record named WALDEN into a file:

```
WRITE WALDEN
```

- EXTEND Mode - A WRITE to a storage file opened in the EXTEND mode simply adds new records logically in sequence after the last record in the file. As the statement extends the file, the Record Management Services automatically handles requests for additional storage space. (Print-files on disk should only be opened for EXTEND if they are being opened as a print-file.)

6.1.7.5 **Closing Sequential Files** - The CLOSE statement terminates processing on the file referred to in the statement. The following sample CLOSE statement terminates processing on the file named THOREAU:

```
CLOSE THOREAU
```

When the CLOSE statement closes a file, no other I/O operation can access that file until another OPEN statement opens the file.

If the statement specifies the LOCK option, the program cannot open the file again in this run. The CLOSE statement with the LOCK clause is shown below:

```
CLOSE THOREAU WITH LOCK
```

The lock option has no effect on the physical device containing the file.

If a SAME AREA clause contains the name of the file just closed, the program may open one of the other files named in the clause.

6.2 RELATIVE FILE ORGANIZATION

Relative file organization arranges the records of the file into numbered record positions. It assigns each record position a number that identifies that position relative to the beginning of the file (the first record position in the file has record number 1, the second has record number 2, etc.).

1	2	3	4	5	6	7	8	9	10 ...

Record Positions in a Relative File

When a program executes a random DELETE, REWRITE, READ or WRITE operation on a relative file, the value in the relative key is used to select records from these numbered record positions in the same way that a subscript selects an item in a table.

Thus, while sequential and relative files both arrange their record positions in a serial order, COBOL statements can address the record positions of a relative file by their position numbers, and successive accesses do not have to proceed through the file in a prescribed, serial, order.

Another significant feature of relative file organization is that each record position does not have to contain a valid record. Although each position actually occupies one record space, a byte preceding the record on the storage medium indicates whether or not that space contains a valid record. Thus, a file may have fewer records than it has record positions, and the indicated empty record positions may be anywhere in the file.

The numerical order of the record positions remains the same during all operations on a relative file; however, the accessing statements can move a record from one position to another, delete a record from a position, or insert new records into empty positions.

6.2.1 Record Size

A relative file may contain either fixed-length or variable-length records. (Fixed-length records have one or more record descriptions that describe the same size record. Variable-length records have more than one record description that describe several different sized records.) However, the COBOL compiler allocates a record area on the I/O device, equal to the largest record described plus one. This extra byte is an existence byte. It indicates whether the record area contains a valid record. For variable length records in a relative file, the software adds a two byte count field. On a write operation the actual record is written out to the I/O device not the maximum length record. The length of this record is placed in the two byte count field. On a read operation this two byte count field is used to determine the length of the record to be read in.

6.2.2 RECORD CONTAINS Clause

The RECORD CONTAINS clause, when specified without the "integer-1 TO" option, is for documentation purposes only. The compiler determines record size from the data descriptions. When the "integer-1 TO" option is specified, it forces the compiler to generate a variable length record file, even if the data descriptions describe fixed length records.

Conversely, if the data descriptions for a sequential file describe variable-length records, the software sets up variable sized records automatically and ignores this clause.

Even though the software ignores the values in the "integer-1 TO..." phrase, the clause may be used in any program to document record sizes.

6.2.3 SAME RECORD AREA Clause

The SAME RECORD AREA clause is identical for all file organizations. See Section 6.1.3.

6.2.4 Record Blocking

The size of a file is expressed as an integral number of virtual blocks. Virtual blocks are physical storage structures. That is, each virtual block within a file is a unit of data whose size depends on the physical medium on which the file resides.

Relative files may reside only on disk. The size of virtual blocks within files on disk devices is always 512 bytes.

Relative files use a logical storage structure known as a logical block or bucket. A bucket consists of from 1 to 32 virtual blocks.

This distinction should be made clear. A virtual block is a physical entity which is fixed in size and cannot be changed. A bucket, however, is a logical entity. Its size is directly under your control. Records may span virtual block boundaries. They may never span bucket boundaries.

Increasing the bucket size increases the speed of sequential processing of a file because fewer I/O operations are needed to access the smaller number of buckets in the file. On the other hand, a larger bucket size means that more memory space is taken up by the I/O buffers. Increasing the bucket size may not increase the speed of random processing of a relative file.

There are three ways that the bucket size may be specified in a COBOL program; by default, by using the construct BLOCK CONTAINS integer RECORDS, or by using the construct BLOCK CONTAINS integer CHARACTERS.

The default is to make the bucket size as small as possible, to minimize the memory buffer space required. By using the BLOCK CONTAINS integer (RECORDS of integer CHARACTERS) clause, you can increase the memory buffer space required. Increasing the buffer space allows for faster I/O by decreasing the number of operations required to access a file. The following paragraphs further define the three blocking methods:

Default

The default philosophy is to make the bucket size as small as possible to minimize the memory buffer space required. The algorithms for calculating the bucket size follow:

```
Bnum= ((1+Rlen)/512)+1  Fixed length record

Bnum= ((3+Rmax)/512)+1  Variable length record
```

Where:

Bnum — is the number of virtual blocks per bucket, ranging from 1 to 9.

Rlen — is the fixed record length (in bytes).

Rmax — is the maximum record length (in bytes) if the record length is variable.

The number 1 is for the existence byte. The number 3 is for the existence byte plus 2 bytes for the record length.

Table 6-4 gives the bucket size for possible record lengths.

Table 6-4
Bucket Sizes for Possible Record Lengths

Bnum	Rlen	Rmax
1	1-511	1-509
2	512-1023	510-1021
3	1024-1535	1022-1533
4	1536-2047	1534-2045
5	2048-2559	2046-2557
6	2560-3071	2558-3069
7	3072-3583	3070-3581
8	3584-4095	3582-4093
9		4094-4095

BLOCK CONTAINS Rnum RECORDS

If the BLOCK CONTAINS Rnum RECORDS clause is used, where Rnum is an integer, then the following algorithms are used to calculate the bucket size.

```
Bnum= (((Rlen+1)*Rnum)/512)+1  Fixed length record

     or

Bnum= (((Rmax+3)*Rnum)/512)+1  Variable length record
```

Where:

Bnum — is the number of virtual blocks per bucket, ranging from 1 to 32.

Rlen — is the fixed record length (in bytes).

Rmax — is the maximum record length (in bytes) if the record length is variable.

Rnum — is the number of records per bucket as given in the BLOCK CONTAINS clause.

BLOCK CONTAINS Cnum CHARACTERS

If the BLOCK CONTAINS Cnum CHARACTERS clause is used, where Cnum is an integer, then Cnum is subject to the following constraints.

(1) Cnum Rlen+1 for fixed length records

or

Cnum Rmax+3 for variable length records

(2) Cnum mod 512 = 0

Based on CNUM, the bucket size is calculated as follows:

Bnum=Cnum/512

where:

Cnum is the number of characters per bucket as given in the BLOCK CONTAINS clause.

Rlen is the fixed record length (in bytes).

Rmax is the maximum record length (in bytes) if the record length is variable.

Bnum is the number of virtual blocks per bucket, ranging from 1 to 32.

Violation of constraint (1) causes a warning error and the default method is used to calculate the bucket size. Constraint (2) means that Cnum should be a multiple of 512. If not, a warning error is given and Cnum is increased to the next even multiple of 512.

The bucket size must be the same when the file is created and each time the file is accessed. Therefore, the BLOCK CONTAINS clause must never change for a particular file.

Note: The previous discussion has used the following format:

```
[ BLOCK CONTAINS integer { RECORDS    } ]
                         { CHARACTERS }
```

If the following format is used:

```
[ BLOCK CONTAINS [integer-1 TO] integer-2 { RECORDS    } ]
                                          { CHARACTERS }
```

the compiler ignores integer-1, and integer-2 is used as the integer.

6.2.5 Buffering

When the system performs a sequential or random input operation, it reads a bucket from the medium into the buffer, and moves a record from the buffer to the current record area. Any subsequent sequential read operations move a record from the buffer to the current record area. When it has exhausted the buffer (has read an entire bucket), the system reads another bucket into the buffer.

When performing a random read operation, the appropriate bucket is read into a file's buffer. The record is then moved from the buffer to the current record area.

When performing a sequential output operation, each write operation moves a record from the file's current record area into the file's buffer. Each subsequent sequential write operation moves a record from the current record area into the buffer. The system writes the bucket to the medium when it has filled the buffer.

When performing a random output operation, the appropriate bucket is read and the record is moved from the file's current record area into the appropriate position in the file's buffer. The system writes the bucket back out to the medium before reading any additional blocks.

The following subsections discuss the size of the buffers, the number of buffers, and the sharing of buffers.

6.2.5.1 **Buffer Size -** Buffer size depends on the size of the largest record in the file and on the blocking factor. For relative files, buffer size must be some multiple of 256 words (512 bytes).

6.2.5.2 **I/O Buffer Areas -** The RESERVE clause in the Environment Division specifies the number of I/O buffer areas to be allocated for each file where an area represents the space for one bucket. A minimum of one and a maximum of two I/O areas are permitted for relative files. One is the default. It is recommended that this clause not be used, because two I/O areas do not increase the speed of access and take up additional space.

6.2.5.3 **Buffer Space -** To calculate the total amount of buffer space in bytes required for each Relative file, the following algorithm may be used:

Buffer space = record size + bucket size + 266

In addition, there are 76 bytes of buffer space that are shared among all files.

6.2.5.4 **Sharing Buffer Space Among Files -** The SAME AREA clause provides a simple method of sharing buffer space among several files. This clause is identical for all file organizations. See Section 6.1.6.4.

6.2.6 Relative I/O Statements

The COBOL I/O statements, CLOSE, DELETE, OPEN, READ, WRITE, REWRITE, and START can refer to relative files.

A COBOL program may open a relative file in one of three modes, INPUT, OUTPUT, or I-O, and access an open relative file in one of three ways, sequentially, randomly, or dynamically. In INPUT mode, records may be read from the file; in OUTPUT mode, the file is created and records may be written to the file; in I-O mode, records may be read from the file, updated on the file, deleted from the file, or written to the file. The following table shows which statements and access methods apply to the three different OPEN modes of relative files.

Table 6-5
Relative OPEN Modes

FILE ACCESS MODE	STATEMENT	OPEN MODE		
		INPUT	OUTPUT	I-O
Sequential	DELETE			X
	READ	X		X
	REWRITE			X
	START	X		X
	WRITE		X	
Random	DELETE			X
	READ	X		X
	REWRITE			X
	START			
	WRITE		X	X
Dynamic	DELETE			X
	READ	X		X
	READ NEXT	X		X
	REWRITE			X
	START	X		X
	WRITE		X	X

NOTE

The term, current record pointer, used in the following sections, refers to a location in the operating system used to determine the record number of the next available record in a file.

6.2.6.1 **Access Modes** - The ACCESS MODE clause in the File-Control paragraph dictates which of the three access modes may be used on that file.

When the ACCESS MODE clause specifies SEQUENTIAL, the I/O statements must refer to the records in the file sequentially, starting (after opening) with the first record and stepping through with each reference to the end of the file. The I/O statements ignore record positions that do not contain valid records.

When the ACCESS MODE clause specifies RANDOM, the I/O statements refer to the records in the file by record position. Thus, the statements may refer to record positions that do not contain valid records. The program must specify the desired record position number by placing a value in the file's relative key. If an I/O statement refers to a record position with the relative key, and that record position does not exist (either because the position does not contain a record or because it is beyond the end of the file), the INVALID KEY imperative statement may be executed depending on the particular I/O statement used. (The INVALID KEY imperative statement is explained with each of the relative I/O statements in this section.)

When the ACCESS MODE clause specifies DYNAMIC, the I/O statements may refer to the records in the file either sequentially or randomly. The OTS determines which access method to use from the OPEN mode (INPUT, OUTPUT, or I-O) and the form of the I/O statement. For example, if the statement READ ...INVALID KEY is to access an open input file dynamically, the OTS uses the relative key for random access; if the statement READ NEXT ... is to access an open input file dynamically, the OTS sequentially accesses the next existing record.

The following sections (6.2.5.2 through 6.2.5.8) on using the I/O statements themselves contain additional information about access modes.

6.2.6.2 **Opening Relative Files -** The OPEN statement for a relative file makes an INPUT, OUTPUT, or I-O mode file available so the COBOL program can access the records in the file sequentially, randomly, or dynamically.

The OPEN statement sets the current record pointer for the file to zero.

For example, the following sample OPEN statement opens the file named ARTICHOKE for input, and sets ARTICHOKE's current record pointer to zero. The program containing this statement could, after executing the statement, access ARTICHOKE with READ and START statements in the sequential access mode, READ statements in the random access mode, or READ, READ NEXT, and START statements in the dynamic access mode.

```
OPEN INPUT ARTICHOKE.
```

When the OTS executes an OPEN statement, it performs the following actions for the file named in the statement:

- If the file is already open, the OTS generates an error message and performs the USE procedure section (if specified). (Section 6.9 discusses USE procedures and Section 12.3 discusses error messages.)

- When opening an existing file, the attributes (i.e., record length, block size, etc.) of the file are used for accessing the file. Those specified in the program are ignored. Be sure that the attributes specified in the COBOL program agree with the actual attributes of the file.

- If a SAME AREA clause contains the name of the file and none of the other files named in the clause is open, the OTS allocates buffers space for the file.

- When the file has passed all of the preceding checks and is ready for opening, the OTS instructs the Record Management Services to open the file. If the Record Management Services fails to open the file, the OTS reports an error condition and performs any applicable USE procedure (if present).

- Finally, depending on which statements apply to the open mode, the OTS enables or disables all of the program's I/O statements that refer to the file (see Table 6-5). For example, if the OPEN mode is INPUT, it enables all READ and START statements for that file and disables all REWRITE, DELETE and WRITE statements for that file.

If the file is being accessed randomly or dynamically, the program must maintain a correct value in the relative key. If the file is being accessed sequentially, the OTS ignores the value of the relative key, but updates it to contain the position number of the record being accessed.

6.2.6.3 **Reading Relative Files -** When applied to a file being accessed sequentially, the READ statement makes the next logical record of an open file available to the program.

When applied to a file being accessed randomly, the READ statement selects a specified record from an open file and makes it available to the program. The value of the relative key for the file identifies the specific record.

When applied to a file being accessed dynamically, the READ statement has two formats so that it can either select the next logical record (sequentially) or select a specified record (randomly) and make it available to the program. The READ NEXT statement takes the number in the current record pointer and finds the next present record. The following sample READ statement reads the file named ARTICHOKE sequentially and, when it exhausts the file, causes program control to transfer to the subroutine named FILEOUT:

```
READ ARTICHOKE NEXT RECORD
     AT END GO TO FILEOUT.
```

For further information concerning the mechanics of the READ NEXT statement, see Section 6.2.5.7, Specifying the Next Record to be Read.

The READ with key takes the value in the relative key, moves it to the current record pointer, and reads the record being pointed to. The following READ (with key) statement reads the file named ARTICHOKE randomly, selecting records through the value in the file's relative key. If the relative key supplies a value that does not contain a valid record, the statement causes program control to transfer to the subroutine named NO-REC.

```
READ ARTICHOKE RECORD
     INVALID KEY GO TO NO-REC.
```

If the file has more than one record description, the records automatically share the same current record area. The OTS does not clear this area before it executes the READ statement (no blank filling, etc.). Therefore, if the record read by the latest READ statement does not fill the entire current record area, the area not overlaid by the incoming record remains unchanged. For example, if the file's record area contains ten 3's, and a READ operation moves in a 6-character record containing all 1's, the current record area then contains six 1's followed by four 3's. Consider the following example:

Current Record Area with all 3's	3333333333
Next Record in the File	111111
Current record Area after READ	1111113333

6.2.6.4 **Rewriting Records into a Relative File -** The REWRITE statement places a record back into its file on disk or magnetic tape. The following sample statement writes the record, BREAKERS, back into its file.

```
REWRITE BREAKERS.
```

If the file is open in the sequential access mode, the statement rewrites the record just successfully read. If the file is open in either the random or dynamic access mode, the statement rewrites the record to the record position specified by the relative key.

6.2.6.5 **Writing Records in a Relative File -** The WRITE statement releases a logical record to a file. The following sample WRITE statement releases the record BREAKERS to the device assigned to that record's file. If the record already exists, program control transfers to the subroutine, WRITE-ERR.

```
WRITE BREAKERS
     INVALID KEY GO TO WRITE-ERR.
```

The WRITE statement releases records to files that are open in either the OUTPUT or I/O mode. The following text discusses the two modes separately:

- OUTPUT Mode - The WRITE statement's only function with output files is to place entirely new records into the file. If more space is required for new record positions, the Record Management Services automatically extends the file size, regardless of the access mode being employed.

- I/O Mode - The statement's function with input-output files is to place records in record positions that already exist and are empty. The length of the records must not exceed the maximum length record specified for the file when it was created.

The relative WRITE statement creates only storage files since print-files are sequential files. The following SAMPLE statement writes a record named BREAKERS into its file:

```
WRITE BREAKERS.
```

6.2.6.6 **Deleting Records from a Relative File -** The DELETE statement logically removes an existing record from a relative file. After a DELETE statement has successfully removed a record from a file, that record can no longer be accessed.

If the file is open in the sequential access mode, the statement removes the record just successfully read. For example, the following sample statement removes the record just read from the file named ARTICHOKE:

```
DELETE ARTICHOKE RECORD.
```

If the file is open in either the random or dynamic access mode, the statement removes the record from the record position specified by the relative key. For example, the following sample statement deletes the record specified by the relative key from the file named ARTICHOKE; if the relative key supplies a value that does not contain a valid record, the statement transfers control to the subroutine named NO-REC.

```
DELETE ARTICHOKE RECORD
     INVALID KEY GO TO NO-REC.
```

6.2.6.7 **Specifying the Next Record to be Read -** The START statement specifies which record in a file will be the next one to be referenced sequentially.

A READ NEXT statement should follow the START statement since the READ NEXT statement reads the next record from the one being pointed to by the current record pointer.

If the data area, SOMETHING, in the following example contains a 30 and position 33 in the file contains the next present record, the START statement sets the current record pointer to one less than 33 (32). The READ NEXT statement would then find the next present record, which we know is 33.

```
WORKING-STORAGE SECTION.
77 SOMETHING PIC S99 VALUE 30.
77 ARTKEY PIC 99.
.
.
.
RD-SET.    MOVE SOMETHING TO ARTKEY.
           START ARTICHOKE
                 KEY IS GREATER THAN ARTKEY
                 INVALID KEY GO TO NEWKEY.

IN1.       READ ARTICHOKE NEXT RECORD
                 AT END GO TO FILEOUT.
```

The value of the RELATIVE KEY data item specified in the statement (ARTKEY in the preceding example) together with the conditional phrase specified in the statement (IS GREATER THAN in the preceding example) determines which record in the file will be accessed by the READ NEXT statement.

The START statement uses the value in the RELATIVE KEY data item to set the current record pointer. If record positions 30 and 33 contain valid records and ARTKEY contains 30, the START statement would set the current record pointer and RELATIVE KEY data item as follows:

1. If the conditional phrase specifies KEY IS GREATER THAN ARTKEY, the statement sets the current record pointer to 32.

2. If the conditional phrase specifies KEY IS EQUAL TO ARTKEY or NOT LESS THAN ARTKEY, the statement sets the current record pointer to 29.

The READ NEXT statement takes the number in the current record pointer and finds the next present record from that number. (If the pointer contains a 30 and the next present record is in position 33, it finds record number 33). The READ NEXT statement gets that record and places its record position number (33) into the current record pointer and the relative key.

A subsequent READ NEXT takes the number in the current record pointer, which is now 33 in our example, and finds the next present record. It fetches that record and places its record position number in the current record pointer and relative key.

6.2.6.8 **Closing Relative Files -** The CLOSE statement terminates processing on the file referred to in the statement. The following sample CLOSE statement terminates processing on the file named ARTICHOKE:

```
CLOSE ARTICHOKE.
```

When the statement closes a file, no other I/O operation can access that file until another OPEN statement opens the file.

If the statement specifies the LOCK option, the program cannot open the file again in that run.

If a SAME AREA clause contains the name of the file just closed, the program may open one of the other files named in the clause.

6.3 INDEXED FILE ORGANIZATION

Unlike the physical ordering of records in a sequential file or the relative positioning of records in a relative file, the location of records in the indexed file organization is transparent to your program. The presence of keys in the records of the file governs the placement of records in an indexed file.

A key is a character string present in every record of an indexed file. The location and length of this character string is identical in all records. When creating an indexed file, you decide which character string in the file's records is to be a key. By selecting such a character string, the contents (i.e., key value) of that string in any particular record written to the file can be used by a program to identify that record for subsequent retrieval.

You must define at least one key for an indexed file. This mandatory key is the primary key of the file. Optionally, you can define up to 255 additional keys (i.e., alternate keys). Each alternate key represents an additional character string in records of the file. The key value in any one of these additional strings can also be used as a means of identifying the record for retrieval.

As programs write records into an indexed file, the values contained in the primary and alternate keys are used to locate the record in the file. From the values in keys within records a tree-structured table known as an index is built. An index consists of a series of entries. Each entry contains a key value copied from a record that a program wrote into the file. With each key value is a pointer to the location in the file of the record from which the value was copied. A separate index is built and maintained for each key you define for the file. Each index is stored in the file. Thus, every indexed file contains

at least one index, the primary key index. When you define alternate keys, an additional index is built and maintained for each alternate key. Figure 6-3 shows the general structure of an indexed file that has been defined with only a single key. Figure 6-4 depicts an indexed file defined with two keys, a primary key and one alternate key.

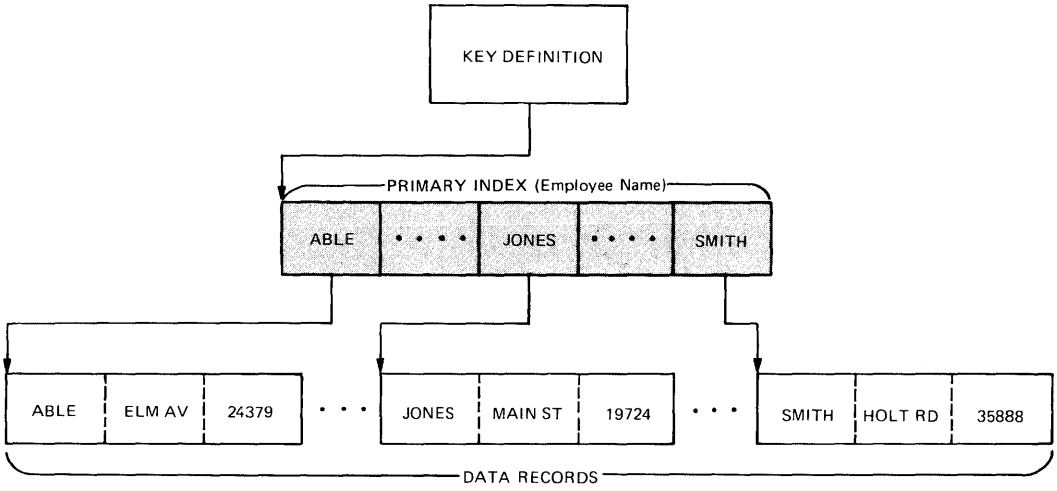


Figure 6-3 Single Key Indexed File Organization

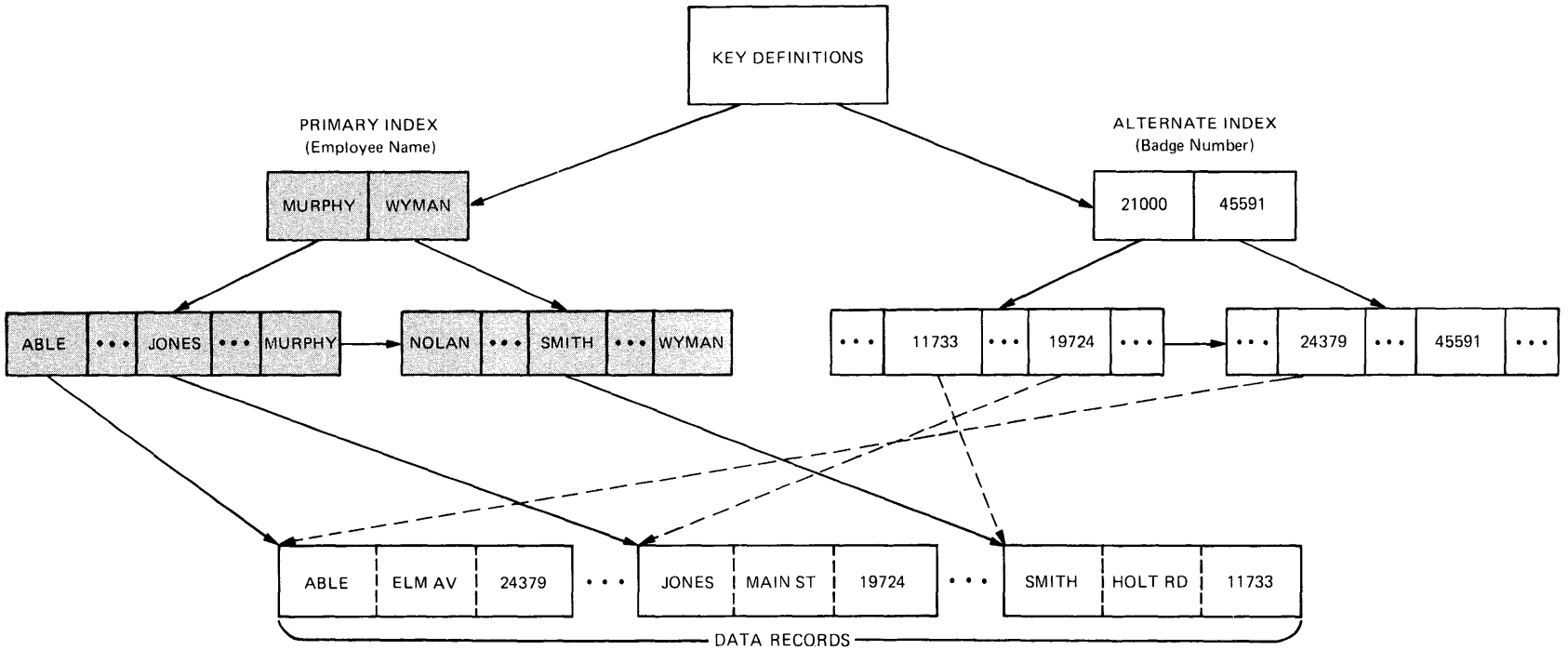


Figure 6-4 Multi-key Indexed File Organization

6.3.1 Record Size

A relative file may contain either fixed-length or variable-length records. (Fixed-length records have one or more record descriptions that describe the same size record. Variable-length records have more than one record description that describe several different sized records.) For variable length records in an indexed file, the software adds a two byte count field. On a write operation the actual record is written out to the I/O device not the maximum length record. The length of this record is placed in the two byte count field. On a read operation this two byte count field is used to determine the length of the record to be read in.

6.3.2 RECORD CONTAINS Clause

The RECORD CONTAINS clause, when specified without the "integer-1 TO" option, is for documentation purposes only. The compiler determines record size from the data descriptions. When the "integer-1 TO" option is specified, it forces the compiler to generate a variable length record file, even if the data descriptions describe fixed length records.

Conversely, if the data descriptions for a sequential file describe variable-length records, the software sets up variable sized records automatically and ignores this clause.

Even though the software ignores the values in the "integer-1 TO..." phrase, the clause may be used in any program to document record sizes.

6.3.3 SAME RECORD AREA Clause

The SAME RECORD AREA clause is identical for all file organizations. See Section 6.1.3.

6.3.4 Record Blocking

The size of a file is expressed as an integral number of virtual blocks. Virtual blocks are physical storage structures. That is, each virtual block within a file is a unit of data whose size depends on the physical medium on which the file resides.

Indexed files may reside only on disk. The size of virtual blocks within files on disk devices is always 512 bytes.

Indexed files, like relative files, use a logical storage structure known as a logical block or bucket. A bucket consists of 1 to 32 virtual blocks. The user may specify the number of virtual blocks contained within each bucket by using the BLOCK CONTAINS clause. This distinction should be made clear. A virtual block is a physical entity which is fixed in size and cannot be changed by the user. A bucket is a logical entity and its size is directly under user control. Records may span virtual block boundaries. They may never span bucket boundaries.

Increasing the bucket size increases the speed of processing of a file because fewer I/O operations are needed to access the smaller number of buckets in the file. On the other hand, a larger bucket size means that more memory space is taken up by the I/O buffers.

There are three ways that the bucket size may be specified by the user in a COBOL program: by default, by using the construct BLOCK CONTAINS integer RECORDS, or by using the construct BLOCK CONTAINS integer CHARACTERS.

The default is to make the bucket size as small as possible to minimize the memory buffer space required. By using the BLOCK CONTAINS (integer RECORD or integer CHARACTERS) clause, you can increase the memory buffer space required. Increasing the buffer space allows faster I/O by decreasing the number of operations to process a file. The following paragraphs further define the three blocking methods:

Default

The default philosophy is to make the bucket size as small as possible to minimize the memory buffer space required. The algorithms for calculating the bucket size follow:

Bnum= ((22+Rlen)/512)+1 Fixed length record

or

Bnum= ((24+Rmax)/512)+1 Variable length record

where:

Bnum is the number of virtual blocks per bucket, ranging from 1 to 9.

Rlen is the fixed record length (in bytes).

Rmax is the maximum record length (in bytes) if the record length is variable.

The number 22 comes from a bucket overhead of 15 bytes and a fixed length record header of 7 bytes; 24 comes from a bucket overhead of 15 bytes and a variable length record header of 9 bytes.

Table 6-6 gives the bucket size for possible record lengths.

Table 6-6
Bucket Size for Possible Record Lengths

Bnum	Rlen	Rmax
1	1-490	1-488
2	490-1002	489-1000
3	1003-1514	1001-1512
4	1515-2026	1513-2024
5	2027-2538	2025-2536
6	2539-3050	2537-3048
7	3051-3562	3049-3560
8	3563-4074	3561-4072
9	4075-4095	4073-4095

BLOCK CONTAINS Rnum RECORDS

If the BLOCK CONTAINS num RECORDS clause is used, where num is an integer, then the following algorithms are used to calculate the bucket size.

```
Bnum= ((15+(Rlen+7)*Rnum)/512)+1   Fixed length record

          or

Bnum= ((15+(Rlen+9)*Rnum)/512)+1   Variable length record
```

where:

Bnum — is the number of virtual blocks per bucket, ranging from 1 to 32.

Rlen — is the fixed record length (in bytes).

Rmax — is the maximum record length (in bytes) if the record length is variable.

Rnum — is the number of records per bucket as given in the BLOCK CONTAINS clause.

The number 15 is bucket overhead, 7 is the fixed length record header and 9 is the variable length record header.

BLOCK CONTAINS Cnum CHARACTERS

If the BLOCK CONTAINS Cnum CHARACTERS clause is used, where Cnum is an integer, then Cnum is subject to the following constraints.

(1) Cnum $\leq$Rlen+1 for fixed length records

or

Cnum $\leq$Rmax+3 for variable length records

(2) Cnum mod 512=0

Based on Cnum, the bucket size is calculated as follows:

```
Bnum=Cnum/512
```

where:

Cnum — is the number of characters per bucket as given in the BLOCK CONTAINS clause.

Rlen — is the fixed record length (in bytes).

Rmax — is the maximum record length (in bytes) if the record length is variable.

Bnum — is the number of virtual blocks per bucket, ranging from 1 to 32.

Violation of constraint (1) causes a fatal error and the default method is used to calculate the bucket size. Constraint (2) means that Cnum should be a multiple of 512. If not, a warning error is given and Cnum is increased to the next even multiple of 512.

The bucket size must be the same when the file is created and each time the file is accessed. Therefore, the BLOCK CONTAINS clause must never change for a particular file.

Note: The previous discussion has used the following format:

```
[ BLOCK CONTAINS integer                    { RECORDS    } ]
                                            { CHARACTERS }
```

If the following format is used:

```
[ BLOCK CONTAINS [integer-1 TO] integer-2   { RECORDS    } ]
                                            { CHARACTERS }
```

the compiler ignores integer-1, and integer-2 is used as the integer.

6.3.5 Buffering

When the system performs a sequential or random input operation, one or more index buckets are read into the buffer area until the bucket containing the specified record is located. The bucket containing the record is then read into the buffer area. Any subsequent sequential read operations will use the current index buffer to locate and read subsequent records in the current or other record buckets. When it has exhausted the current index buffer (has read all the records identified in the bucket), the system reads the next index bucket into the buffer area.

When performing a sequential or random output operation, the system moves a record from the files current record area into the files buffer. Each subsequent write operation moves a record from the current record area into the buffer. The system writes the bucket to the medium when it has filled the buffer. Every output operation also causes the appropriate index bucket to be read into the buffer area, the indexes for each of the keys to be added to the appropriate buckets, and the buckets to be rewritten to the storage medium.

6.3.5.1 **Buffer Size** - Buffer size depends on the size of the largest record in the file and on the blocking factor. For indexed files, buffer size must be some multiple of 256 words (512 bytes).

6.3.5.2 **I/O Buffer Areas** - The RESERVE clause in the Environment Division specifies the number of I/O buffer areas to be allocated for each file. Each I/O area represents the space for one bucket. A minimum of two is required for an Indexed file (this is the default). Three areas will increase the speed of random access. Four areas will increase the speed of random access if the file is being accessed on two different keys. For each additional key, an additional area will increase the speed of access. Therefore, to speed up random access

time, the optimum number of buffer areas is equal to the number of keys by which the file is being accessed plus two. Of course, each area means that more memory space is being taken up.

6.3.5.3 **Buffer Space -** To calculate the total amount of buffer space required for each Indexed file, the following algorithm may be used:

```
Buffer Space = record size+((bucket size+20)*no.  of areas)

+(48*no.  of keys in file)+((MAXKSIZ*2+MAXNKEY+3)/4*4)

+272
```

where:

MAXKSIZ is the maximum key size in the program.

MAXNKEY is the maximum number of record keys for any file in the program.

Note that in the division, the result is truncated to the next lowest integer.

In addition to the above, there are 76 bytes of buffer space that are shared among all files and 44 times MAXNKEY bytes of buffer space that are shared among all indexed files.

6.3.5.4 **Sharing Buffer Space Among Files -** The SAME AREA clause provides a simple method of sharing buffer space among several files. This clause is identical for all file organizations and is described in Section 6.1.6.4.

6.3.6 Indexed I/O Statements

The COBOL I/O statements, CLOSE, DELETE, OPEN, READ, WRITE, REWRITE, and START can refer to indexed files.

A COBOL program may open an indexed file in one of three modes, INPUT, OUTPUT, or I-O, and access an open indexed file in one of three ways, sequentially, randomly, or dynamically. In INPUT mode, records may be read from the file; in OUTPUT mode, the file is created and records may be written to the file; in I-O mode, records may be read from the file, updated on the file, deleted from the file, or written to the file. The following table shows which statements and access methods apply to the three different OPEN modes of indexed files.

Table 6-7
Indexed OPEN Modes

File Access Mode	Statement	Open Mode		
		Input	Output	I-O
Sequential	DELETE			X
	READ	X		X
	REWRITE			X
	START	X		X
	WRITE		X	
Random	DELETE			X
	READ	X		X
	REWRITE			X
	START			
	WRITE		X	X
Dynamic	DELETE			X
	READ	X		X
	READ NEXT	X		X
	REWRITE			X
	START	X		X
	WRITE		X	X

NOTE

The term, current record pointer, used in the following sections, refers to a location in the operating system used to store the record number of available record in a file.

6.3.6.1 **Access Mode** - The ACCESS MODE clause in the File-Control paragraph indicates which of the three access modes may be used on that file. When the ACCESS MODE clause specifies SEQUENTIAL, the I/O statements must refer to the records in the file sequentially, starting (after opening) with the first record and stepping through with each reference to the end of the file.

When the ACCESS MODE clause specifies RANDOM, the I/O statements refer to the records in the file by the value of the key or keys. Usually the prime key is used unless a specific alternate key is designated. If an I/O statement refers to a record with a key, and that record does not exist, the INVALID KEY imparative statement may be executed depending on the particular I/O statement used. (The INVALID KEY imperative statement is explained with each of the indexed I/O statements in this section.)

When the ACCESS MODE clause specifies DYNAMIC, the I/O statements may refer to the records in the file either sequentially or randomly. The OTS determines which access method to use from the OPEN mode (INPUT, OUTPUT, or I-O) and the form of the I/O statement. For example, if the statement READ ...INVALID KEY is to access an open input file dynamically, the OTS uses the designated key for random access. If the statement READ NEXT ... is to access an open input file dynamically, the OTS sequentially accesses the next existing record.

The following sections (6.3.6.2 through 6.3.6.8) on using the I/O statements themselves contain additional information about access modes.

6.3.6.2 **Opening Indexed Files -** The OPEN statement for an indexed file makes an INPUT, OUTPUT, or I-O mode file available so the COBOL program can access the records in the file sequentially, randomly, or dynamically. Consider the following example:

Example

The following sample OPEN statement opens the file named ARTICHOKE for input, and sets ARTICHOKE's current record pointer to the first record in the file. The program containing this statement could, after executing the statement, access ARTICHOKE with READ and START statements in the sequential access mode, READ statements in the random access mode, or READ, READ NEXT, and START statements in the dynamic access mode.

```
OPEN INPUT ARTICHOKE.
```

When the OTS executes an OPEN statement, it performs the following actions for the file named in the statement:

- If the file is already open, the OTS generates an error message and performs the USE procedure section (if specified). (Section 6.9 discusses USE procedures and Section 12.3 discusses error messages.)

- When opening an existing file, the attributes (i.e., record length, block size, etc.) of the file are used for accessing the file. Those specified in the program are ignored. Be sure that the attributes specified in the COBOL program agree with the actual attributes of the file.

- If a SAME AREA clause contains the name of the file and none of the other files named in the clause is open, the OTS allocates buffer space for the file.

- When the file has passed all of the preceding checks and is ready for opening, the OTS instructs the Record Management Services to open the file. If the Record Management Services fails to open the file, the OTS reports an error condition and performs any applicable USE procedure (if present).

- Finally, depending on which statements apply to the open mode, the OTS enables or disables all of the program's I/O statements that refer to the file (see Table 6-7). For example, if the OPEN mode is INPUT, it enables all READ and START statements for that file and disables all REWRITE, DELETE and WRITE statements for that file.

The OPEN statement sets the current record pointer for the file to the first existing record in the file as established by the prime record key. If the file is being accessed randomly or dynamically, the program should maintain correct values in the prime and aternate key fields.

6.3.6.3 **Reading Indexed Files -** When applied to a file being accessed sequentially, the READ statement makes the next logical record of an open file available to the program. The information made available is based on positioning by the OPEN, START, or last READ operation.

When applied to a file being accessed randomly, the READ statement selects a specified record from an open file and makes it available to the program. The value of the specified key (prime key, if the no key is specified) identifies the record.

When applied to a file being accessed dynamically, the READ statement has two formats so that it can either select the next logical record (sequentially) or select a specified record (randomly) and make it available to the program. The READ NEXT statement takes the number in the current pointer and finds the next present record. The following sample READ statement reads the file named ARTICHOKE sequentially and, when it exhausts the file, causes program control to transfer to the subroutine named FILEOUT:

```
READ ARTICHOKE NEXT RECORD
     AT END GO TO FILEOUT.
```

For more information concerning the mechanics of the READ NEXT statement see Section 6.3.6.6, Specifying the Next Record To Be Read.

The READ with key takes the value in the specified key, moves it to the current record pointer, and reads the record being pointed to. The following READ (with key) statement reads the file named ARTICHOKE randomly, selecting records through the value in the file's primary key. If the designated key supplies a value that is not identified with a valid record, the statement causes program control to transfer to the subroutine named NO-REC.

```
READ ARTICHOKE RECORD

     INVALID KEY GO TO NO-REC.
```

Note: a random read repositions the current record pointer and thus effects further sequential reads.

If the file has more than one record description, the records automatically share the same current record area. The OTS does not clear this area before it executes the READ statement (no blank filling, etc.). Therefore, if the record read by the latest READ statement does not fill the entire current record area, the area not overlaid by the incoming record remains unchanged. For example, if the file's record area contains ten 3's, and a READ operation moves in a 6-character record containing all 1's, the current record area then contains six 1's followed by four 3's. Consider the following example:

Current Record Area with all 3's	3333333333
Next Record in the File	111111
Current Record Area after READ	1111113333

6.3.6.4 **Rewriting Records into an Indexed File -** The REWRITE statement releases a logical record to an output or input-output file. In all of the access modes, the record is positioned based on the prime key, any alternate keys are also processed properly, including

duplicate keys. If more space is required for new record positions, the Record Management Services automatically extends the file size, regardless of the access mode being employed.

If the file is open in sequential access mode and the records are not written in ascending order of the prime key values, an INVALID KEY condition exists. In any access mode an attempt to write an existing record having the same prime key value or an alternate key value where duplicates are not allowed, results in an INVALID KEY condition.

The following sample WRITE statement releases the record BREAKERS to the indexed file. If the record already exists, program control transfers to WRITE-ERR.

```
WRITE BREAKERS
     INVALID KEY GO TO WRITE-ERR.
```

The indexed WRITE statement creates only storage files because print-files are sequential files.

6.3.6.5 **Deleting Records from an Indexed File** - The DELETE statment logically removes an existing record from a file. After a DELETE statement has successfully removed a record from a file, that record can no longer be accessed.

If the file is open in the sequential access mode, the statement removes the record just successfully read. For example, the following sample statement removes the record just read from the file named ARTICHOKE:

```
DELETE ARTICHOKE RECORD.
```

If the file is open in either the random or dynamic access mode, the statement removes the record from the record specified by the prime key. For example, the following sample statment deletes the record specified by the prime key from the file named ARTICHOKE. If the prime key supplies a value that does not contain a valid record, the statement transfers control to NO-REC.

```
DELETE ARTICHOKE RECORD
     INVALID KEY GO TO NO-REC.
```

6.3.6.6 **Specifying the Next Record to be READ** - The START statement specifies which record will be the next record to be referenced sequentially in a file opened for INPUT or I-O processing. The START statement updates the current record pointer for future sequential READs.

Suppose we have the following START statement:

```
START FILE-A KEY IS EQUAL TO SUB-KEY-A.
```

SUB-KEY-A must be alphanumeric. In addition, SUB-KEY-A must be a record key or alternate record key or subordinate to a record key or alternate record key whose leftmost character position corresponded to its own leftmost character position. For example, if the following fields were defined in the record:

```
02 KEY-A.
     03 SUB-KEY-A.
          04 SUB-KEY-A1 PIC XXX.
          04 SUB-KEY-A2 PIC XX.
     03 SUB-KEY-B PIC XXX.
```

and if KEY-A was a record key or alternate record key, then the following would be legal START statements:

```
START FILE-A KEY IS EQUAL TO KEY-A.

START FILE-A KEY IS EQUAL TO SUB-KEY-A.

START FILE-A KEY IS EQUAL TO SUB-KEY-A1.
```

The following START statements are illegal.

```
START FILE-A KEY IS EQUAL TO SUB-KEY-A2.

START FILE-A KEY IS EQUAL TO SUB-KEY-B.
```

The leftmost character positions of SUB-KEY-A2 and SUB-KEY-B do not correspond to the leftmost character position of KEY-A.

The relational operator IS EQUAL TO (or IS =) means that the current record pointer is set to point to the record associated with the first key equal to SUB-KEY-A. If SUB-KEY-A is shorter than the record key or alternate record key, then the record keys or alternate record keys in the file are truncated on the right to the same length as SUB-KEY-A for the purposes of the comparison.

If the following START statement is used:

```
START FILE-A KEY IS GREATER THAN SUB-KEY-A.
```

or

```
START FILE-A KEY IS > SUB-KEY-A.
```

then the current record pointer is set to point to the record associated with the first key that is greater than SUB-KEY-A. Thus, if the file had records with the following keys:

Record #	743	629	015	891	233	371
KEY-A	ABCDDZZX	ABCDEABC	ABCDEXYZ	ABCDEZZZ	ABCDGAAA	ABCDGZZX

and SUB-KEY-A contained ABCDE, then the current record pointer would be set to point to record number 233.

If the following START statement is used:

```
START FILE-A KEY IS NOT LESS THAN SUB-KEY-A.
```

or

```
START FILE-A KEY IS NOT < SUB-KEY-A.
```

then the current record pointer is set to point to the record associated with the first key that is greater than or equal to SUB-KEY-A. In the previous example that would be record number 629.

If there is no record that satisfies the comparison, the invalid key exit is taken. In our example the following statement:

```
START FILE-A KEY IS EQUAL TO SUB-KEY-A.
```

would take the invalid key exit if SUB-KEY-A contained ABCDF.

If the comparison is satisfied and the current record pointer is set, then subsequent READs would update the current record pointer using KEY-A as the key of reference.

If the key phrase is not specified, then the default key is the prime record key and the default comparison is IS EQUAL TO.

6.3.6.7 **Closing Indexed Files** - The CLOSE statement terminates processing on the file referred to in the statement. The following sample CLOSE statement terminates processing on the file named ARTICHOKE:

```
CLOSE ARTICHOKE.
```

When the statement closes a file, no other I/O operation can access that file until another OPEN statement opens the file. If the statement specifies the LOCK option, the program cannot open the file again in that run. If a SAME AREA clause contains the name of the file just closed, the program may open one of the other files named in the clause.

6.4 DEVICES

The TRAX COBOL object time system supports any devices supported by the Record Management Services. Table 6-8 contains a partial list of these devices:

Table 6-8
Device Codes

Device	Device Code
Disk	
Disk (RM02/03)	DR
Disk (RK07)	DM
Disk (RP04/05/06)	DB
Line Printer	LP
Magnetic Tape (TE16/TU45)	MM

Some devices are better suited to certain uses than others. For example, since TRAX COBOL is a disk-oriented system, the disk provides COBOL files with the best performance and reliability. On the other hand, COBOL files on magnetic tape are limited to sequential organization.

The following subsections discuss the devices that are available and how to use them to best advantage.

6.4.1 Disk

The primary means for storage and processing TRAX COBOL files is a disk. Several disk units are supported, including RK05, RF11, RP11/RP03, RP04 and RS04. Each device has its own file handling characteristics, and differs with respect to capacity, speed, and portability. The following table compares these characteristics.

Table 6-9
Comparison of TRAX System Disk Devices

Device	RP05/06	RM02/03	RK07
CAPACITY	VERY HIGH (80,000 BLOCKS)	VERY HIGH (65,000 - 130,000 BLOCKS)	HIGH (54,000 BLOCKS)
SPEED	HIGH	HIGH	HIGH
PORTABILITY	HIGH (EASY)	HIGH (EASY)	HIGH (EASY)

6.4.2 Magnetic Tape

TRAX systems support magnetic tape files; all COBOL operations concerned with magnetic tape are fully supported by the compiler, including the MULTIPLE-FILE TAPE clause and the CLOSE REEL [WITH NO REWIND] clause.

6.4.3 Line Printer

COBOL programs can use both a support terminal and a line printer as I/O devices.

The default device for the ACCEPT and DISPLAY statements is the TRAX support terminal. For example, consider the following coding:

```
    ...
    ...
PROCEDURE DIVISION.
    ...
     ACCEPT INREC.
    ...
     DISPLAY OUTREC.
    ...
```

Figure 6-5 Use of ACCEPT and DISPLAY Statements With TRAX Support Terminal

If filenames have been assigned to these devices in the SELECT clause of the File-Control paragraph, the READ and WRITE statements can access them for I/O files. For example, consider the following coding:

```
    ...

FILE CONTROL.
    SELECT OUTFILE ASSIGN TO "LP:".

    ...

FD OUTFILE
    DATA RECORD IS OUTREC.

    ...

PROCEDURE DIVISION.

    ...

    OPEN OUTPUT OUTFILE.

    ...

    WRITE OUTREC.
```

Figure 6-6 Assigning the Line Printer to Files

6.5 FILES AND FILENAMES

The OTS and the operating system use the device codes described in Section 6.4 to communicate with the devices. Further, the COBOL OTS uses the operating system's file specification and interfaces for all file manipulation with file storage devices (disk and magtape). The VALUE OF ID clause (discussed in the following subsection) in the FD entry describes the file specification to the OTS. The format for the full file specification follows:

```
dev:[uic] filename.typ;version/switches
```

where:

dev: - device code

[uic] - user's identification code or the code of the user for whom the file was created - the user directory ID. (The brackets [ ] are required.)

filename - an alphanumeric field containing up to nine characters that identifies the file.

typ - an alphanumeric field containing up to three characters that qualify the filename.

version - a numeric field containing up to five octal digits that give the version number of the file. By specifying version numbers, the user can maintain several versions of the same file on a directory device.

switches - identifies certain actions for the operating system to perform for the file. (Subsection 6.5.1.1 discusses these switches.)

These entries default as follows:

dev: - the device code of the disk containing the operating system.

[uic] - the user identification code of the user currently using the system.

filename - null

typ - null

version - • input files - the highest numbered version of the file (thus selecting the latest version);

• output files - one greater than that of the highest numbered version of the file (thus creating the latest version).

switches - null

For example, the following sample file specification causes the file system to process version 3 of a file on disk named ARIES. The user has an identification code of 140,222.

```
DB:[140,222]ARIES;3
```

6.5.1 Using Explicit Filenames (VALUE OF ID Clause)

The VALUE OF ID clause, in the FD entry, describes the file specification to the COBOL OTS. The VALUE OF ID clause is optional; however, the system requires it whenever the program refers to an explicit file unless a sufficient file description is provided in the ASSIGN clause. The clause accepts either a literal entry or an identifier entry. Consider the following sample literal form of the clause:

```
VALUE OF ID IS "DB:[140,222]ARIES;3"
```

Elements of the file specification appearing in the VALUE OF ID clause supersede their counterparts specified in the ASSIGN clause for the file. (Subsection 6.5.2 discusses the ASSIGN clause.)

When written in the literal form, the literal may be a complete file specification or a part of a file specification.

When written in the identifier form, the value of the identifier may be a complete or partial file specification.

The identifier form of this clause is especially useful when different runs of a program process different files. If a program must process different files in the same way on different runs, an ACCEPT statement in the Procedure Division can request a file specification from the user at the user's console or from a batch input stream.

The following example illustrates how a COBOL program could request a file specification from an interactive terminal:

```
DATA DIVISION.
   .
   .
   .
FD FILEIN
    VALUE OF ID IS INFILE.
   .
   .
   .
WORKING-STORAGE SECTION.
    77 INFILE PIC X(20).
PROCEDURE DIVISION.
   .
   .
   .
    DISPLAY "TYPE IN INPUT FILE SPEC".
    ACCEPT INFILE.
   .
   .
   .
    OPEN INPUT FILEIN.
```

This sample coding causes the following interaction between the program and the user (the message printed by the program is underlined):

```
TYPE IN INPUT FILE SPEC
DB1:THOREAU  RET
```

Following this interaction, the sample OPEN statement will open (for input) the file, THOREAU on DB1.

6.5.1.1 **Switches** - There are four optional switches which may qualify the file specification. These switches modify the processing performed by the COBOL OTS when it opens the file.

Table 6-10 contains a list of the file switches and their meanings to the OTS.

Table 6-10
File Specifier Switches

SWITCH	MEANING
/CL:n	Allocate disk space in clusters of n virtual blocks whenever the file needs additional storage space during output operations. (n may be any number from 1 to 256 in powers of 2.) If the number is followed by a decimal point, the software considers the number to be decimal; if it does not have a decimal point, it is considered to be octal). This switch would be used only when very large files are to be created and the output device can hold the entire file (i.e., an RM02/03 disk). The effect of this switch is to make file accessing faster when the file is being processed sequentially.
/CO:n	Allocate a contiguous file of n disk blocks to the file when it is opened. This switch ensures that n blocks are available for the file prior to actual processing. (When many users are sharing the same disk, you can use this switch to ensure that your entire file will fit on the disk.) It applies only to output files being created. If a decimal point follows the number, the system considers it to be decimal; otherwise, octal.)
/SH	This file is shared for output or I/O mode, available for writing or altering by other tasks (or jobs) running concurrently with the COBOL program. The /SH switch must not be specified for sequential files. For all other files, the following rules apply. • The /SH switch should be used consistently among concurrently executing tasks. That is, if the /SH is specified for one task sharing the file, all tasks sharing the file should have it specified, and vice-versa. • If a file is being opened for OUTPUT or I/O with the /SH switch specified, all other tasks currently using the file must also have the /SH switch specified. • If a file is being opened for input without the /SH switch set, no other task can be using the file for output or I/O. • If a file is being opened for INPUT and no /SH switch is specified, all other tasks currently using the file should not have the /SH switch specified. If access is denied when the file is opened because of one of the above reasons, a file status code of 91 is stored in the FILE-STATUS data-item associated with the file if one is specified.
/AL:n	Same as the /CO:n switch with the following exception. The /CO:n specifies that all blocks be contiguous, and the /AL:n switch specifies that all blocks need not be contiguous.

6.5.2 Device Assignment by ASSIGN Clause

If the VALUE OF ID clause does not specify a complete file specification, the ASSIGN clause in the File-Control paragraph can assign a defalt to those components not specified. The ASSIGN clause must be written as part of the SELECT statement as shown below:

```
SELECT THOREAU ASSIGN TO "DB1:"
```

This example assigns a default device code "DB1:" for the location of the file THOREAU. Another device code specification in the VALUE OF ID clause could override it later in the source program.

6.5.3 Files and Logical Units

Each file in an executable task must have a unique Logical Unit Number (LUN) assigned to it. The COBOL compiler can only generate a relative LUN assignment for each file in a COBOL program, because there may be multiple COBOL programs in a task. (See Figure 2-8 which contains a sample file-to-relative-LUN assignment table.) Actual LUN assignments are made by the COBOL Object Time System (OTS) at task execution time. The number of LUNs needed by a task is equal to 1+n, where n is the total number of individual files included in each program comprising the task. For example, if a task consists of three programs, each program requiring three files, then the number of LUNs required is 10. (The first LUN is reserved for ACCEPT/DISPLAY and message processing.) If more than six LUNs are required for an executable task, the UNITS option must be specified at link time, because the TRAX Linker default is 6.

Each LUN must have a physical device associated with it before the associated file can be opened. You can assign a physical device to the file by specifying the VALUE OF ID or ASSIGN clause in your COBOL program, or you can specify the ASG option at task-build time.

NOTE

The default LUN assignments generated by the Task Builder do not always equate to the system device.

(Refer to the TRAX Linker Reference Manual for your particular operating system for more information concerning link options.)

As previously stated, each COBOL program receives relative LUN assignments for its files by the compiler. At task-execution time, the OTS converts these relative LUN assignments to actual assignments according to the following rules:

1. If the task consists of only one COBOL program, the OTS adds 1 to each of the relative LUN assignments yielding the actual assignments. Therefore, a file receiving a relative LUN assignment of 2 by the compiler would receive an actual LUN assignment of 3 at execution time.

2. If the task consists of more than one COBOL program having files assigned to it, simply adding 1 to the relative LUN assignments would obviously yield duplicate actual LUN assignments. The OTS, in the case of multiple program tasks, utilizes the relative assignment +1 formula for the first

program in the task. For each subsequent program, it takes the highest actual LUN assignment for the previous program and adds 1 to it to arrive at the first LUN assignment. It then applies the +1 formula to this first LUN assignment to arrive at each subsequent assignment for the program. Consider the following example:

Example

A task consists of three programs (PROGA, PROGB, and PROGC). Each program has three files with relative LUN assignments of 1, 2, and 3. At execution time, assuming that the programs were presented to the Linker or to the Merge Utility in the order PROGA, PROGB, and PROGC, the OTS would assign actual LUNs as follows:

Program	LUN assignment
	1 (reserved for ACCEPT/DISPLAY and message processing)
PROGA	2 1st. File 3 2nd. File 4 3rd. File
PROGB	5 1st. File 6 2nd. File 7 3rd. File
PROGC	8 1st. File 9 2nd. File 10 3rd. File

6.6 OPTIMIZATION

At times a user may wish to optimize his program with regards to space or time. Often, there is a trade-off between the two. The default philosophy of the COBOL compiler has been to optimize space allocation. A discussion of the two types of optimization follows.

6.6.1 Speed Optimization

The following COBOL clauses and phrases may be used to increase execution speed.

SAME RECORD AREA Phrase

Default	- No Same Record Area
Optimal	- Use SAME RECORD AREA phrase
Effect	- May save compute time. If records are being copied from one file to another and if both files share the same Record Area, then no move statement is needed to move the records from one record area to the other.
Use more space?	- No, uses less space
Other potential drawbacks	- Records from both files will not be available simultaneously (unless one is moved so it can be saved), because one record will wipe out the other.

BLOCK CONTAINS Clause

Default	- Bucket or logical block consists of smallest number of virtual blocks.
Optimal	- Make bucket or logical block as large as possible.
Effect	- Speeds sequential access by reducing amount of I/O to disk.
Use more space?	- Yes
Other potential drawbacks	- None

For indexed files, the following clauses and phrases may be used to further increase execution speed.

RESERVE Clause -

Default	- 2 AREAS
Optimal	- Make the number of areas equal to the number of keys of access + 2.
Effect	- Speeds up random access.
Use more space?	- Yes
Other potential drawbacks	- None

WITH DUPLICATES Phrase -

Default	- Duplicates not allowed
Optimal	- Allow duplicates by using this phrase

Effect - Speeds up WRITE and REWRITE time. If this phrase is not used, then the program must check each alternate record key on a write or rewrite, to check that it doesn't already exist on the file.

Use more space? - No

Other potential drawbacks - Duplicate keys are allowed and this may not be wanted. For example, if the social security number is a key, duplicate social security numbers may be illegal.

6.6.2 Space Optimization

The default philosophy is to optimize space usage. However, the following COBOL clauses and phrases may be used to further reduce space requirements.

SAME RECORD AREA

Default - No Same Record Area

Optimal - Use SAME RECORD AREA phrase for as many files as possible.

Effect - Instead of having a record area for each file, all the files use the same record area.

Slows execution time - No

Other potential drawbacks - Records from both files will not be available simultaneously (unless one is moved in order to save it), because one record will wipe out the other.

SAME AREA

Default - No Same Area

Optimal - Use SAME AREA phrase for as many files as possible.

Effect - The buffer areas for all the files in the SAME AREA phrase are shared. Saves much more space than SAME RECORD AREA.

Slows execution time - No

Other potential drawbacks - Not more than one of the files listed in the SAME AREA phrase may be open at any time.

6.7 COMMUNICATING WITH THE PROGRAM

The ACCEPT and DISPLAY statements allow low-volume, terminal-oriented interaction between a COBOL program and the user of the program.

While these statements are intended for use with keyboard devices, TRAX COBOL allows the ACCEPT statement to accept data from a TRAX support terminal, and the DISPLAY statement to display data on a line printer or at a TRAX support terminal. The following two Sections (6.7.1 and 6.7.2) discuss these capabilities in greater detail.

6.7.1 Using the ACCEPT Statement

The ACCEPT statement makes small amounts of data available to the specified data item.

Consider the following example; it causes data to be transferred from the device identified by the mnemonic-name, OPERATOR, to the area represented by the identifier, COMM-AREA.

```
ACCEPT COMM-AREA FROM OPERATOR.
```

OPERATOR must be a mnemonic-name specified for a device in the Special-Names paragraph (in this example, possibly the console). The area represented by the identifier COMM-AREA receives the data requested without any editing.

The ACCEPT statement causes the transfer of a stream of bytes from the device specified in the FROM phrase, if it is present (OPERATOR in the previous example). If the FROM phrase is not present, the data is transferred from the user's console.

Enough bytes are transferred to fill the identifier's area. The size of COMM-AREA in this example dictates the number of bytes being transferred.

If the device contains more data than there are bytes in COMM-AREA, the data is truncated.

- If the length of the identifier exceeds 80 bytes, the OTS performs one or more additional transfers of data until it either fills the identifier or transfers less than 80 bytes.
- If the length of the identifier is less than or equal to 80 bytes and the length of the data is less than the identifier on a teletype or cards, the OTS pads the identifier with blank characters.

The ACCEPT statement has a second format that allows it to retrieve the current DAY, DATE, or TIME from the system and store it in the specified identifier. (DAY, DATE, and TIME are reserved words that the user does not define. The user must define identifiers into which to accept the values in DAY, DATE, or TIME.) The following sample statement places the current date in the identifier, GREENWICH:

```
ACCEPT GREENWICH FROM DATE.
```

DAY and DATE are treated as equivalent. A facility for specifying the day of the year is currently not provided. The date, however, is provided as follows (YY is the year; MM is the month; DD is the day):

```
DATE -- YYMMDD
```

If the date were July 4, 1976, the systems would provide GREENWICH with the number 760704.

The systems provide the time as follows (HH is the hour; MM is the minutes; SS is the seconds; CC is the hundredths of a second):

```
TIME -- HHMMSSCC
```

If the time were 20 seconds after 5:15 PM, the systems (which have a 24-hour clock) would provide the numbers 17152000. (Since the PDP-11 clock has no hundredths of a second capability, the systems place zeroes in the last two positions.)

The identifier receives the data according to the rules for the MOVE statement. Chapters 3 and 4 discuss the MOVE statement as applied to non-numeric fields (Chapter 3) and numeric fields (Chapter 4).

6.7.2 Using the DISPLAY Statement

The DISPLAY statement transfers small amounts of data from he specified data item or literal to the specified device.

Consider the following example; it causes the transfer of data from the area represented by the identifier, COMM-AREA, to the device with the mnemonic-name, OPERATOR:

```
DISPLAY COMM-AREA UPON OPERATOR.
```

OPERATOR must be a mnemonic-name specified for a device in the Special-Names paragraph (possibly the console in this example). The area represented by the identifier, COMM-AREA, contains the data being transferred.

The DISPLAY statement causes the transfer of a stream of bytes to the device specified in the UPON phrase if it is present (OPERATOR in the preceding example). If the UPON phrase is not present, the OTS transfers the data to the user's console.

All of the bytes in all of the identifiers or literals in the DISPLAY statement are transferred first. The size of COMM-AREA, in this example, dictates the number of bytes being transferred.

The system does not convert COMP items from binary to ASCII; it simply transfers them as they exist in storage.

If a single DISPLAY statement must transfer large amounts of data, that data must contain appropriate vertical and horizontal form control characters. If the data being transferred does not contain form control characters and the length of the data stream exceeds the device's single line capacity, the excess characters will all print in the last position (overprinting each other).

Table 6-11 contains several of the terminal form control characters:

Table 6-11
Form Control Characters

Octal Code	Control Character	Function
007	BEL (CTRL G)	Bell ringer
011	HT (CTRL I)	Horizontal tab
012	LF (CTRL J)	Line feed or line space (new line)
013	VT (CTRL K)	Vertical tab
014	FF (CTRL L)	Form feed to head of form
015	CR (CTRL M)	Carriage return

When it has transferred all of the data from all of the items listed in the statement, a carriage return and linefeed character are automatically appended onto the data. The WITH NO ADVANCING phrase suppresses this appending operation.

NOTE

The WITH NO ADVANCING phrase is an extension to the ANS-74 standard.

6.8 FILE COMPATIBILITY WITH OTHER PROGRAMMING LANGUAGES

All files generated by other programming languages are compatible with COBOL provided that they were generated using Record Management Services. Files generated by other file systems must conform to Record Management Services formats.

6.8.1 Writing Files For Other Programming Languages

TRAX COBOL writes files that can be read only by languages using the Record Management Services system interface for user program I/O. When creating a file that is to be read by a language, that does not use the Record Management Services interface (i.e., BASIC-PLUS), adhere to the following restrictions:

- Ensure that the file has sequential file organization.
- Ensure that the file is not a COBOL print-file (no LINAGE or APPLY PRINT-CONTROL clauses are applicable to the file). Printer control is handled differently by each PDP-11 programming language.
- Do not use the ADVANCING option in WRITE statements when creating the file.

The file may contain fixed-length or variable-length records, and the records should only contain only printable ASCII character data.

6.8.2 Reading Files Written in Other Programming Languages

TRAX COBOL reads files that were written only by languages using the Record Management Services (RMS) system interface for user program I/O. Before reading a file that was written by another language that does not use the Record Management Services interface, be certain that the file meets the following restrictions:

- Ensure that the file is an ASCII file.
- Ensure that the file does not have a carriage control attribute (the FORTRAN carriage control file attribute must not be set).

FORTRAN meets these restrictions when it writes ASCII (not binary) data with formatted WRITE statements. However, the user must disable the carriage control attributes in the OPEN statement for the file.

```
CALL OPEN (UNIT=n, CARRIAGE CONTROL="NONE"
     .
     .
     .
WRITE (n,100) list

FORMAT (.....)
```

BASIC+2 is capable of reading and writing all Record Management Services files. Therefore, files written by BASIC+2 programs are compatible with COBOL.

BASIC-PLUS meets all of these restrictions when it writes a formatted ASCII (sometimes called sequential) file as described in the BASIC-PLUS Language Manual. TRAX COBOL cannot read BASIC-PLUS Virtual Array files.

6.8.3 Data File Transportability

The user who wishes to transport data files from one language processor to another or from a TRAX system to some other RMS supported system should be careful to write such files using the Record Management Services. Record Management Services is the only file interface used by TRAX COBOL.

Non-printable ASCII characters are subject to misinterpretation by the different language processors and operating system utilities. If, for example, COBOL were to write records which contained COMPUTATIONAL (binary) data items, the values these items could contain would be written in the file in the same binary format as represented in the computer. Such binary values may look like non-printable ASCII characters such as CR, LF, CTRL/Z, escape, which could cause system utilities to perform in an unpredictable manner while processing the records.

Other ways that non-printable ASCII characters can get into a file are:

1. having data definitions that contain the USAGE IS INDEX clause;
2. moving HIGH-VALUES or LOW-VALUES;
3. moving any redefinition of a COMP or USAGE IS INDEX field;

4. reading a data file that contains non-printable ASCII characters;

5. having multiple record definitions of varying sizes and filling a shorter record area then writing a longer one. (The excess characters, not filled, may be non-printing.)

This list is not complete. There are many other ways for non-printing ASCII characters to find their ways into printable ASCII files.

6.9 PROCESSING I/O ERRORS - USE STATEMENT

The USE statement provides COBOL programs with a way to process I/O errors. It allows the program to specify possible recovery steps following the I/O handling procedures performed by the software.

When a COBOL program contains a USE procedure and an I/O error occurs, the OTS and Record Management Services execute their standard I/O error handling procedures and then transfer control to the procedure following the USE statement. (For further information concerning run-time I/O errors, see section 12.3.)

Consider the following sample coding. When either THOREAU or ARTICHOKE causes an I/O error, the OTS executes its standard I/O error procedures and then transfers control to the paragraph (or paragraphs) that follow the USE statement.

```
PROCEDURE DIVISION.
DECLARATIVES.
REPAIR SECTION.
    USE AFTER STANDARD ERROR PROCEDURE
              ON THOREAU ARTICHOKE.
DISPLAY-ERROR.
    IF ...
```

The paragraphs following the USE statement may contain any valid COBOL statement, except for the following:

1. Those statements that refer to a procedure outside of the DECLARATIVES. (Any attempt to transfer control out of the DECLARATIVES causes the OTS to abort the program.)

2. Those statements that would cause the USE procedure being executed to be invoked again. (Recursive USE procedures cause the OTS to abort the program.)

   USE procedures are executed in the same manner PERFORM ranges in Procedure Division coding. Therefore, paragraphs with the USE procedure section should follow all rules specified for paragraphs within PERFORM ranges. For further information on PERFORM ranges, see Use of the PERFORM Statement in Chapter 7 of this guide.)

   If a status key is declared for the file in error, all status information is made available for processing in the USE procedure.

CHAPTER 7

GOOD PROGRAMMING PRACTICES

7.1 FORMATTING THE SOURCE PROGRAM

Since most COBOL programs are usually long, the programmer needs techniques that will help him to simplify and improve the readability of his COBOL programs. The guidelines in this chapter, if followed, will help produce source programs that are easy to read and maintain.

The guidelines described in this chapter are based on the use of Terminal format which is the TRAX COBOL default format. Besides the obvious advantage of an uncluttered printout, the Terminal format has other programming advantages:

1. it requires less storage area;

2. it requires no line numbers;

3. its statements may be aligned with tab characters.

Further, whenever required, the REFORMAT utility program will convert Terminal format programs to the Conventional format. (The REFORMAT utility program is discussed in Chapter 2).

The following suggestions should help to further simplify even the most complicated source programs.

1. Begin division, section, and paragraph names in column 1. Although these names may start anywhere in Area A, aligning them in column 1 produces a much more readable listing. When required, place the * and - in column 1. (Column 1 then becomes column 0.)

2. Insert a blank line, or one or more comment lines (describing the purpose of the file) before each SELECT statement in the FILE-CONTROL paragraph. Place the phrases of the SELECT statement on separate lines and begin each of them in column 5 (use the tab character to skip over Area A). Consider the following illustration of a typical SELECT statement:

```
AREA A          | AREA B

1 . . .         | 5 . . . . . .
                | SELECT MASTER-FILE
                | ASSIGN TO "DK1:"
                | ORGANIZATION IS RELATIVE
                | ACCESS IS SEQUENTIAL.
```

3. Place the phrases of the file description statement on separate lines and begin each of them in column 5. (Use the tab to skip over Area A.) Consider the following illustration of a typical file description entry:

```
AREA A          | AREA B

1 . . .         |  5 . . . . . .
FD              | MASTER-FILE
                | LABEL RECORDS ARE STANDARD
                | VALUE OF ID IS MASTER-FILE-NAME
                | DATA RECORD IS MASTER-RECORD.
```

4. In both the File and Working-Storage sections, begin all 01 level items in column 1.

   Indent, by four columns, all subordinate items with higher-valued level numbers. (For example, if the item that is subordinate to a 01-level record description is 05, begin the record description level number in column 1 and the 05 level number in column 5.) Use the tab character for the first indentation, a tab and four spaces for the second, two tabs for the third, etc. When indented in this manner, the listing will show, clearly and neatly, the hierarchical relationships of all of the data names in the program as well as their level number values.

   Increment level numbers by 5; then later, if it becomes necessary to insert additional group items, they may be inserted without having to change the level numbers of all items that are subordinate to that group.

   If desired, write the level numbers as single digits (such as 1 instead of 01).

   Use level number 01 instead of 77 in the Working-Storage Section. (77, as a level number has the same meaning as 01, and 77 may eventually be omitted from the COBOL standard.)

   Since all elementary items, except for index data items, require PICTURE clauses, these clauses fill a good part of the source program listing. However, the PICTURE clause itself may be simplified to enhance the listing's readability as follows:

   a. use PIC as an abbreviation for PICTURE,

   b. omit the noiseword IS, and

   c. align the PIC clauses on successive lines. (Use the tab character to align the clauses.)

5. Put all paragraph name declarations in the Procedure Division on lines separate from the statements in the paragraph. This not only makes the program more readable, it also makes modification of the first statement in the paragraph easier.

6. Follow all imperative statements with a period, making them 1-statement sentences. Place only one statement on a line. In addition to making the lines shorter and more readable, this will prove quite helpful when debugging the program. For example, if the program contains a coding error, it will be on one line and therefore easier to modify without affecting the other portions of the sentence; further, the diagnostic messages will refer to the correct line and their meanings will be clearer.

   Since left-aligned statements in any program enhance the readability of that program, develop the habit of starting all COBOL sentences in column 5. (Use the tab character to skip over Area A.) Some statements, however, should be further indented, as explained in the following paragraphs.

7. If the true path of a conditional statement contains another conditional statement or more than one imperative statement, place all statements in the true path on lines immediately following the conditional statement and indent them to show their dependence upon that statement. Consider the following illustration of an IF statement and its true path:

```
IF COMPUTED-TAX > TAX-LIMIT
   SUBTRACT TAX-LIMIT FROM COMPUTED-TAX GIVING EXCESS-TAX
   MOVE TAX-LIMIT TO COMPUTED-TAX
   ADD EXCESS-TAX TO TOTAL-EXCESS-TAX.
```

   If the statement has an ELSE (or false) path, align the word ELSE under the preceding IF and indent all statements that are dependent on the ELSE statement. Thus:

```
IF condition
   true path statement
   true path statement
   . . .
ELSE
   false path statement
   false path statement.
```

   Be sure to place the period after the last statement only!

   Another good method for simplifying conditionals is to write only a single imperative statement in the true or false path. If the path requires more statements, place them in a separate paragraph and either PERFORM the paragraph from the path or GO to it. This technique avoids the possibility of inadvertently placing a period at the end of a statement within the path, thereby terminating it prematurely.

   When writing a GO TO ... DEPENDING statement, place each procedure name on a separate line and indent them all. Consider the readability of the following sample statement:

```
GO TO P35
      P40
      P45
      P60
      P65
      DEPENDING ON P-SWITCH.
```

8. When grouping statements into paragraphs and sections, use the following organizational ideas:

   Group together logical units of processing into a section. Select a section name that reflects the type of processing being conducted within that section (such as TAX-COMPUTATION SECTION, PRINT-LINE-FORMATTER SECTION, etc.). Follow the section name with sufficient comment lines to explain the processing that is carried out by the statements within that section.

   Make paragraph names as short and simple as possible. A numbered abbreviation of the section name often suffices. Thus the paragraph names in the TAX-COMPUTATION section might be TC10, TC20, TC30, etc. Use paragraph names sparingly, placing them only where the true and false paths of conditional statements require branch points for GO TO statements. If the temptation arises to give a paragraph a longer name in an attempt to reflect the type of processing in that paragraph, use comment lines instead. (Comment lines usually convey more information, more clearly.)

   When using simple numbered paragraph names, assign increasing numeric characters to sequential paragraphs. If the numeric portion of the names increases by 5 or 10, new ones may be inserted later without disturbing the sequence of the names.

   Do not use the PERFORM verb in the form, PERFORM a THRU b. If the paragraphs a thru b must be performed, place them in a section by themselves and PERFORM the section, thus avoiding the use of the THRU option.

   Place single paragraphs that are to be performed into sections and use the section name as the object of PERFORM verbs. Then, if future design changes introduce complicated conditional logic into the paragraph, requiring additional paragraph names, the PERFORM statements need not be altered.

   The preceding guidelines divide the Procedure Division into modular blocks of coding. If these guidelines are used, the following additional techniques may be applied.

   a. Restrict entry to all sections through the first statement of the section by use of a GO TO, a PERFORM, or a "fall through" from the preceding section;

   b. Ensure that all GO TO statements refer to only section names or paragraph names that are internal to the section containing the GO TO statement.

7.2 USE OF PUNCTUATION

Avoid using the COBOL punctuation characters, comma and semicolon. They lend little to the readability of programs that have their statements neatly aligned, as discussed earlier in this chapter. Further, it is quite easy to misuse these characters, which can cause serious errors for many compilers. (Other compilers either ignore incorrect punctuation characters or flag them with warning messages.) At best, even when used correctly and in the proper places, they have no effect on the meaning of the program.

7.3 USE OF THE ALTER STATEMENT

Avoid using the ALTER statement to change the flow of control in a program. It is impossible to test the setting of an alterable GO statement except by executing it. Also, unless explicit comments accompany an alterable GO statement, it is difficult to tell whether or not it is referenced by ALTER statements or what the possible destinations might be. All of this makes debugging programs that contain these statements quite difficult. There are two other techniques that may be used in their place:

1. If control branches one of two ways (i.e., a binary switch), write the switch as a conditional variable. Consider the following sample coding:

```
01  P-SWITCH PIC S9 COMP VALUE 0.
    88 NO-PRINT VALUE 1.

    MOVE 1 TO P-SWITCH
    .
    .
    .
    IF NO-PRINT GO TO P40.

P40.
    MOVE 0  TO P-SWITCH.
```

2. If control branches more than two ways, use MOVE statements to place integers into a data item, and a GO TO ... DEPENDING ... statement to test the data item and branch accordingly. Consider the following sample coding:

```
01  P-SWITCH PIC S9999 COMP VALUE 0.
    .
    .
    .
    MOVE 1 TO P-SWITCH
    .
    .
    .
    MOVE 3 TO P-SWITCH.
    .
    .
    .
    GO TO
         PART-TIME
         PIECE-WORK
         HOURLY
         SALARIED-WEEKLY
         SALARIED-OTHER
         DEPENDING ON P-SWITCH.
*   FALL THROUGH IS A BUG
    DISPLAY "?17".
    STOP RUN.
```

7.4 USE OF THE PERFORM STATEMENT

The general rules for the PERFORM statement are augmented with the following rules:

1. The endpoint of a section and the endpoint of the last paragraph in the same section are two distinct points. This means that it is possible to execute a PERFORM of the section, then while that PERFORM is still active, to execute a PERFORM of the last paragraph.

2. On the start of a PERFORM, if the end point of the new PERFORM is the end point of an already active PERFORM, the OTS aborts the task and issues an error message.

3. At the end of any procedure, a check is made to see if the procedure being ended is the end of the most recent PERFORM range. If so, the most recent PERFORM range is exited. If not, the end point of the most recent procedure is checked against the end point of all currently active PERFORMs. If the end point of the procedure is the end point of any currently active PERFORM range, the OTS issues an error message and aborts the task because the perform ranges are not being exited in the reverse of the order in which they were entered.

NOTE

The OTS error messages are discussed in Section 11.4, Run-Time Error Messages.

7.5 USE OF LEVEL 88 CONDITION-NAMES

Condition-names provide a convenient method for testing a value or range of values in a field. The use of condition-names makes programs easier to maintain, because it ensures a uniform method of testing fields and helps to reduce recoding when the specifications of the program change.

The following example illustrates the use of condition-names and shows the advantages inherent in their use.

Suppose the records of a file each describe a student in an educational institution (or an employee in a corporation). Some of the records contain categories of information which are not present in other records. A "code" field, which contains a digit or letter, indicates the presence (or type) of some categories; while a special value in the information itself (such as a numeric value being zero, negative, or maximum) indicates the presence of other categories. The processing of such a record may vary considerably depending on these indicator fields. The fields may require interrogation at various points in the program, and the interrogation may require more than a simple relation test.

Consider a "code" field that holds one of seven values, coded as a mnemonic character. For example, S,1,2,3,4,G,P might be seven values that indicate student categories of Special, 1st year, 2nd year, 3rd year, 4th year, Graduate, and Postgraduate. The field is described as follows:

```
05 STUDENT-CATEGORY PIC X.
```

Program logic requires certain processing for enrolled undergraduates, different processing for special students, and still different processing for all students except enrolled undergraduates. Without the aid of condition-names, statements might be written as follows to resolve this problem:

```
IF STUDENT-CATEGORY = "S" ...

IF STUDENT-CATEGORY NOT LESS THAN "1"
       IF STUDENT-CATEGORY NOT GREATER THAN "4" ...

IF STUDENT-CATEGORY EQUAL TO "G" NEXT SENTENCE
       ELSE IF STUDENT-CATEGORY EQUAL TO "P"
            NEXT SENTENCE ELSE GO TO ...
```

However, if various level 88 entries follow the STUDENT-CATEGORY description, as shown below, condition-names can simplify this coding.

```
05 STUDENT-CATEGORY PIC X.
   88 UNDERGRADUATE VALUE "1" THRU "4".
   88 SPECIAL-STUDENT VALUE "S".
   88 GRAD-STUDENT VALUE "G" "P".
   88 SENIOR VALUE "4".
   88 NON-DEGREE-STUDENT VALUE "S" "P".
```

Now, the following procedural statements can solve the problem:

```
IF SPECIAL-STUDENT ...
IF UNDERGRADUATE ...
IF GRAD-STUDENT ...
```

Procedural statements with condition-names are much easier to read and debug than those containing the complete test. For example, the procedural statements, IF UNDERGRADUATE ..., and IF STUDENT-CATEGORY NOT LESS THAN "1" IF STUDENT-CATEGORY NOT GREATER THAN "4" both accomplish the same thing, but the first statement is simpler and less confusing.

In addition, the statement, IF NOT UNDERGRADUATE ... can test the category of not being an undergraduate, which is equivalent to any one of the following statements:

```
IF NOT (STUDENT-CATEGORY NOT < "1" AND
       STUDENT-CATEGORY NOT > "4") ...
```

or

```
IF STUDENT-CATEGORY < "1" OR
   STUDENT-CATEGORY > "4" ...
```

or

```
IF STUDENT-CATEGORY < "1" NEXT SENTENCE
   ELSE IF STUDENT-CATEGORY > "4" NEXT SENTENCE
       ELSE GO TO ...
```

Statements such as these are tedious to write and a frequent source of coding errors. Further, if a change creates a new student category, the recoding takes more time and is even more error prone. A careful and controlled use of condition-names forces a higher degree of programming control and checkout. If the program logic does require the modification of the STUDENT-CATEGORY field, it can even be named FILLER thus removing the opportunity to shortcut the use of condition-names.

To apply condition-names, follow the description of the item to be tested with a level 88 entry. The item being tested, known as the conditional variable (STUDENT-CATEGORY in the preceding illustrations), may be either DISPLAY or COMPUTATIONAL usage, but not INDEX usage; it may also be a group item.

The compiler stores all of the values supplied by the level 88 entries in the object program exactly as written. (They are pooled with all of the literals from the Procedure Division.) A value supplied by a level 88 entry for a conditional variable of COMPUTATIONAL usage is stored in binary format to save conversion at object time. The compiler stores all other values as byte strings with the proper attributes. It does not make the level 88 entries equal to their conditional-variables in size. This means that it neither truncates nor pads (with spaces) non-numeric literals. Further, it neither truncates nor pads (with zeros) numeric literals, but stores them as written or, if converted to binary, in the minimum size COMP item that will hold the converted value. It stores signs as trailing overpunches on numeric DISPLAY literals, and removes and remembers decimal points.

Do not enter level 88 items under group items that have subordinate entries containing any of the following clauses: SYNCHRONIZED, JUSTIFIED, COMPUTATIONAL, INDEX.

7.6 USE OF QUALIFIED REFERENCES

7.6.1 Qualified Data References

The COBOL language provides facilities to define and reference user-defined data items. Data items are programmer-defined variables declared in the Data Division of a COBOL program. Such variables include, among others, file record descriptions and internal working areas. These data items are processed by procedural statements such as the WRITE, MOVE, and ADD statements. Procedural operations on these data are facilitated through references to the data items by name. For example, to update a variable, YTD-GROSS-PAY, by a weekly gross pay amount WEEKLY-GROSS, write the program fragment shown in Figure 7-1.

```
.
.
.
WORKING-STORAGE SECTION.
01 YTD-GROSS-PAY  PIC 9(5)V99.
01 WEEKLY-GROSS  PIC 999V99.
.
.
.
   ADD WEEKLY-GROSS TO YTD-GROSS-PAY.
```

Figure 7-1
Unqualified Data Item Reference

In this example, YTD-GROSS-PAY and WEEKLY-GROSS are defined in the Working Storage Section of the Data Division as COBOL variables with a level number of 01. The variable representing the "year-to-date gross

pay (YTD-GROSS-PAY)" is computed by incrementing its present value by the "weekly gross pay (WEEKLY-GROSS)" amount through reference to the appropriate data items in the ADD statement. References are made to the data items by the singular, unqualified names of YTD-GROSS-PAY and WEEKLY-GROSS. Since YTD-GROSS-PAY and WEEKLY-GROSS are defined with level numbers of 01 in the Working Storage Section, these variables must be unique in their spelling and, hence, can only be referenced by the spelling of each data item's name without any COBOL qualification.

The example in Figure 7-1 is artificial because the data item representing the "year-to-date gross pay" is defined as a level 1 variable in the Working Storage Section. More realistically, YTD-GROSS-PAY is defined as a field within an employee payroll record residing on an external master payroll file. The process of updating the "year-to-date gross pay" by a "weekly gross pay" amount is shown more appropriately in Figure 7-2.

```
.
.
.
FILE SECTION.
FD MASTER-IN
   LABEL RECORD IS STANDARD
   VALUE OF ID IS "MASTER.PAY".
01 PAY-RECORD.
   03 NAME              PIC X(30).
   03 EMPLOYEE-NO       PIC 9(9).
   03 YTD-GROSS-PAY     PIC 9(5)V99.
.
.
.
FD MASTER-OUT
   LABEL RECORD IS STANDARD
   VALUE OF ID IS "MASTER.PAY".
01 PAY-RECORD.
   03 NAME              PIC X(30).
   03 EMPLOYEE-NO       PIC 9(9).
   03 YTD-GROSS-PAY     PIC 9(5)V99.
.
.
.
WORKING-STORAGE SECTION.
01 WEEKLY-GROSS         PIC 999V99.
.
.
.
PROCEDURE DIVISION.
INIT.
   OPEN INPUT MASTER-IN.
   OPEN OUTPUT MASTER-OUT.
.
.
.
   ADD WEEKLY-GROSS, YTD-GROSS-PAY OF MASTER-IN
               GIVING YTD-GROSS-PAY OF MASTER-OUT.
.
.
.
```

Figure 7-2
Qualified Data Item Reference

In this example, YTD-GROSS-PAY is defined as a field in both the input and output record descriptions. There are two separate data items whose spellings are identical.

To reference each data item, it is necessary to qualify the name of each data item with sufficient information to constitute a unique reference. Thus, to reference the "year-to-date gross pay" amount in the output record, we write "YTD-GROSS-PAY OF MASTER-OUT" where such a reference is called a qualified reference. The filename MASTER-OUT is functioning as a qualifier in the reference. The reserved word "OF" is the qualification connector and may be used interchangeabely with the reserved word "IN" in this context. Another way of referencing the same data item is to write "YTD-GROSS-PAY OF PAY-RECORD IN MASTER-OUT". This reference is called a completely qualified reference because all possible qualifiers are specified in the reference. A reference of the form "YTD-GROSS-PAY" or "YTD-GROSS-PAY OF PAY-RECORD" is illegal since it does not uniquely identify which of the two data items is desired. Such a reference is termed an ambiguous reference.

In the area of data item definition and referencing, COBOL is unlike other languages such as FORTRAN and ALGOL 60. While FORTRAN requires each data item to have a unique name (i.e., no two data items may have a name of identical spelling), COBOL relaxes this requirement to the extent that each data item must be uniquely referable. That is, two or more data items may have their names spelled identically, but there must exist a way to reference each distinct data item. Thus, there is a distinction between a data item and its name. Central to understanding this distinction is understanding the concept of unique referability.

The functionalities of data item definition and referencing may be understood by stating three guidelines which relate the concepts of data item definition, reference format, and unique referability.

7.6.2 Guideline 1 (Data Item Definition)

Each data item has a name. Each name is immediately preceded by an associated positive integer called its level number. A name either refers to an elementary item or else it is the name of a group of one or more items whose names follow. In the latter case, each item in the group must have the same level number, which must be greater than the level number of the group item.

7.6.3 Guideline 2 (Reference Format)

Data-name qualification is performed by following a data-name or condition-name by one or more phrases of a qualifier preceded by IN or OF. IN and OF are logically equivalent. The general format of a qualified reference to an elementary item or group of items named "name-0" is given in Figure 7-3.

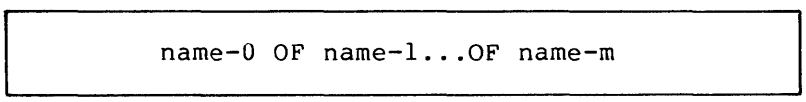


Figure 7-3
General Format of a Qualified Data Reference

where m >= 0 and where, for 0 <= j < m, name-j is the name of some item contained directly or indirectly within a group item named "name-j+1". A reference of the form given in Figure 7-3 is called a (partially) qualified reference with name-1,name-2,...,name-m being called qualifiers. Such a reference is termed a completely qualified reference if "name-j+1" is the father of name-j for 0 <= j <= m-1.

In the hierarchy of qualification, names associated with an FD indicator are the most significant, then the names associated with level-number 01, then names associated with level-number 02,...,49. The most significant name in the hierarchy must be unique and cannot be qualified. Subscripted or indexed data-names, unsubscripted data-names, and condition variables may be made unique by qualification. The name of a condition variable can be used as a qualifier for any of its condition-names. Enough qualification must be mentioned to make the reference unique; however, it may not be necessary to mention all levels of the hierarchy as the example in Figure 7-2 demonstrates.

7.6.4 Guideline 3 (Unique Referability)

If more than one data item is defined with the same name "name-0", there must be a way to refer to each use of the name by using qualification. That is, each definition of "name-0" must be uniquely referable. A data item is uniquely referable if the complete set of qualifiers for the data item are not identical to any partial (including complete) set of qualifiers for another data item.

7.6.5 Qualified Procedure References

The facility of qualification may be applied to procedure references. A procedure name is either a paragraph or section name. By definition, a paragraph name is unique only within a section containing the paragraph while, on the other hand, section names must be unique within a COBOL program. The general format of a qualified procedure reference is shown in Figure 7-4.

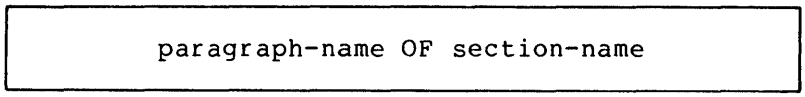


Figure 7-4
General Format of a Qualified Procedure Reference

A paragraph name may be qualified by its containing section name; a section name may never be qualified in a procedure reference. When a paragraph name is referenced without an explicit section name qualifier, the paragraph name is implicitly qualified by the appropriate section name.

If a paragraph name is unique within a COBOL program it is not necessary to qualify the paragraph name in the procedure reference. Finally, if a paragraph name is not unique within a COBOL program, the paragraph name must be qualified in a procedure reference when the reference is made outside of the section which contains the paragraph.

7.6.6 Qualification and Compiler Performance

Qualification is a powerful language facility for the development of COBOL programs. Used wisely, it increases the readability of COBOL programs. However, the user pays a price for utilization of this facility in terms of a slower compilation rate (i.e., COBOL source lines per unit of time).

Qualification requires a tree-structured symbol table at compile-time. The time required for building and looking up on a tree-structured symbol table is considerably longer than for a non-tree-structured symbol table. This translates into a general degradation of compiler performance. If qualification is not employed in a program compiled by the TRAX COBOL compiler, compilation speed is not affected. However, when qualification is used, the compilation rate slows down due to the additional system overhead.

In general, if there are deeper levels of qualification, there will be a slower compilation. This is especially so at the end of the Data Division text where duplicate data-name declarations are detected by the compiler. Object-time performance is not affected by usage of the qualification facility.

CHAPTER 8

SEGMENTATION

TRAX COBOL allows you to break the Procedure Division up into overlayable and non-overlayable program segments to optimize memory utilization. An overlayable program segment can be overlayed by any other overlayable segment. However, a non-overlayable program segment can never be overlayed.

NOTE

The object code generated for the Identification Division through the Data Division is non-overlayable.

8.1 USING THE TRAX COBOL SEGMENTATION FACILITY

The TRAX COBOL Segmentation Facility allows you to specify your own segmentation requirements. To effect segmentation, you must define a segment limit by specifying the SEGMENT-LIMIT IS clause in the Environment Division of your source program. The value you specify in this clause is used by the compiler as a basis for determining whether a program segment is overlayable or non-overlayable. A segment consists of one or more COBOL sections. Each COBOL section should be composed of a series of closely related operations designed to collectively perform a particular function. To designate a section as belonging to an overlayable or non-overlayable segment, assign a segment number to it using the following format:

```
Section-name SECTION segment-number.
```

Where:

Section-name Is a user-defined COBOL word that names the section

Segment-number Is an integer ranging from 0 to 49.

If you specify a segment-number whose value is less than the value specified in the SEGMENT-LIMIT IS clause, you have defined the section as being non-overlayable. A segment-number whose value is greater than or equal to the value specified in the SEGMENT-LIMIT IS clause defines the segment as being overlayable.

8.1.1 Programming Considerations

The most frequently used sections of your program should be made non-overlayable. Assign segment-numbers that are less than the value specified in the SEGMENT-LIMIT IS clause to these sections. Infrequently used sections should be made overlayable. Assign segment-numbers that are greater than or equal to the value specified in the SEGMENT-LIMIT IS clause to these sections. Sections that communicate with each other should be assigned to the same segment. Assign the same segment-number to these sections. Sections having identical segment-numbers are assigned to the same segment.

8.2 SEGMENTATION AND THE PDP-11 COBOL COMPILER

The previous sections provided you with detailed information on how to segment. This section describes what segmentation means in terms of code generation. The TRAX COBOL compiler breaks up the object code it generates into program sections called PSECTs. One or more PSECTs are generated for each program SECTION. The maximum size PSECT generated is 2000 decimal words. However, this maximum size can be altered by specifying the /CSEG:nnnn switch in the compiler command line. (PSECTs are described in Appendix E: The /CSEG:nnnn Switch is described in Section 8.4, and Section 2.2.4).

Also generated, are Overlay Description Language (ODL) directives that group together all PSECTs that belong in the same overlay. These ODL directives are placed in an ODL file to be used as input to the Task Builder. The Task Builder uses the ODL file to generate a task image containing the correct combination of overlayable/non-overlayable PSECTs.

If the source program is written without explicit segmentation, all of the generated PSECTs are concatenated into one non-overlayable program. If the source program does contain explicit segmentation, ODL directives are created to group PSECTs together into the correct combination of overlayable and non-overlayable program segments.

8.3 SEGMENTATION USING THE /OV SWITCH

The /OV switch, when appended to the compiler command line, directs the compiler to produce ODL directives that make all of the procedural PSECTs overlayable. Therefore, the amount of memory required to store the program is equal to that required to contain the root (non-overlayable portion) and the largest PSECT. (See Figure 8-1, Segmentation Using The /OV Switch; and Section 2.2.4, Compiler Switches).

The /OV switch is particularly useful for quickly segmenting programs that were written without explicit segmentation or for overriding explicit segmentation.

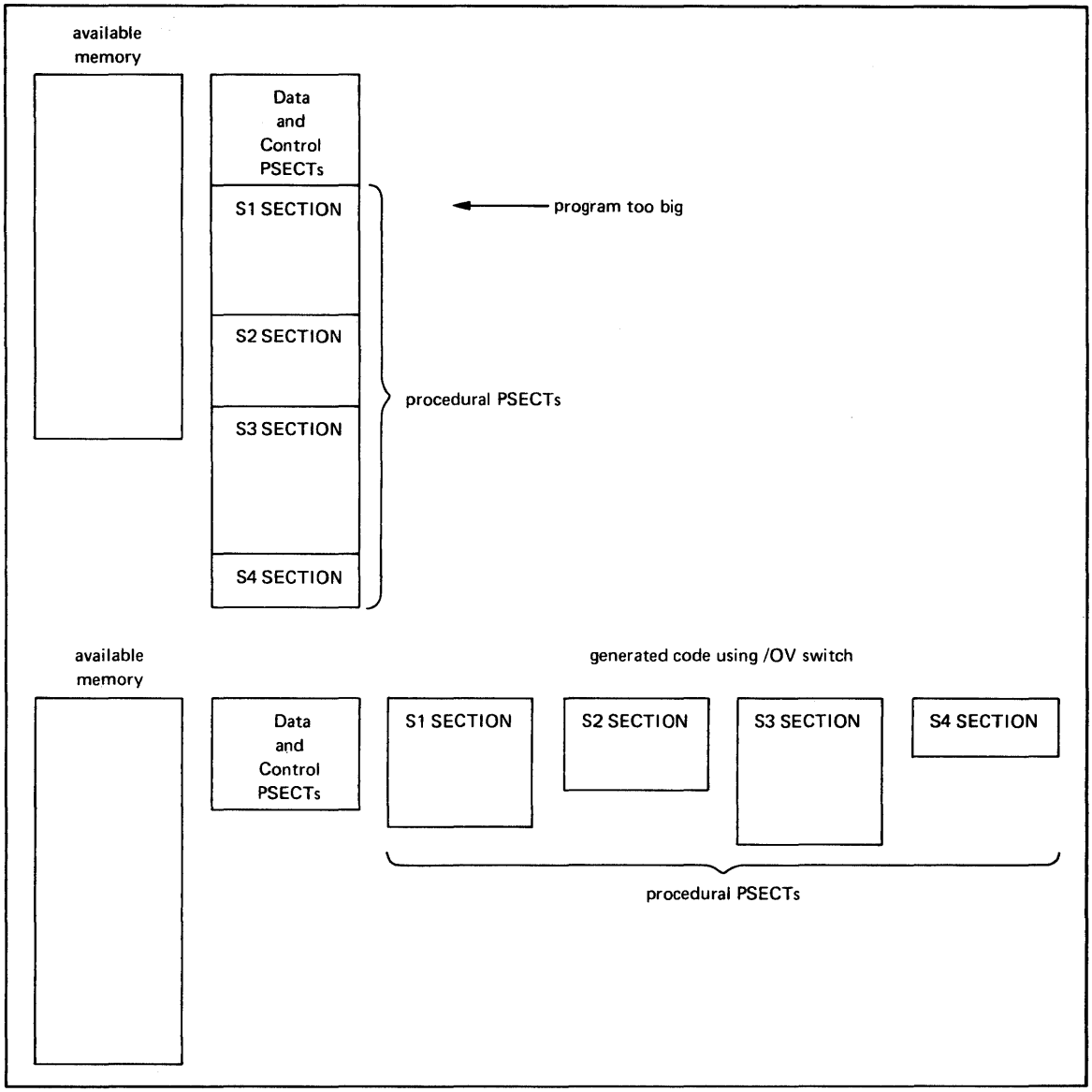


Figure 8-1 Segmentation Using the /OV Switch

8.4 USING THE /CSEG:nnnn SWITCH

The TRAX COBOL compiler generates a PSECT for each COBOL section. If the code generated for a particular section exceeds the default maximum size for a PSECT (4000 decimal bytes), more than one PSECT is generated. TRAX COBOL provides a switch (/CSEG:nnn) that allows you to control the size of PSECTs generated by the compiler. (See Section 2.2.4 Compiler Switches).

If, for example, you compile a program that produces a PSECT that is too large to be linked, you can recompile the program using the /CSEG:nnn switch to reduce the size of the PSECTs generated. See Figure 8-2 for an example of using the /CSEG:nnnn switch.

Command Line (Without /CSEG:nnnn switch specified)

```
COBOL/SWITCHES:(/MAP CBLMRG<RET>
```

```
                        SEGMENTATION MAP

        SECTION NAME    SEGMENT NO.      NAME          SIZE

    OUTPUT-ODL-USE          00          $C$001    000172    00061
    INPUT-ODL-USE           00          $C$002    000172    00061
*   MAIN-CONTROL            00          $C$003    003336    00879
    PROCESS-INPUT-ODL       00          $C$004    001130    00300
    HDR-CHECK               00          $C$005    000322    00105

*  One large PSECT is generated
```

Command Line (With the /CSEG:nnnn switch specified)

```
COBOL/SWITCHES:(/MAP/CSEG:1000) CBLMRG<RET>
```

```
                        SEGMENTATION MAP

        SECTION NAME    SEGMENT NO.      NAME          SIZE

    OUTPUT-ODL-USE          00          $C$001    000172    00061
    INPUT-ODL-USE           00          $C$002    000172    00061
*   MAIN-CONTROL            00          $C$003    001744    00498
                            00          $C$004    001426    00395
    PROCESS-INPUT-ODL       00          $C$005    001130    00300
    HDR-CHECK               00          $C$006    000322    00105

*  Two PSECTs are generated
```

Figure 8-2 Using the /CSEG:nnnn Switch

CHAPTER 9

INTER-PROGRAM COMMUNICATIONS

Inter-program communications is the passing of control and optional data from one program within a task to another. TRAX COBOL provides you with the ability to Link separately compiled COBOL programs into a single task image. During task execution, these separately compiled programs can communicate with each other using the COBOL CALL statement.

A task can consist of a stand-alone program or a main program and one or more subprograms. A stand-alone program is one that does not call subprograms and cannot itself be called. A COBOL main program is one that calls subprograms but can never be called in return. A COBOL subprogram, however, is always called by another program, either the main program or a subprogram. Inter-program communications deals only with main programs and subprograms.

Developing a program as a main program and a set of subprograms offers a number of advantages:

1. Large monolithic programs are no longer required. These large programs can be replaced by a controlling main program and a set of subprograms, where each subprogram is designed to perform a well-defined function.

2. Small subprograms can be developed independently by several members of a programming staff.

3. Small subprograms can be tested more easily than large programs.

4. Small subprograms can be modified and recompiled faster than large programs.

5. General purpose subprograms can be developed and used in more than one programming application.

9.1 COBOL MAIN PROGRAMS VERSUS SUBPROGRAMS

A COBOL main program is one that calls other programs (subprograms) but cannot be called in return. A COBOL main program contains at least one CALL statement. A COBOL subprogram is one that is called by another program, either the main program or another subprogram. The main program is automatically activated at task execution time. A subprogram, however, is activated only when called by another program.

The COBOL compiler differentiates between a main program and a subprogram by the presence or absence of a USING phrase in the Procedure Division header of the program being compiled. The USING

phrase is used only in COBOL subprograms. It defines the program as being a subprogram and optionally identifies the data expected from the calling program. The Procedure Division header has the following format:

```
PROCEDURE DIVISION [USING  [data-name-1  ,  data-name-2]...].
```

A subprogram, that does not process data (arguments) passed to it by a calling program, has only the word USING appended to the Procedure Division header. For example:

```
PROCEDURE DIVISION USING.
```

A subprogram that processes passed data, has a USING phrase with one or more data-names specified. If a data-name(s) is specified, the program must also contain a Linkage Section in the Data Division. The Linkage Section describes the size and type of data being passed. (See Figure 9-1, Sample LINKAGE SECTION and USING phrase).

```
LINKAGE SECTION.

*     SUBPROGRAM-DATA.

01        1ST-PARAMETER  PIC X(5).

01        2ND-PARAMETER  PIC X(5).

01        3RD-PARAMETER  PIC X(5).

PROCEDURE DIVISION USING 2ND-PARAMETER, 3RD-PARAMETER.
```

NOTES

1. All of the data-names appearing in the using phrase must also appear in the LINKAGE SECTION.

2. Not all of the data-names in the LINKAGE SECTION need appear in the USING phrase.

3. A LINKAGE SECTION can appear in a subprogram even if the USING phrase does not contain a data-name. However, if any of the data-items contained in the LINKAGE SECTION are referenced in procedures, the compiler will issue a fatal diagnostic.

Figure 9-1 Sample LINKAGE SECTION and USING Phrase

9.1.1 Calling a COBOL Subprogram from a COBOL Program

To call a subprogram from a COBOL program, a CALL statement having the following format must be used:

```
CALL literal [USING data-name-1 [, data-name-2]...].
```

Where:

literal	is the name that appears in the PROGRAM-ID entry of the called program.
data-name-1 through data-name-n	identify those data-items in the calling program that can be referred to by the called program.

9.1.2 Returning from a COBOL Subprogram

In addition to the required USING phrase and optional LINKAGE SECTION, a subprogram should contain at least one EXIT PROGRAM statement. The EXIT PROGRAM statement identifies the subprogram return point. That is, the point in the subprogram at which control is returned to the calling program. If the EXIT PROGRAM statement is missing, the COBOL compiler will generate one after the last statement in the program.

NOTE

More than one EXIT PROGRAM statement is allowed in a subprogram.

9.2 UNIQUENESS OF PSECT NAMES

The names of all PSECTs within a task must be unique. When a task is composed of more than one COBOL program, you must insure that the PSECTs generated by the COBOL compiler for each program are unique. (See Appendix E, Section E.1, PSECT Naming Conventions).

9.3 COBOL OTS - ERROR CHECKING

At task execution, the COBOL OTS performs a check to insure that the number of arguments passed to a called COBOL subprogram is the same as the number expected. That is, the subprogram Procedure Division USING phrase must contain the same number of data-names as the USING phrase in the calling programs CALL statement. If the number of data-names in each USING phrase are not equal, the OTS issues a diagnostic error message and aborts the task. No checks are made to insure that the passed arguments are the same size as the expected arguments. It is your responsibility to insure that these sizes are compatible.

Recursive calls to COBOL subprograms are not allowed. If a COBOL subprogram contains a CALL statement that directly or indirectly causes a subprogram to be re-entered before it has exited from its original entry, the OTS will issue a diagnostic error message and abort the task.

9.4 INCLUDING A MACRO OBJECT MODULE IN A COBOL TASK

MACRO object modules can be combined with COBOL object modules at link time to produce a single task image. To activate a COBOL subprogram, a MACRO calling program must contain the equivalent of a COBOL CALL statement. If data is being passed to the COBOL subprogram, program register R5 must be set to the address of an argument list. The argument list must contain pointers to the data being passed. (See Figure 9-2, Argument List Format.)

A MACRO subprogram, to be activated by a COBOL program, must contain the equivalent of the COBOL PROGRAM-ID statement and the COBOL EXIT PROGRAM statement (See Example 1 below). If data is being passed, the MACRO subprogram can access that data using program register R5.

The following sections provide an example of how MACRO programs can be written for inclusion in a COBOL task image.

Example 1 - (Calling MACRO Programs from COBOL)

The format for calling any program from COBOL is:

```
CALL literal [USING data-name-1[, data-name-2]...]
```

when a MACRO program is being called, literal contains the global entry point specified in the MACRO program. If the COBOL program contains:

```
CALL "BILBO" USING BOFFIN, BOMBUR, BOFUR.
```

The MACRO program must contain:

```
.GLOBL BILBO  )
              }  ;entry point - equivalent to PROGRAM-ID
BILBO:        )
      .
      .
      .
      .
    RTS PC      ;return point - equivalent to EXIT PROGRAM
```

If there are any arguments to be passed to the called program (BOFFIN, BOMBUR, and BOFUR in this example), these arguments can be accessed through program register R5.

Example 2 - (Calling COBOL Programs from MACRO)

When the calling program is a MACRO program, control is passed to the called program with the following instruction:

```
JSR PC,subprogram-name
```

Where: Subprogram-name is the first six characters of the COBOL PROGRAM-ID.

If the MACRO program contains:

```
.GLOBL  FRODO
        .
        .
        .
        .
        MOV #ARGLST,R5      ;point R5 to argument list

        JSR PC,FRODO        ;subprogram call statement
```

The COBOL subprogram will contain:

```
PROGRAM-ID.  FRODO
        .
        .
        .
        .
LINKAGE SECTION.

*     FRODO-ARGUMENTS.

01    BOFFIN          PIC X(5).

01    BOMBUR          PIC X(5).

01    BOFUR           PIC X(5).
        .
        .
        .
        .
PROCEDURE DIVISION USING BOFFIN,BOMBUR.
        .
        .
        .
        .
        EXIT PROGRAM.
```

The MACRO program, in this example, has set R5 to point to the argument list expected by the COBOL program. The COBOL OTS will use R5 to access the passed arguments.

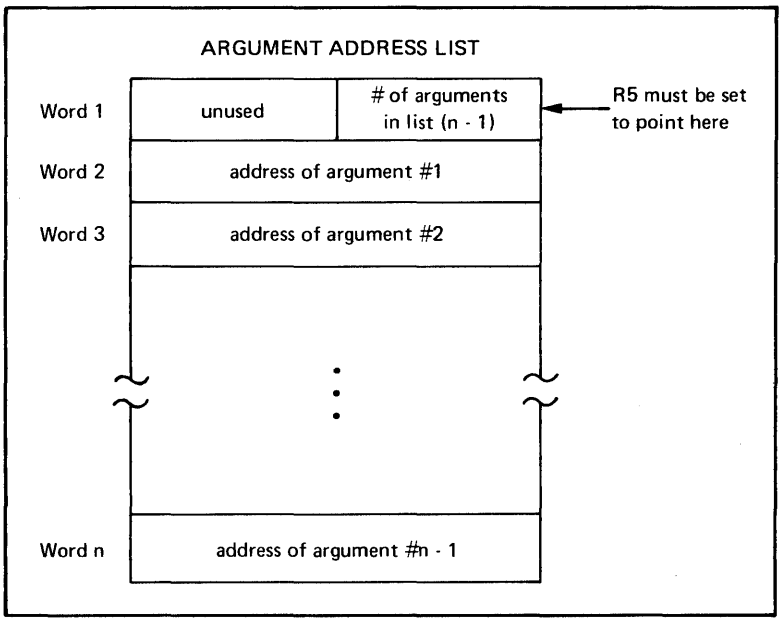


Figure 9-2 Argument Address List

CHAPTER 10

HAND-TAILORING ODL FILES

This chapter is provided as a guide to those of you who are faced with the problem of having to generate ODL files that are compatible with either the Merge Utility or the TRAX Linker. The most common reason for having to hand tailor an ODL file occurs when non-COBOL programs are being merged into a COBOL task image. The information presented here is predicated on the assumption that you have read and are familiar with the TRAX Linker Reference Manual that pertains to your operating system. The following sections describe the standard ODL file as it pertains to TRAX COBOL.

10.1 STANDARD ODL FILE

The standard ODL file generated by the TRAX COBOL compiler consists of a header and a body. The header contains information that is required to merge one or more ODL files. The body contains ODL directives that describe the object program.

10.2 ODL FILE HEADER

The ODL file header consists of a sequence of comment lines. Two are required in every ODL file, others are supplied as needed. The required comment lines are:

```
;COBOBJ=XXXXXX.OBJ
;COBKER=KK
```

Where:

XXXXXX.OBJ	is the name of the object module being described
KK	is the kernel that was used to generate the PSECT names for the COBOL program.

The following comment lines are supplied as needed:

;COBMAIN	This comment line is supplied if the program being described is a main program. The absence of this line means that the ODL file was generated for a COBOL subprogram.
;RMSSEQ=CIOOXY	This comment line is specified if the program requires RMS-11 I/O support. One or more lines may be supplied. X and Y represent integer codes that respectively specify the file organization and operational support required for that

organization. File organization is specified by the following codes:

CODE	ORGANIZATION
1	sequential
2	relative
3	indexed

The values allowed for the operational support code are meaningful only to future versions of TRAX COBOL and the Merge Utility. Therefore, they are not defined here.

10.3 ODL FILE BODY

The ODL file body describes the overlay structure of the COBOL program. The body contains the following ODL directive types:

1. .PSECT defines the name of the code PSECT and makes it known to the TRAX Linker.
2. .NAME defines the name to be assigned to the overlay segment by the Task Builder.
3. .FCTR describes the contents of the segments.
4. .ROOT defines the root.
5. .END informs the TRAX Linker that the end of the ODL file has been reached.
6. ;comments contains comment entries.

The .ROOT and .END directives are not supplied by the COBOL compiler. They are inserted into the ODL file generated by the Merge Utility. If you are generating a stand alone ODL file, these directives must be supplied by you. If the ODL file you are generating is to be used as input to the Merge Utility, leave these directives out.

Within a compiler-generated ODL file, the directives .PSECT, .NAME, and .FCTR are generated around the PSECT kernel. If the PSECT name kernel for a given program is KK, the format of the names generated in the ODL file is:

Entity	Format of Name
.PSECT	$KKMMM
.NAME	KK$MMM
.FCTR	KKMMM$

Each .PSECT defined in the ODL file begins with a $ followed by the two character kernel ($KK). Each .NAME directive begins with the two character kernel followed by $ (KK$). Finally, each .FCTR directive begins with the two-character kernel and ends with a $ (KKMMM$).

10.4 COMPILER-GENERATED ODL FOR COBOL PSECTS

The following sections discuss the ODL directives generated for different types of overlay requirements. The characters NNN when used in examples refer to the three character suffix generated by the compiler for each PSECT. The characters KK refer to the kernel characters that make the PSECT unique to a particular compilation.

10.4.1 ODL Generated for Overlays Containing Only One PSECT

For overlays containing only one PSECT, the following lines are generated:

```
            .PSECT    $KKNNN,GBL,RW,CON,I

            .NAME     KK$NNN,GBL

KKNNN$      .FCTR     *KK$NNN-$KKNNN
```

10.4.2 ODL Generated for Overlays Containing More Than One PSECT

For each overlay that contains more than one PSECT, a .PSECT directive is generated for each PSECT in the overlay. These .PSECT directives are followed by a .NAME and .FCTR directive. Consider the following example.

Example

Two PSECTs, $AA001 and $AA002, are to be placed in the same overlay. The segment-number assigned to the PSECTs is 20. The following ODL directives are generated:

```
            ;DEFINE   PSECT $AA001

            .PSECT    $AA001,GBL,RW,CON,I

            ;DEFINE   PSECT $AA002

            .PSECT    $AA002,GBL,RW,CON,I

            ;DEFINE THE OVERLAY NAME

            .NAME     AA$020,GBL

            ;DEFINE OVERLAY CONTENTS

AA020$:     .FCTR     *AA$020-$AA001-$AA002
```

10.4.3 ODL Generated for All Overlayable PSECTs

All .FCTR directives that describe the overlayable PSECTs must be collapsed into one final .FCTR directive. This directive describes the entire overlayable portion of the object code. The name associated with this .FCTR directive is derived from the two-character kernel assigned to the PSECTs. If the kernel is KK, then the name of the .FCTR directive that describes the entire overlayable part of the object code is KKOVR$.

The following example shows how the KKOVR$ factor is developed for various overlay configurations:

Example 1: All Code Psects Overlay One Another

```
          .PSECT    $AA001,GBL,RW,CON,I
          .NAME     AA$001,GBL
AA001:    .FCTR     *AA$001-$AA001
          ;
          .PSECT    $AA002,GBL,RW,CON,I
          .NAME     AA$002,GBL
AA002$:   .FCTR     *AA$002-$AA002
          ;
          .PSECT    $AA003,GBL,RW,CON,I
          .NAME     AA$003,GBL
AA003$:   .FCTR     *AA$003-$AA003
          ;
          .PSECT    $AA004,GBL,RW,CON,I
          .NAME     AA$004,GBL
AA004$:   .FCTR     *AA$004-$AA004
          ;
          .PSECT    $AA005,GBL,RW,CON,I
          .NAME     AA$005,GBL
AA005$:   .FCTR     *AA$005-$AA005
          ;IN THIS EXAMPLE, ALL PSECTS OVERLAY
          :ONE ANOTHER.
AAOVR$:   .FCTR     (AA001$,AA002$,AA003$,AA004$,AA004$,AA005$)
```

Example 2: Two Code Psects Are in the Same Overlay

```
          .PSECT    $AA001,GBL,RW,CON,I
          ;
          .PSECT    $AA002,GBL,RW,CON,I
          ;
          .NAME     AA$001,GBL
AA001$:   .FCTR     *AA$001-$AA001-$AA002
          ;
          .PSECT    $AA003,GBL,RW,CON,I
          .NAME     AA$003,GBL
AA003$:   .FCTR     *AA$003-$AA003
          ;
          .PSECT    $AA004,GBL,RW,CON,I
          .NAME     AA$004,GBL
AA004$:   .FCTR     *AA$004-$AA004
          ;
          .PSECT    $AA005,GBL,RW,CON,I
          .NAME     AA$005,GBL
AA005$:   .FCTR     *AA$005-$AA005
          ;
AAOVR$:   .FCTR     AA001$,AA003$,AA004$,AA005$
```

Example 3: Two Occurrences of Two Psects in the Same Overlay

```
          ;IN THIS EXAMPLE, PSECTS $AA001 AND $AA002
          ;ARE IN THE SAME OVERLAY. PSECTS $AA003
          ;AND $AA004 ARE IN THE SAME OVERLAY.
          ;PSECT $AA005 IS IN AN OVERLAY ALL BY ITSELF
          ;
          ;PSECT    $AA001,GBL,RW,CON,I
          ;
          ;PSECT    $AA002,GBL,RW,CON,I
          ;
          .NAME     AA$001,GBL
```

```
AA001$:   .FCTR     *AA$001-$AA001-$AA002
          ;
          ;PSECT    $AA003,GBL,RW,CON,I
          ;
          .PSECT    $AA004,GBL,RW,CON,I
          ;
          .NAME     AA$003,GBL
AA003$:   .FCTR     *AA$003-$AA003-$AA004
          ;
          .PSECT    $AA005,GBL,RW,CON,I
          .NAME     AA$005,GBL
AA005$:   .FCTR     *AA$005-$AA005
          ;
AAOVR$:   .FCTR     AA001$,AA003$,AA005$
```

10.5 MERGING STANDARD ODL FILES

To develop an ODL file for a task composed of more than one COBOL object program, it is necessary to merge the ODL files for each individual object program into a single ODL file that describes the overlay requirements for the task.

All of the ODL files to be merged are partial ODL files. That is, none of these ODL files can be submitted directly to the Linker to link a task; because, none of the compiler generated ODL files contain a .ROOT directive. The .ROOT directive that describes the task is supplied by the Merge Utility.

Merging COBOL compiler generated ODL files is accomplished by executing the ODL merge utility. (See Section 2.6, Using The ODL Merge Utility).

10.6 INCLUDING NON-COBOL PROGRAMS IN A TASK

To use the Merge Utility to include a non-COBOL object module in a task image, you must:

1. Create a standard COBOL ODL file (use the DEC editor)

2. Specify this ODL file as input to the ODL Merge Utility.

10.6.1 Creating a Standard COBOL ODL File

A standard COBOL ODL file for a non-COBOL object module contains one or two directive lines:

1. Object Program ID Line - This line is required. It identifies the object module to be included in the task image. The format of this line is:

   ```
   ;COBOBJ=XXXXXX.OBJ
   ```

   Where XXXXXX.OBJ is the name of the object module to be included in the task image.

2. Main Program ID Line - This line is present only for non-COBOL object modules that are main programs as opposed to being subprograms. The format of the line is:

```
;COBMAIN
```

For each invocation of the COBOL ODL Merge Utility, one and only one main program ODL file can be specified. If no main program ODL file is specified, the Merge Utility continues to request more input until a main program ODL file is specified. If more than one main program ODL file is specified, all but the first is rejected, and appropriate diagnostic error messages are issued. Consider the following examples.

Example 1

MACRO program START.OBJ is a main program in a task consisting of a main program and several subprograms. The ODL file to be hand-generated is:

```
;COBOBJ=START.OBJ
;COBMAIN
```

Example 2

Macro subprogram SUBX.OBJ is to be part of a task image that consists of several COBOL subprograms and a COBOL main program. The ODL file to be hand-generated is:

```
;COBOBJ=SUBX.OBJ
```

10.7 REARRANGING A COMPILER-GENERATED ODL FILE

The ODL file generated by the compiler can be rearranged to modify the overlay structure of a task. If the ODL file describes a task that has overlayable segments, one or more of these segments can be converted into non-overlayable segments by:

1. Modifying the compiler-generated ODL file.

2. Specifying a one-line Linker option at Link time for each segment made non-overlayable.

10.7.1 Modifying the Compiler-Generated ODL File

Modifying the compiler generated ODL file requires the following steps:

1. Each overlayable segment is named in the ODL file by an ODL .NAME directive. This .NAME directive must be removed.

2. Each name appearing in a .NAME directive is marked with an * and placed as the first element of a .FCTR directive. For each .NAME directive removed by step 1, this .FCTR directive must be removed.

3. All references to the name of the .FCTR directive removed in step 2 must be removed from the ODL file.

4. All PSECTs referenced in the .FCTR directive that was removed in step 3, must be removed from the ODL file.

Example

The task image contains three overlayable segments, C$$010, C$$015, and C$$020. Segment C$$020 is to be forced into the root. Figure 10-1 contains a listing of the merged ODL file.

```
;MERGED ODL FILE CREATED ON 26-JAN-77 AT 10:50:00
;COBOL STANDARD ODL FILE GENERATED ON: 26-JAN-77   10:48:37
;COBOBJ=TEST1.OBJ
;COBKER=C$
;COBMAIN
          .NAME C$$010,GBL
          .PSECT $C$003,GBL,I,RW,CON
C$010$:   .FCTR *C$$010-$C$003
          .NAME C$$015,GBL
          .PSECT $C$004,GBL,I,RW,CON
C$015$:   .FCTR *C$$015-$C$004
          .NAME C$$020,GBL
          .PSECT $C$005,GBL,I,RW,CON
C$020$:   .FCTR *C$$020-$C$005
C$OVR$:   .FCTR          C$010$,C$015$,C$020$
CBOBJ$:   .FCTR TEST1.OBJ
CBOVR$:   .FCTR C$OVR$
CBOTS$:   .FCTR [320,13]COBLIB/LB
RMS$:     .FCTR  [1,1]RMSLIB/LB
OBJRT$:   .FCTR CBOBJ$-CBOTS$-RMS$
          .ROOT OBJRT$-(CBOVR$)
          .END
```

Figure 10-1 Merged ODL File Listing

To force segment C$$020 into the root, the merged ODL file must be modified as follows:

1. The .NAME directive referencing C$$020 must be removed.

2. The .FCTR directive containing *C$$020 must be removed.

3. All references to the PSECTs in the removed .FCTR directive must be removed.

Figure 10-2 contains the ODL listing after the modifications have been made.

```
;MERGED ODL FILE CREATED ON 26-JAN-77 AT 10:55:22
;COBOL STANDARD ODL FILE GENERATED ON: 26-JAN-77   10:48:37
;COBOBJ=TEST1.OBJ
;COBKER=C$
;COBMAIN
          .NAME C$$010,GBL
          .PSECT $C$003,GBL,I,RW,CON
C$010$:   .FCTR *C$$010-$C$003
          .NAME C$$015,GBL
          .PSECT $C$004,GBL,I,RW,CON
C$015$:   .FCTR *C$$015-$C$004
C$OVR$:   .FCTR          C$010$,C$015$
CBOBJ$:   .FCTR TEST1.OBJ
CBOVR$:   .FCTR C$OVR$
CBOTS$:   .FCTR [1,1]COBLIB/LB
RMS$:     .FCTR  [1,1]RMSLIB/LB
OBJRT$:   .FCTR CBOBJ$-CBOTS$-RMS$
          .ROOT OBJRT$-(CBOVR$)
          .END
```

Figure 10-2 Modified ODL File

10.7.2 Specifying LINKER Options

For each overlayable segment made non-overlayable, a GBLDEF LINKER option must be specified at link time. The format of the option is:

```
GBLDEF=KK$MMM:O
```

Where:

KK$MMM is the name of the segment that is being made non-overlayable. (This is the name in the .NAME ODL directive that was deleted when the ODL file was modified).

Consider the following example.

Example

To make the overlayable segment (C$$020) described in the example in Section 11.7 non-overlayable, enter the following in response to the Linker ENTER OPTIONS prompt:

```
GBLDEF C$$020 (RET)
```

Figure 10-3 shows the overlay description of the task image before and after segment C$$020 was made non-overlayable.

```
BEFORE

TEST1.TSK;1     MEMORY ALLOCATION MAP  TKB M27
                       26-JAN-77   10:51



PARTITION NAME : GEN
IDENTIFICATION : 026108
TASK  UIC      : [320,4]
STACK    LIMITS: 000176 001175 001000 00512.
PRG XFR ADDRESS: 022514
TOTAL ADDRESS WINDOWS: 1.
TASK  IMAGE  SIZE  : 6880. WORDS
TASK ADDRESS LIMITS: 000000 032657



TEST1.TSK;1 OVERLAY DESCRIPTION:


BASE      TOP         LENGTH


000000    032507   032510  13640.       TEST1
032510    032607   000100  00064.            C$$010   3 overlayable
032510    032657   000150  00104.            C$$015
032510    032617   000110  00072.            C$$020   segments
```

```
AFTER


TEST2.TSK;2     MEMORY ALLOCATION MAP  TKB M27
                       26-JAN-77   10:57



PARTITION NAME : GEN
IDENTIFICATION : 026108
TASK  UIC      : [320,4]
STACK    LIMITS: 000176 001175 001000 00512.
PRG XFR ADDRESS: 022514
TOTAL ADDRESS WINDOWS: 1.
TASK  IMAGE  SIZE  : 6912. WORDS
TASK ADDRESS LIMITS: 000000 032743



TEST2.TSK;2 OVERLAY DESCRIPTION:


BASE      TOP         LENGTH


000000    032573   032574  13692.       TEST1
032574    032673   000100  00064.            C$$010   2 overlayable
032574    032743   000150  00104.            C$$015   segments
```

Figure 10-3 Overlay Description Map Before and After Modification

CHAPTER 11

ERROR MESSAGES

11.1 COMPILER SYSTEM ERRORS

The TRAX COBOL compiler is a complex system program consisting of many program overlays that manipulate numerous data structures. Throughout the compiler, consistency checks are performed on program flow and the contents of data fields. If the compiler detects an inconsistency, it types a message on the console and terminates the compilation. A system error message has the following format:

```
SYSTEM ERROR NNNNN
```

where NNNNN is a number used by the DEC COBOL developers to determine the probable cause of the error. When a system error occurs, the compiler's input file is closed and all output files (object, list, and ODL) are closed and deleted.

In the event of a TRAX COBOL compiler system error, contact your DEC Software Support Specialist immediately.

11.2 DIAGNOSTIC ERROR MESSAGES

This chapter contains a numerical listing of the diagnostic messages generated by the TRAX COBOL compiler. The compiler generates these messages whenever it detects an error in the source program. In general, a source error detected by the compiler results in the associated diagnostic message being embedded within the source program listing. That is, when an error is detected in the source program, the compiler prints the diagnostic message either before or after the erroneous source program line. There are two exceptions to the general concept of "embedded diagnostics":

1. There may be diagnostic messages listed after the last entry in the Data Division and before the Procedure Division header. These are diagnostics which logically can not be issued until the entire Data Division text is processed.

2. There may be diagnostic messages listed after the last line of the Procedure Division. These are diagnostics which logically can not be issued until the entire Procedure Division text is processed.

In addition to the error message number and message text, the display contains a source line number, which identifies the error line, and an alphabetic code (discussed below) which informs the user of the seriousness of the error. The information within a diagnostic message line is displayed (from left to right) in the following order:

1. Alphabetic code,

2. Source line number,

3. Numerical error number,

4. Text of the diagnostic message.

For convenience, the alphabetic code is left-justified in the listing so the user merely scans the listing to identify any diagnostic message issued during compilation. Again, for the user's convenience, a summary of the number of errors detected during the compilation is given at the end of the source listings. If no errors are detected during the compilation, the compiler prints "NO ERRORS" at the end of the source listing.

The following illustration shows a typical diagnostic message and the manner in which it appears on the source listing:

```
  00096          MOVE 72.5 TO N2
  00097          IF N2 NOT = T2 DISPLAY "? #10".
  00098      *
  00099          MOVE 3250 TO N3.

I 00099 372 POSSIBLE LOW ORDER RECEIVING FIELD TRUNCATION.

  00100          IF N3 NOT = T3 DISPLAY "? #11".
  00101      *
  00102          MOVE -432 TO N4.
  00103          IF N4 NOT = T4 DISPLAY "? #12".
  00104      *
```

In the example, the diagnostic message is immediately identified by the appearance of the left-justified alphabetic code I. The alphabetic code indicates that the message is an I-type (informational) diagnostic; the diagnostic is issued for source line number 99; the error number is 372; and the text of the message is POSSIBLE LOW ORDER RECEIVING FIELD TRUNCATION. Note that the diagnostic message line, in this example, appears after the source line for which it was issued.

The error messages, used in conjunction with this chapter, provide the user with an important debugging tool. This chapter contains information necessary for interpreting the messages. It explains what caused the error and how the compiler handled the error.

Since different errors cause varying degrees of problems for the compiler (some do not affect the compilation at all, while others may be so critical that they cause an abort of the compilation), the TRAX COBOL compiler provides four general types (or severity levels) of diagnostic messages. Alphabetic codes (I, W, F, and A) identify these error levels. When it detects an error in the source program, the compiler attempts to recover from the error and continue to compile the program. This recovery action may force the compiler to make an assumption about the source program. The four levels of diagnostic messages are categorized according to the likelihood that the result of the compiler's assumption will be an object program that runs as originally intended by the programmer.

The following list explains the purpose of and the compiler's action for each of the four message levels:

I (Informational) Informative diagnostic. The purpose of such a diagnostic is to convey information to the user in an observational or advisory capacity. The compiler's error recovery (if any is required) is almost certain to be that desired by the user.

W (Warning) Warning diagnostic. The purpose of this type of message is to warn the user that something is wrong with the associated source statement, but that the compiler can take corrective action on the source element in error. The compiler's recovery action may not be that desired by the user, but the statement, as corrected by the compiler, will be executable.

F (Fatal) Fatal diagnostic. The purpose of such a diagnostic is to indicate to the user that something is fatally wrong with the indicated source statement. By fatal, the compiler means it cannot generate the object code required for the functionality the programmer coded in the erroneous source statement. The compiler's error recovery action will probably leave out a portion of the source program. In general, the compiler will not produce an object program for COBOL source programs which have F-type errors in them. However, the user can force the compiler to generate an object program by specifying the /ACC:2 switch in the command string input to the compiler prior to compilation (See Section 2.4, Compiler Switches for a detailed explanation of the /ACC:n switch.) The /ACC:2 switch instructs the compiler to generate an object program, even if the source program contains F-type errors. In this case, when an F-type error is detected in the Procedure Division, the compiler generates special error trap object code in place of the incorrect source statement. When the object program is executed and the special error trap code is encountered, the software displays the following message on the console and aborts the program execution:

FATAL ERROR ON SOURCE LINE XXXXX

where XXXXX is the source line number for which an F-type diagnostic was issued during compilation. For F-type diagnostics issued in the Identification, Environment, and Data Divisions, no special error trap coding is generated since, in general, executable code is not generated for these divisions. However, the fact that F-type diagnostics are issued for these divisions can have a definite effect on the behavior of the execution of the object program.

WARNING

When the user specifies the /ACC:2 switch, the user is formally acknowledging to the software a willingness to let the program go into execution even though it may have fatal errors in it. Because the source program has very severe errors in it, the behavior of the associated object program is, in general, unpredictable. In certain cases, such as a COBOL program with files opened in I-O mode, letting the program with F-type errors go into execution could be disastrous. Thus, the /ACC:2 switch should be used with caution. The facility is provided as an extra debugging option. It can be useful in shortening the compile-debug cycle, particularly if

applied to large COBOL programs which take considerable compilation time. The point is that the user should use the /ACC:2 facility wisely and discretely.

A (Abortive) Abortive diagnostic. The purpose of this type of diagnostic is to inform the user that the compiler must abort compilation. The compiler's error recovery is not possible: it can make no valid assumptions and has no choice but to abort the compilation.

Appendix G contains the TRAX COBOL compiler diagnostic error messages arranged in numerical order for easy reference.

11.3 RUNTIME FILE I/O ERROR PROCEDURES

When an error condition occurs during I/O operations, the following procedure is used:

1. If the file status key for the file is present, it is set to the appropriate code for the error condition. (See Table 11-1 for sequential file status keys, or Table 11-2 for relative and indexed file status keys.)

2. If an AT END or INVALID KEY imperative condition is specified for the I/O operation, the path indicated by the imperative statement is taken. The file system performs no other processing in the file for the current statement. The USE procedure, if one is declared for the file, is not performed.

3. If no AT END or INVALID KEY imperative condition is specified for the I/O operation and a USE procedure is declared for the file, the USE procedure section is performed, and then control is returned to the program. The file system performs no further processing for this file.

   If no USE procedure is declared for the file, a fatal error condition exists; the OTS aborts the program and displays the following I/O error message:

```
"CBL -- 37:  FILE:  NN...  NO USE PROCEDURE FOR
                I/O ERROR"
"CBL -- RECORD MANAGEMENT SERVICES - XX"
```

NN represents the name of the file:

XX represents the Record Management Services error code. (See Appendix H for these error codes.)

ERROR MESSAGES

The following tables show various error numbers and error codes that identify error conditions and messages. The error codes in Tables 11-1 and 11-2 are accessible to the user's program through the declaration and use of the FILE STATUS key in the program. The error codes in Appendix G are not returned to the user's program but represent error conditions detected by Record Management Services.

The error message numbers in Appendix G are merely identifying numbers for the messages and appear at the user terminal in the following form:

"CBL --nn: message ... "

nn is the message number.

Tables 11-1 and 11-2 contain status key codes. The left-hand digit of the status key code is status key 1, and the right-hand digit is status key 2.

Table 11-1
Sequential I/O File Status Key Values (ASCII)

Status Key Code	Meaning
00	No further information (successful)
10	End-Of-File indicator detected
30	Permanent error
34	Permanent error (boundary error on WRITE statement)
91	File locked by another task
93	REWRITE attempted without prior READ
94	Improper operation attempted
95	Allocation failure on OPEN (no file space on device)
96	No buffer space (program tried to open a file that is sharing buffer space (SAME AREA) with another file)
97	No such file (the file named in an OPEN statement was not found)
98	CLOSE error (error discovered while in the process of closing the file)

Table 11-2
Relative And Indexed I/O File Status Key Values (ASCII)

Status Key Code	Meaning
00	No further information (successful)
02	Duplicate alternate record key values were successfully created during the execution of a WRITE or REWRITE statement
10	End-Of-File indicator detected
21	Sequence error on primary key during the execution of a WRITE or REWRITE statement
22	Duplicate key error
23	No such record error
24	Boundary error on WRITE statement
30	Permanent error
91	File locked by another task
92	Record locked by another task
93	REWRITE or DELETE attempted without prior READ
94	Improper operation attempted
95	Allocation failure (no file space on device)
96	No buffer space (program tried to open a file that is sharing buffer space (SAME AREA) with another file)
97	No such file (the file named in an OPEN statement was not found)
98	CLOSE error (error discovered while in the process of closing the file)

11.4 RUN-TIME ERROR MESSAGES

Appendix I contains a list of the COBOL Object Time System (OTS) error messages. Wherever it can, the COBOL OTS will list auxiliary information along with the error message. This auxiliary information is defined in Section 11.4.1.

11.4.1 OTS Auxiliary Error Message Information

Following each OTS error message, the OTS will attempt to display additional clarifying information. This information is intended to direct you to the exact source line statement causing the error. The auxiliary information has the following format:

```
PROGRAM-ID AAAAAA , IDENT:  BBBBBB

IN PSECT:  CCCCCC

AT OFFSET:  DDDDDD
```

Where:

AAAAAA — is the first six characters of the PROGRAM-ID specified in the source program.

BBBBBB — is the value appearing in the IDENT field of compiler listing.

CCCCCC — is the name of the procedural code PSECT containing the error.

DDDDDD — is the octal byte offset (within PSECT CCCCCC) at which the error occurred.

If the statement in error is a PERFORM, the nested PERFORM stack, containing the source line location of every PERFORM statement encountered thus far, is displayed (see Example 1). If an error is detected while a chain of nested CALL statements is being processed, auxiliary information is displayed for each element in the chain (see Example 2).

To take full advantage of this auxiliary information, you must have compiled the source program with the /MAP and /OBJ switches specified. Using the PSECT name (CCCCCC) and octal byte offset (DDDDDD), in conjunction with the Procedure Name Map, you can identify the two source procedure names that bracket the location of the error. Also, using the octal byte offset (DDDDDD) you can (via the /OBJ output listing) identify the specific verb causing the error. Consider the following examples:

Example 1

Figure 11-1 contains the listings generated for the COBOL program used in this example. Execution of the program depicted in Figure 11-1 will yield the following results:

```
RUN DIAG3

CBL -- 25:  ILLEGAL NESTED PERFORM AT SOURCE LINE 16
       PROGRAM ID:  DIAG3 , IDENT:  038105
       IN PSECT:  $ZZ001
       AT OFFSET:  000074
       NESTED PERFORM SOURCE LINE NUMBERS:
            00014
            00015

CBL -- 15:  STOP RUN

Ready
```

The PROGRAM-ID and IDENT line refer to the corresponding lines is the compiler listing (DIAG3 and 038105 in this example). The IN PSECT line identifies the exact PSECT containing the error ($ZZ001 in this example). See the Procedure Name Map in Figure 11-1. The AT OFFSET line identifies the octal byte offset within the PSECT at which the statement in error exists (000074 in this example). See the /OBJ compiler listing in Figure 11-1. Finally, the last three lines identify the source line location of every PERFORM statement encountered thus far in the program.

SAMPLE /OBJ LISTING

```
     CMD:DIAG3,DIAG3/MAP/OBJ/KE:ZZ=DIAG3
     IDENT:  038105

                                 00001          IDENTIFICATION DIVISION.
                                 00002          PROGRAM-ID. DIAG3.
                                 00003         *
                                 00004         *    INVOKE "?ILLEGAL NESTED PERFORM AT LINE XXXXX"
                                 00005         *
                                 00006          ENVIRONMENT DIVISION.
                                 00007          CONFIGURATION SECTION.
                                 00008          SOURCE-COMPUTER. PDP-11.
                                 00009          OBJECT-COMPUTER. PDP-11.
                                 00010          DATA DIVISION.
                                 00011          WORKING-STORAGE SECTION.
                                 00012          PROCEDURE DIVISION.
                                 00013          S0 SECTION.
     PERFORM  :  001  000024
                                 00014          P0. PERFORM P1 THRU P5.
     PERFORM  :  001  000050
                                 00015          P1. PERFORM P2 THRU P4.
     PERFORM  :  001  000074
                                 00016          P2. PERFORM P3 THRU P4.
                                 00017          P3.
                                 00018          P4.
                                 00019          P5.
```

SAMPLE PROCEDURE NAME MAP

PROCEDURE NAME MAP

NAME	SOURCE LINE	PSECT	OFFSET	SEG	SECT	PARA
S0	00013	$ZZ001	000024	00	S	
P0	00014	$ZZ001	000024	00		P
P1	00015	$ZZ001	000050	00		P
P2	00016	$ZZ001	000074	00		P
P3	00017	$ZZ001	000120	00		P
P4	00018	$ZZ001	000126	00		P
P5	00019	$ZZ001	000134	00		P

Figure 11-1
Sample Listing of Program Used in Example-1

Example 2

Figure 11-2 contains the listings generated for the COBOL programs used in this example. Execution of the programs depicted in Figure 11-2 will yield the following results:

```
RUN TEST
BEGIN MAIN PROGRAM
BEGIN SUB1 SUBPROGRAM
BEGIN SUB2 SUBPROGRAM

CBL -- 13: NULL ALTERABLE GO TO
       PROGRAM ID: SUB2 , IDENT: 080130
       IN PSECT:  $CC001
       AT OFFSET:  000062
       LISTING OF NESTED ENVIRONMENTS:
       PROGRAM ID: SUB1 , IDENT: 080130
       AT OFFSET:  000054
       PROGRAM ID: MAIN , IDENT: 080129
       AT OFFSET: 000042

CBL -- 15: STOP RUN

Ready
```

As in the previous example, the PROGRAM-ID and IDENT lines refer to the corresponding lines in the compiler listing; the IN PSECT line identifies the exact PSECT containing the error; and the AT OFFSET line identifies the octal byte offset. Note also, that this information is repeated for every program within the chain of subprograms comprising the task.

```
SAMPLE /OBJ LISTING (Main Program)


CMD:MAIN,MAIN/KE:AA/OBJ/MAP=MAIN
IDENT: 080129



                                00001          IDENTIFICATION DIVISION.
                                00002          PROGRAM-ID. MAIN.
                                00003          ENVIRONMENT DIVISION.
                                00004          CONFIGURATION SECTION.
                                00005          SOURCE-COMPUTER. PDP-11.
                                00006          OBJECT-COMPUTER. PDP-11.
                                00007          DATA DIVISION.
                                00008          WORKING-STORAGE SECTION.
                                00009          77 A PIC 99.
                                00010          77 B PIC 99.
                                00011          77 C PIC 99.
                                00012          PROCEDURE DIVISION.
                                00013          S0 SECTION.
                                00014          P0.
    DISPLAY  :  01  000024
                                00015              DISPLAY "BEGIN MAIN PROGRAM".
    CALL     :  01  000042
                                00016              CALL "SUB1" USING A B C .
    DISPLAY  :  01  000060
                                00017              DISPLAY "ENDING MAIN PROGRAM".
    STOP     :  01  000076
                                00018              STOP RUN.
```

```
SAMPLE PROCEDURE MAP (Main Program)


                          PROCEDURE NAME MAP

    NAME                          SOURCE   PSECT    OFFSET  SEG  SECT   PARA
                                   LINE

    S0                            00013    $AA001   000024  00    S
    P0                            00014    $AA001   000024  00           P
```

Figure 11-2 Sample Listing of Program Used in Example-2

```
SAMPLE /OBJ LISTING (Subprogram)


CMD:SUB1,SUB1/KE:BB/OBJ/MAP=SUB1
IDENT: 080130



                                00001         IDENTIFICATION DIVISION.
                                00002         PROGRAM-ID. SUB1.
                                00003         ENVIRONMENT DIVISION.
                                00004         CONFIGURATION SECTION.
                                00005         SOURCE-COMPUTER. PDP-11.
                                00006         OBJECT-COMPUTER. PDP-11.
                                00007         DATA DIVISION.
                                00008         WORKING-STORAGE SECTION.
                                00009         LINKAGE SECTION.
                                00010         77 D PIC 99.
                                00011         77 E PIC 99.
                                00012         77 F PIC 99.
                                00013         PROCEDURE DIVISION USING D E F .
                                00014         S1 SECTION.
                                00015         P1.
    DISPLAY  :  01  000024
                                00016             DISPLAY "BEGIN SUB1 SUBPROGRAM".
    SUBTRACT :  01  000042
                                00017             SUBTRACT D FROM E GIVING F .
    CALL     :  01  000054
                                00018             CALL "SUB2" USING D E F .
    DISPLAY  :  01  000072
                                00019             DISPLAY "EXITING SUB1 SUBPROGRAM".
    STOP     :  01  000110
                                00020             STOP RUN .
```

```
SAMPLE PROCEDURE MAP (Subprogram)


                        PROCEDURE NAME MAP

    NAME                          SOURCE   PSECT    OFFSET  SEG  SECT   PARA
                                   LINE

    S1                            00014    $BB001   000024  00    S
    P1                            00015    $BB001   000024  00          P
```

Figure 11-2 (Cont.) Sample Listing of Program Used in Example-2

APPENDIX A

THE COBOL FORMATS

COBOL NOTATION USED IN FORMATS

- Underlined upper-case words (key words) - required words;
- Upper-case words (not underlined) - optional words;
- Lower-case words - generic terms, must be supplied by the user;
- Brackets [] - enclosed portion is optional; if several enclosed words are vertically stacked, only one of them may be used;
- Braces {} - a selection must be made from the vertical stack of enclosed words;
- Ellipsis ... - the position at which repetition may occur;
- Comma and semicolon - optional punctuation;
- Period - required where shown in the formats.

```
IDENTIFICATION DIVISION.

PROGRAM-ID. program-name.
[AUTHOR. [comment-entry]...]
[INSTALLATION. [comment-entry]...]
[DATE-WRITTEN. [comment-entry]...]
[DATE-COMPILED. [comment-entry]...]
[SECURITY. [comment-entry]...]


ENVIRONMENT DIVISION.

CONFIGURATION SECTION.

SOURCE-COMPUTER.    PDP-11
OBJECT-COMPUTER.    PDP-11    [ MEMORY SIZE integer { WORDS      } ]
                                                    { CHARACTERS }
                                                    { MODULES    }
                    [PROGRAM COLLATING SEQUENCE IS alphabet-name]
                    [SEGMENT-LIMIT IS segment-number].
```

```
[SPECIAL-NAMES.

[CARD-READER IS mnemonic-name-1]
[CONSOLE IS mnemonic-name-2]
[LINE-PRINTER IS mnemonic-name-3]
[PAPER-TAPE-PUNCH IS mnemonic-name-4]
[PAPER-TAPE-READER IS mnemonic-name-5]
[SWITCH integer-1   {ON STATUS IS condition-name-1}
                    {OFF STATUS IS condition-name-2}
    [OFF STATUS IS condition-name-2]
    [ON STATUS IS condition-name-1] ]  ...
[Alphabet-name IS   {NATIVE       }]
                    {STANDARD-1   }
[CURRENCY SIGN IS literal-1]
[DECIMAL-POINT IS COMMA.]]

[INPUT-OUTPUT SECTION.

FILE-CONTROL. {file-control-entry}... .,
```

Format 1:

```
SELECT [OPTIONAL] file-name

     ASSIGN TO literal-1

     [; RESERVE integer-1      [AREA ]]
                               [AREAS]

     [; ORGANIZATION IS SEQUENTIAL]
     [; ACCESS MODE IS SEQUENTIAL]
     [; FILE STATUS IS data-name-1] .
```

Format 2:

```
SELECT file-name

     ASSIGN TO literal-1

     [; RESERVE integer-1      [AREA ]]
                               [AREAS]

      ; ORGANIZATION IS RELATIVE

     [; ACCESS MODE IS  {  SEQUENTIAL   [, RELATIVE KEY IS data-name-1]}]
                        {{ RANDOM    }                                  }
                        {{ DYNAMIC   }  RELATIVE KEY IS data-name-1     }

     [; FILE STATUS IS data-name-2] .
```

Format 3:

```
SELECT file-name

     ASSIGN TO literal-1

     [; RESERVE integer-1      [AREA ]]
                               [AREAS]

      ; ORGANIZATION IS INDEXED

     [; ACCESS MODE IS    {SEQUENTIAL}]
                          {RANDOM    }
                          {DYNAMIC   }

      ; RECORD KEY IS data-name-1
     [; ALTERNATE RECORD KEY IS data-name-2 [WITH DUPLICATES]]...
     [; FILE STATUS IS data-name-3] .

[I-O-CONTROL.
     [SAME [RECORD] AREA FOR file-name-1 {file-name-2}...]...
     [MULTIPLE FILE TAPE CONTAINS file-name-3 [POSITION integer-1]
       [file-name-4 [POSITION integer-2]...]...

     [APPLY     PRINT-CONTROL     ON file-name-5 [file-name-6]...] ...]]

DATA DIVISION.

[FILE SECTION.
[FD file-name

     [BLOCK CONTAINS [integer-1 TO] integer-2      {RECORDS   }]
                                                   {CHARACTERS}
     [RECORD CONTAINS [integer-3 TO]    integer-4    CHARACTERS]
     LABEL {RECORD IS  }      {STANDARD}
           {RECORDS ARE}      {OMITTED }
     [VALUE OF ID IS {data-name-1}]
                     {literal-1  }
     [DATA  {RECORD IS  }      data-name-3    [data-name-4] ...] ...
            {RECORDS ARE}
     [LINAGE IS      {data-name-5}   LINES    [WITH FOOTING AT  {data-name-6}]
                     {integer-5  }                              {integer-6  }
       [LINES AT TOP    {data-name-7}]  [LINES AT BOTTOM    {data-name-8}]]
                        {integer-7  }                       {integer-8  }
     [CODE-SET IS alphabet-name].
[record-description-entry]...]...]
[WORKING-STORAGE SECTION.
     [77-level-description-entry]
     [record-description-entry  ]    ...]
[LINKAGE SECTION.
     [77-level-description-entry]
     [record-description-entry  ]...]
```

Data description entry:

Format 1:

```
level-number { data-name-1 }
             { FILLER      }
        [REDEFINES data-name-2]
    [{ PICTURE } IS character-string]
    [{ PIC     }                    ]
    [                                                    ]
    [[USAGE IS] { COMPUTATIONAL }                        ]
    [           { COMP          }                        ]
    [           { DISPLAY       }                        ]
    [           { DISPLAY-6     }                        ]
    [           { DISPLAY-7     }                        ]
    [           { INDEX         }                        ]
    [                                                    ]
    [ [SIGN IS] { LEADING  } [SEPARATE CHARACTER]         ]
    [           { TRAILING }                             ]
    [{ SYNCHRONIZED } [{ LEFT  }]                        ]
    [{ SYNC         } [{ RIGHT }]                        ]
    [{ JUSTIFIED } RIGHT                                 ]
    [{ JUST      }                                       ]
        [BLANK WHEN ZERO]
        [VALUE IS literal]
    [OCCURS { integer-1 TO integer-2 TIMES DEPENDING ON data-name-3 }
            { integer-2 TIMES                                       }
        [{ ASCENDING  } KEY IS data-name-4 [data-name-5]... ] ...
        [{ DESCENDING }                                     ]
          [INDEXED BY index-name-1 [index-name-2] ...]    ] .
```

Format 2:

```
66 data-name-1 RENAMES data-name-2
    [{ THROUGH } data-name-3]
    [{ THRU    }             ]
```

Format 3:

```
88 condition-name { VALUE IS } literal-1 [{ THROUGH } literal-2]
                  { VALUES ARE }         [{ THRU    }          ]
    [literal-3 [{ THROUGH } literal-4]] ... .
               [{ THRU    }          ]
```

```
PROCEDURE DIVISION [USING [data-name-1][,data-name-2] ...].
```

Format 1:

```
[DECLARATIVES.
{section-name SECTION [segment-number] . declarative-sentence
[paragraph-name.[sentence]...]...}...
END DECLARATIVES.]
{section-name SECTION [segment-number].
[paragraph-name.[sentence]...]...}...
```

Format 2:

```
{paragraph-name.[sentence]...}...
```

STATEMENTS

```
ACCEPT identifier [FROM mnemonic-name]

ACCEPT identifier FROM  { DATE }
                        { DAY  }
                        { TIME }

ADD { identifier-1 } [ identifier-2 ]  ...  TO identifier-m [ROUNDED]
    { literal-1    }                        [identifier-n[ROUNDED]]...[ON SIZE ERROR imperative-statement]

ADD { identifier-1 } { identifier-2 } [ identifier-3 ]  ...
    { literal-1    } { literal-2    } [ literal-3    ]
  GIVING identifier-m [ROUNDED]  [identifier-n [ROUNDED]]  ...
         [ON SIZE ERROR imperative-statement]

ADD { CORRESPONDING } identifier-1 TO identifier-2 [ROUNDED]
    { CORR          }
     [ON SIZE ERROR imperative-statement]

ALTER procedure-name-1 TO [PROCEED TO] procedure-name-2
   [procedure-name-3 TO [PROCEED TO] procedure-name-4]  ...

CALL literal-1
   [USING data-name-1 [,data-name-2]...]

CLOSE file-name-1  [ { REEL } [ WITH NO REWIND ] ]
                   { UNIT } [ FOR REMOVAL      ] ]
                   [ WITH { NO REWIND } ]
                          { LOCK      } ]

      [ file-name-2  [ { REEL } [ WITH NO REWIND ] ] ]
                     { UNIT } [ FOR REMOVAL      ] ]
                     [ WITH { NO REWIND } ]
                            { LOCK      } ] ]

COMPUTE identifier-1 [ROUNDED] [identifier-2 [ROUNDED]] ...
  = arithmetic-expression [ON SIZE ERROR imperative-statement]

DELETE file-name RECORD    [INVALID KEY imperative-statement]

DISPLAY { identifier-1 } [ identifier-2 ]  ...
        { literal-1    } [ literal-2    ]
  [UPON mnemonic-name] [WITH NO ADVANCING]

DIVIDE { identifier-1 }    INTO identifier-2 [ROUNDED]
       { literal-1    }
         [identifier-3[ROUNDED]] ... [ON SIZE ERROR imperative-statement]

DIVIDE { identifier-1 }    INTO { identifier-2 }    GIVING identifier-3[ROUNDED]
       { literal-1    }        { literal-2    }
         [identifier-4[ROUNDED]]...[ON SIZE ERROR imperative-statement]

DIVIDE { identifier-1 }    BY   { identifier-2 }    GIVING identifier-3[ROUNDED]
       { literal-1    }        { literal-2    }
         [identifier-4[ROUNDED]]...[ON SIZE ERROR imperative-statement]

DIVIDE { identifier-1 }    INTO { identifier-2 }    GIVING identifier-3[ROUNDED]
       { literal-1    }        { literal-2    }
         REMAINDER identifier-4[ON SIZE ERROR imperative-statement]

DIVIDE { identifier-1 }    BY   { identifier-2 }    GIVING identifier-3[ROUNDED]
       { literal-1    }        { literal-2    }
         REMAINDER identifier-4[ON SIZE ERROR imperative-statement]
```

```
EXIT [PROGRAM]

GO TO [procedure-name-1]
GO TO procedure-name-1 [procedure-name-2]...procedure-name-n DEPENDING ON identifier

IF condition  { statement-1 }      { ELSE statement-2 }
              { NEXT SENTENCE }    { ELSE NEXT SENTENCE }

INSPECT identifier-1 TALLYING
    { identifier-2 FOR { { { ALL       } { identifier-3 } [ { BEFORE } INITIAL
                         { { LEADING   } { literal-1    } ] { AFTER  }
                         { CHARACTERS }
      { identifier-4 } ] } ... }
      { literal-2    } ]       ...

INSPECT identifier-1 REPLACING
    { CHARACTERS BY { identifier-6 } [ { BEFORE } INITIAL { identifier-7 } ]
                    { literal-4    } [ { AFTER  }         { literal-5    } ]
    { { { ALL       } { identifier-5 }    BY { identifier-6 } [ { BEFORE } INITIAL
      { { LEADING   } { literal-3    }       { literal-4    } [ { AFTER  }
      { { FIRST     }
      { identifier-7 } ] } ... }      ... }
      { literal-5    } ]

INSPECT identifier-1 TALLYING
    { identifier-2 FOR { { { ALL       } { identifier-3 } } [ { BEFORE } INITIAL
                       { { LEADING   } { literal-1    } } [ { AFTER  }
                       { CHARACTERS }
      { identifier-4 } ] } ... }      ...
      { literal-2    } ]

REPLACING
    { CHARACTERS BY { identifier-6 } [ { BEFORE } INITIAL { identifier-7 } ]
                    { literal-4    } [ { AFTER  }         { literal-5    } ]
    { { { ALL       } { identifier-5 }    BY { identifier-6 } [ { BEFORE } INITIAL
      { { LEADING   } { literal-3    }       { literal-4    } [ { AFTER  }
      { { FIRST     }
      { identifier-7 } ] } ... }      ... }
      { literal-5    } ]

MOVE  { identifier-1 }  TO identifier-2 [identifier-3] ...
      { literal      }

MOVE  { CORRESPONDING }  identifier-1 TO identifier-2
      { CORR          }

MULTIPLY { identifier-1 }  BY identifier-2 [ROUNDED]
         { literal-1    }
    [identifier-3 [ROUNDED]] ... [ON SIZE ERROR imperative-statement]

MULTIPLY { identifier-1 }  BY { identifier-2 }  GIVING identifier-3 [ROUNDED]
         { literal-1    }     { literal-2    }
    [identifier-4 [ROUNDED]] ... [ON SIZE ERROR imperative-statement]
```

```
OPEN  { INPUT file-name-1[WITH NO REWIND] [file-name-2 [WITH NO REWIND]]... }
      { OUTPUT file-name-3[WITH NO REWIND] [file-name-4 [WITH NO REWIND]]... }  ...
      { I-O file-name-5 [file-name-6]...                                      }
      { EXTEND file-name-7 [file-name-8]...                                   }

PERFORM procedure-name-1 [ { THROUGH } procedure-name-2 ]
                         [ { THRU    }                  ]

PERFORM procedure-name-1 [ { THROUGH } procedure-name-2 ] { identifier-1 } TIMES
                         [ { THRU    }                  ] { integer-1    }

PERFORM procedure-name-1 [ { THROUGH } procedure-name-2 ] UNTIL condition-1
                         [ { THRU    }                  ]

PERFORM procedure-name-1 [ { THROUGH } procedure-name-2 ]
                         [ { THRU    }                  ]

    VARYING { identifier-2 } FROM { identifier-3 }
            { index-name-1 }      { index-name-2 }
                                  { literal-1    }

        BY { identifier-4 } UNTIL condition-1
           { literal-2    }

    [ AFTER { identifier-5 } FROM { identifier-6 }
            { index-name-3 }      { index-name-4 }
                                  { literal-3    }

        BY { identifier-7 } UNTIL condition-2
           { literal-4    }

    [ AFTER { identifier-8 } FROM { identifier-9 }
            { index-name-5 }      { index-name-6 }
                                  { literal-5    }

        BY { identifier-10 } UNTIL condition-3 ] ]
           { literal-6     }

READ [ WITH UNLOCK ] file-name [NEXT]RECORD[INTO identifier][AT END imperative-statement]
     [ WITH LOCK   ]

READ [ WITH UNLOCK ] file-name RECORD[INTO identifier] [INVALID KEY imperative-statement]
     [ WITH LOCK   ]

READ [ WITH UNLOCK ] file-name RECORD[INTO identifier] [;KEY IS data-name]
     [ WITH LOCK   ]
    [;INVALID KEY imperative-statement]

REWRITE [ WITH UNLOCK ] record-name[FROM identifier][INVALID KEY imperative-statement]
        [ WITH LOCK   ]

REWRITE [ WITH UNLOCK ] record-name[FROM identifier]
        [ WITH LOCK   ]

SEARCH identifier-1 [ VARYING { identifier-2 } ]  [AT END imperative-statement-1]
                    [         { index-name-1 } ]

    WHEN condition-1 { imperative-statement-2 }
                     { NEXT SENTENCE          }

  [ WHEN condition-2 { imperative-statement-3 } ] ...
                     { NEXT SENTENCE          }
```

```
SEARCH ALL identifier-1[AT END imperative-statement-1]
       WHEN { data-name-1      } { IS EQUAL TO } { identifier-3                  }
            { condition-name-1 } { IS =       } { literal-1                     }
                                                 { arithmetic-expression-1       }
            [ AND { data-name-2      } { IS EQUAL TO } { identifier-4                  } ... ]
                  { condition-name-2 } { IS =       } { literal-2                     }
                                                     { arithmetic-expression-2       }
            { imperative-statement-2 }
            { NEXT SENTENCE          }

SET { identifier-1 } [identifier-2]... } TO { identifier-3 }
    { index-name-1 } [index-name-2]...  }   { index-name-3 }
                                            { integer-1    }

SET index-name-4 [index-name-5]... { UP BY   } { identifier-4 }
                                   { DOWN BY } { integer-2    }

START file-name [ KEY { IS EQUAL TO                } data-name ]
                      { IS =                       }
                      { IS GREATER THAN            }
                      { IS >                       }
                      { IS NOT LESS THAN           }
                      { IS NOT <                   }
      [INVALID KEY imperative-statement]

STOP { RUN     }
     { literal }

STRING { identifier-1 } [identifier-2] ... DELIMITED BY { identifier-3 }
       { literal-1    } [literal-2    ]                 { literal-3    }
                                                        { SIZE         }
  [ { identifier-4 } [identifier-5] ... DELIMITED BY { identifier-6 } ] ...
    { literal-4    } [literal-5    ]                 { literal-6    }
                                                     { SIZE         }
    INTO identifier-7 [WITH POINTER identifier-8]
        [ON OVERFLOW imperative-statement]

SUBTRACT { identifier-1 } [identifier-2] ... FROM identifier-m[ROUNDED]
         { literal-1    } [literal-2    ]
    [identifier-n[ROUNDED]]...[ON SIZE ERROR imperative-statement]

SUBTRACT { identifier-1 } [identifier-2] ... FROM { identifier-m }
         { literal-1    } [literal-2    ]      { literal-m    }
    GIVING identifier-n[ROUNDED] [identifier-o[ROUNDED]]...
    [ON SIZE ERROR imperative-statement]

SUBTRACT { CORRESPONDING } identifier-1 FROM identifier-2 [ROUNDED]
         { CORR          }
    [ON SIZE ERROR imperative-statement]

UNLOCK [ RECORD      ] filename
       [ ALL RECORDS ]

UNSTRING identifier-1
  [ DELIMITED BY [ALL] { identifier-2 } [ OR [ALL] { identifier-3 } ] ... ]
                       { literal-1    }           { literal-2    }
    INTO identifier-4[DELIMITER IN identifier-5] [COUNT IN identifier-6]
    [identifier-7 [DELIMITER IN identifier-8][COUNT IN identifier-9]]...
    [WITH POINTER identifier-10][TALLYING IN identifier-11]
    [ON OVERFLOW imperative-statement]
```

```
USE AFTER STANDARD  {EXCEPTION}  PROCEDURE ON  {file-name-1 [file-name-2]...}
                    {ERROR    }                {INPUT                       }
                                               {OUTPUT                      }
                                               {I-O                         }
                                               {EXTEND                      }

WRITE [WITH UNLOCK] record-name [FROM identifier-1]
      [WITH LOCK  ]

      [{BEFORE}  ADVANCING  {{{identifier-2} [LINE ]}}]
       {AFTER }             {{{integer     } [LINES]}}
                            {[PAGE]                  }

      [AT {END-OF-PAGE} imperative-statement]
          {EOP        }

WRITE [WITH UNLOCK] record-name [FROM identifier] [INVALID KEY imperative-statement]
      [WITH LOCK  ]
```

```
COPY  {text-name}
      {literal-3}

      [REPLACING  {{literal-1}  BY  {literal-2}} ...]
                  {{word-1   }      {word-2   }}
```

NOTE: A COPY statement may appear anywhere that a word appears in the COBOL source program.

APPENDIX B

COBOL DATA CONVERSION SUBROUTINES

TRAX COBOL provides two data conversion subroutines which are accessed through the CALL statement. These are CNVT which converts one specified data type to another specified data type, and STRNUM which converts a specified character string to numeric format.

B.1 CNVT

CNVT accepts a value of a specified data type and converts it to a value of another designated data type. The data types recognized by CNVT along with a description of each data type are listed below:

ASCII -- an ASCII string of digits with an optional leading sign and an optional decimal point.

Overpunch right -- an ASCII string of digits with the sign of the number encoded into the right-most digit.

Overpunch left -- an ASCII string of digits with the sign of the number encoded into the left-most digit.

Separate right -- an ASCII string of digits with a required ASCII "+" or "-" following the right-most digit.

Separate left -- an ASCII string of digits with a required ASCII "+" or "-" to the left of the left-most digit.

Zoned decimal -- an ASCII string of digits with the sign encoded in the sixth bit of the right-most digit. Also known as DIBOL format.

Short -- a single word, (16 bits) two's complement, binary value.

Fortran -- a double word, two's complement, binary value in which the most significant word follows the least significant word.

COBOL -- a double word two's complemented binary value in which the most significant bits occur first.

Short floating-point -- a 32 bit floating point number.

Long floating-point -- a 64 bit floating point number.

Packed decimal -- a string of decimal digits packed 2 digits to a byte, with the sign in the last half of the last byte. A 10, 12, 14, or 15 represents a plus (+), and an 11 or 13 represents a minus (-).

Table B-1 summarizes the conversions performed by CNVT. An "x" indicates that CNVT will convert the data type on the left to, the data type above. Note that the only conversions that cannot be made are those which are made to overpunch, separate, and zoned data types.

Table B-1
Data Type Conversions Performed by CNVT

FROM \ TO	ASCII	OPR	OPL	SR	SL	Short	FORT	COBOL	FLO	FLO	PACKED
ASCII	-					x	x	x	x	x	x
Overpunch Right	x					x	x	x	x	x	x
Overpunch Left	x					x	x	x	x	x	x
Separate Right	x					x	x	x	x	x	x
Separate Left	x					x	x	x	x	x	x
Zoned	x					x	x	x	x	x	x
Short	x					-	x	x	x	x	x
FORTRAN	x					x	-	x	x	x	x
COBOL	x					x	x	-	x	x	x
Short Floating	x					x	x	x	-	x	x
Long Floating	x					x	x	x	x	-	x
PACKED Decimal	x					x	x	x	x	x	-

B.1.1 **CALL Statement**

The following statement is used to call CNVT:

```
CALL "CNVT" USING VAL1,TYP1,LEN1,VAL2,TYP2,LEN2,STAT.
```

Each of the arguments for CNVT are described below:

VAL1 (input) -- The address of the value to be converted.

TYP1 (input) -- The data type code for VAL1. The valid data type codes are shown below.

```
 0 - Ascii number
 1 - Overpunch right
 2 - Overpunch left
 3 - Separate right
 4 - Separate left
 5 - Short decimal
 6 - Fortran long decimal
 7 - Cobol long decimal
 8 - Short floating-point
 9 - Long floating-point
10 - Packed decimal
```

LEN1 (input) -- The length in bytes of TYP1.

VAL2 (output) -- The address where the converted value is to be transferred.

TYP2 (input) -- The data type code in which VAL1 is to be converted. The data type codes are the same as TYP1, except values 1 - 5 may not be used.

LEN2 (output) -- The length in bytes of VAL2.

STAT (output) -- A status code. The possible returned values are:

```
  1 - Warning: binary overflow. Value truncated.
  0 - Success
 -1 - Arithmetic overflow
 -2 - Value too big
 -3 - invalid overpunch sign
 -4 - illegal placement of minus sign
 -5 - Non-digit in number
 -6 - Bad input data type
 -7 - Bad output data type
 -8 - Multiple decimal point
 -9 - Illegal placement of sign in Separate data type
-10 - Bad packed decimal digit
```

B.1.2 **Details on Use of CNVT**

For ASCII input to CNVT, the length of a string may be up to 20 bytes long and the string may contain leading, trailing, or imbedded blanks. For ASCII output from CNVT, the string length will be the exact length of the numeric string with no imbedded or padding blanks. The string is placed left-justified in the space designated by VAL2. Any characters not over-written in VAL2 will remain as they were before CNVT was called. The length of VAL2 will never be greater than 20.

Overpunch, Separate and Zoned inputs are treated in the same manner as Ascii. However, these data types are not allowed as output.

For Short data, the input length argument, LEN1, is always assumed to be 2. The output length argument, LEN2, will always be 2.

For Fortran and Cobol, the input length is always assumed to be 4 and the output length will also be 4.

For floating-point data, the input length for short floating is assumed to be 4, as long floating is 8. The output length will be 4 and 8 respectively.

B.2 **STRNUM**

STRNUM accepts a character string with either leading or trailing spaces and stores it into a COBOL numeric data item with a usage of display and a picture of S9(12)V(6). This data item can then be used within the object program for arithmetic or any other valid COBOL operations on numeric items.

B.2.1 **CALL Statement**

The following statement is used to call STRNUM:

CALL STRNUM using identifier-1, identifier-2, identifier-3, identifier-4.

Syntax Rules

1. Identifier-1 is the source string and must be usage is display.

2. Identifier-2 is the destination string and must be numeric where the usage is display, sign is leading separate, and a picture is S9(12)V9(6).

3. Identifier-3 must be numeric with usage computational and picture 9(3). It must contain the number of character positions in the source string identifier-1.

4. Identifier-4 must be numeric with usage computational and picture 9(3). The status code is returned in identifier-4 at the completion of the call.

General Rules

1. Identifier-1 can contain the following characters in the order specified:

   a. optional leading spaces

   b. optional plus, '+', or minus, '-', sign. If not present, positive assumed

   c. numeric characters representing integer part

   d. optional decimal point, '.', if function used

   e. optional numeric characters representing fractional part

   f. optional trailing spaces

   g. commas are ignored

   If a character is found that is out of order or invalid, as defined above, then an error code is returned (see General Rule 4). Any invalid character will be ignored and the operation will continue until the end of the source string is reached.

2. Identifier-2 at the completion of the operation will contain a valid TRAX COBOL numeric item with leading separate sign and no editing characters.

3. Identifier-3 must contain the length of the source string (Identifier-1) at the time of the "CALL". For example, if Identifier-1 is declared with a picture of X(29) then Identifier-3 must have a value of 29.

4. Identifier-4 at the completion of the STRNUM operation contains the error code. The values and corresponding meanings are:

Value	Meaning
0	No error
1	Illegal character in string
2	Truncation error
3	String contained only spaces

APPENDIX C

LOGICAL UNIT NUMBER (LUN) ASSIGNMENTS

LUN	ASSIGNMENT
1	Console, input
2	Console, output
3	Source input file
4	Source listing output file
5	Object output file
6	ODL output file
7	CREF scratch file
8	COPY library input file
9	Work file
10	Work file
11	Intermediate file
12	Sort work file
13	Sort work file
14	Sort work file

APPENDIX D

TRAX COBOL COMPILER IMPLEMENTATION LIMITATIONS

This appendix documents the implementation limitations for the TRAX COBOL compiler system (compiler and OTS). The reader should not confuse the term "limitations" with "restrictions". Restrictions delimit those language facilities which are not implemented or should not be used due to known bugs in their existent implementation. Implementation limitations quantify the limits of a particular language facility supported by the system. Practical implementation limitations exist in every compiler.

Such limitations are due to the finite size of various compiler tables, compiler data structure representations, etc. Since the TRAX COBOL compiler employs a Virtual Memory System to support many compiler data structures, the quantities specified for various implementation limitations are approximations. However, as a general rule, the following guidelines should not be exceeded in the development of a COBOL program.

IMPLEMENTATION LIMITATIONS

1. The maximum length of any COBOL data item (group item, elementary item, table) is 4095 characters.

2. The default depth of dynamic PERFORM statement nesting is 10. The default depth can be modified by using the /PFM switch at compile time.

3. The maximum number of sending operands in a DISPLAY statement is 16.

4. The maximum number of data-name definitions in a COBOL program is approximately 2000.

5. The maximum number of procedure name definitions in a COBOL program is approximately 2000.

6. The maximum nesting depth of matching parentheses in a COBOL expression is 10.

7. The maximum number of qualifiers in a qualified data-name reference is 48.

8. The maximum number of procedure names in a GO TO DEPENDING statement is 16.

APPENDIX E

COMPILER GENERATED PSECTS

An object program generated by the TRAX COBOL compiler is composed of program sections called PSECTs. Three types of PSECTs are generated:

- Data Psects — Contain the memory for the Data Division of a COBOL program.
- Control PSECTS — Contain the data that is required by the OTS during program execution.
- Procedural PSECTS — Contain the object code generated for the Procedure Division.

Data and Control PSECTs are always non-overlayable. Procedural PSECTs, however, can be optionally overlayable or non-overlayable.

E.1 PSECT NAMING CONVENTIONS

The PSECTs generated by the TRAX COBOL compiler are named entities. Each PSECT name is composed of a three character prefix followed by a three character suffix. There are two different forms of the prefix:

- $KK

  Where: $ Is a sentinel character and is always present.

  KK Is a two character kernel that identifies the PSECT. It is this kernel character that is specified by the /KER:kk switch. The /KER:kk switch is appended to the compiler command line to assign a unique kernel value to the PSECTs generated during the compilation. The default kernel assignment is C$.

- $CB

  Where: $ Is a sentinel character, and is always present.

  CB Is a two character code that identifies the PSECT as a COBOL compiler generated PSECT.

PSECTs with the prefix $CB are generated to provide the control and work space required for I/O operations.

PSECTs with these same names are generated for each COBOL compilation. They are either overlayed or concatenated at task-build time. Those that are overlayed, have a known fixed length at task-build time. Those that are concatenated, have a known length at compile-time and contribute their size to the total size of the PSECT that is built by the TRAX Linker.

The three character suffix identifies the type of code or data the PSECT contains. Table E-1 describes the suffixes assigned to $KK type PSECTs, and Table E-2 describes the suffixes assigned to $CB type PSECTs.

Table E-1
$KK PSECT Name Suffixes

Type	Suffix	Content
Data	DAT	Data Division data storage areas.
	DDD	Data Division directories - contains descriptions of referenced Data Division items.
	ARG	Directories of referenced Linkage Section items.
	LIT	Literal Pool - contains all of the literals referenced in the program.
	LTD	Literal Directory.
	IOB	Input/Output buffers.
Control	WRK	COBOL compile unit work space - contains a description of the compile unit environment.
	PDT	PSECT dispatch table - used for intra-program control of segmented COBOL programs.
	SDT	Subprogram dispatch table - used for inter-program control (i.e., calling subprograms).
	LST	Argument list work space - used to contain the argument list passed to the called subprogram.
	PFM	Perform work space - used to provide control and checking of nested PERFORM statements.
	ADT	ALTER Dispatch Table - used to contain the destination of alterable GO TO statements.

Table E-1 (Cont.)
$KK PSECT Name Suffixes

Type	Suffix	Content
	USE	Default USE procedure table - used to access the default OPEN mode (INPUT, OUTPUT, I-O, or EXTEND) USE procedures, if present.
Procedural	ENT	Code generated by the compiler for the program entry point.
	nnn	Numbered suffixes beginning with 001. These numbered PSECTs contain the object code generated for the Procedure Division of a COBOL program.

Table E-2
PSECT Name Suffixes

Allocation	Suffix	Content
OVR	IOT	Input/Output Table - contains a reference to each COBOL Input/Output OTS routine required by the COBOL compilation.
OVR	FA1	File Access Block (FAB) - used to transmit information to RMS at open and close time.
OVR	XA1	Auxiliary Access Blocks (XABs) - used to transmit information on the keys for indexed files to RMS at open time.
OVR	SWT	COBOL switches flag PSECT. Indicates whether COBOL switches are referenced in the COBOL program.
CON	IF1	Internal File Access Blocks (IFABs) - used internally by RMS to store information.
CON	IRI	Internal Record Access Blocks (IRABs) - used internally by RMS to store information.
CON	KD1	Internal Key Descriptors - used internally by RMS to store information on the keys for indexed files.
CON	BD1	Buffer Descriptor Blocks (BDBs) - used internally by RMS to store information on the buffers.

Table E-2 (Cont.)
PSECT Names Suffixes

Allocation	Suffix	Content
CON	KBl	Key Buffers - used internally by RMS to store keys for indexed files.
CON	FDl	FDA Index Vector - contains address of first FDA in program.
		Note:
		OVR indicates overlayable PSECT.
		CON indicates concatenatable PSECT.

APPENDIX F

SORTING FILES IN A COBOL PROGRAM

Files prepared for or by COBOL programs may be sorted using the SORT utility, which is discussed in the TRAX SORT Reference Manual. A major portion of that facility is available to the COBOL programmer through usage of a set of subroutine linkages, described in detail in this chapter. All such linkages involve use of a CALL statement with an appropriate parameter list.

F.1 CALL STATEMENTS REQUIRED

A set of five CALL statements, each calling a particular SORT subroutine, is required within a COBOL program in order to produce a sorted output file. Each of these subroutines (RSORT, RELES, MERGE, RETRN, ENDS) performs a specialized function in the SORT procedural sequence and lets the COBOL programmer both specify sorting parameters and perform special operations on individual records as they pass through the initial and final phases.

F.1.1 Initializing the SORT - CALL RSORT

The following statement is needed to initialize the sorting operation:

```
CALL "RSORT" USING IERROR, KEYSIZ, MAXREC, KEYLOC, SRTBUF,
BUFSIZ, SCRNUM.
```

Parameter usage is as follows:

IERROR - location in which a SORT subroutine may place a non-zero error code, if necessary, in COMP form, value less than 100.

KEYSIZ - location containing byte count of total key size in COMP form, a positive even integer.

MAXREC - location containing byte count of maximum data record size in COMP form, a positive even integer. The sum of KEYSIZ and MAXREC cannot exceed 16,383 (decimal).

KEYLOC - address of most major word in key. See Section F.2 for details on setting up sort key.

SRTBUF - address of first word in sort work area.

BUFSIZ - location containing byte count of sort work area size in COMP form.

SCRNUM - location containing number of scratch files available to the SORT (not less than 3, not more than 8), in COMP form.

F.1.2 Passing a Record to the Sort - CALL RELES

The following statement is needed to pass a record to the sort:

```
CALL "RELES" USING IERROR, RECSIZ, INREC.
```

Parameter usage is as follows:

IERROR - usage is as described above.

RECSIZ - location containing byte count of data record size in COMP form, a positive even integer not greater than value in MAXREC.

INREC - address of record to be passed to the sort.

F.1.3 Merging the Scratch Files - CALL MERGE

The following statement is needed to merge the scratch files in the sort after all input records have been passed to the sort:

```
CALL "MERGE" USING IERROR.
```

IERROR usage is as described above.

F.1.4 Requesting an OUTPUT Record - CALL RETRN

The following statement is needed to request the output records, one at a time, produced in sorted order by the sort:

```
CALL "RETRN" USING IERROR, RECSIZ, OUTREC.
```

Parameter usage is as follows:

IERROR - usage is as described above.

RECSIZ - location to receive byte count of returned data record size in COMP form, a positive even integer not greater than value in MAXREC.

OUTREC - address of area to receive returned data record.

NOTE

RETRN indicates "no more records" by placing a negative value in IERROR.

F.1.5 Terminating the Sort - CALL ENDS

The following statement is needed to terminate the sort after all sorted output records have been returned:

```
CALL "ENDS" USING IERROR.
```

IERROR usage is as described above.

F.2 SETTING UP THE KEY

Before CALL RELES is executed, the COBOL programmer must first set up the key in an area outside the record itself. Since the key area must begin and end on a word boundary, usage of an 01 level description in the Working - Storage Section is recommended. The most major byte for the key, that byte "on the left", must be stored in the highest memory location of the key area, and the most minor byte, that byte "on the right", must be stored in the lowest memory location.

Thus the data must be moved byte by byte, NOT word by word, to the key area, resulting in the key being stored "backwards" by bytes. If the actual key contains an odd number of bytes, the last unused position must be zeroed out, to insure proper results from word compares. Thus for a key of 7 bytes, KEYSIZ - 8; the contents of the lowest byte address should always be zero.

The form of the comparison is logical, i.e., all eight bits of a byte are significant; there is no implied sign. The programmer is responsible for organizing the key data passed to the sort in a form which ensures the correct sequence.

F.3 WORK AREA SIZE

The size of the sort work area, BUFSIZ, must be at least as large as the result of the following calculation:

```
Minimum BUFSIZE = SCRNUM * (1110 + MAXREC + KEYSIZE)
```

If less space is provided, the sort will keep decreasing the number of work files until either the above equation is satisfied or the number of files drop below three; the latter is an error condition (error code 17).

Any extra memory will be used to expand the in-core sort area. Thus, in general, the more space supplied, the faster the sort.

F.4 TYPICAL USAGE SEQUENCE

Sort the file SORT-IN to produce the file SORT-OUT.

1. Open SORT-IN.
2. Call RSORT to initialize the sort.
3. Read the next logical record from SORT-IN. If no more data, go to step 7.

4. Perform any desired operations upon the input record. If it is not to be submitted to the sort, go to step 3.

5. Set up the keys from the new record.

6. Call RELES to give the record to the sort, then loop back to step 3.

7. Close SORT-IN.

8. Call MERGE to collate the records submitted to the sort.

9. Open SORT-OUT.

10. Call RETRN to get the next sorted output record. If no more records, go to step 13.

11. Perform any desired operations upon the sorted output record. If it is not to be included in the SORT-OUT file, go to step 10.

12. Write the record onto SORT-OUT, then loop back to step 10.

13. Close SORT-OUT.

14. Call ENDS to clean up the sort scratch files.

F.5 LINKING SORT ROUTINES WITH A COBOL PROGRAM

The actual sorting subroutines are contained in SORTS.OBJ and SIORMS.OBJ which are included in the COBOL object library (COBLIB). The programmer can link these to his own calling program, by following the usual procedure for using the TRAX Linker to link any COBOL program.

Note that the sort subroutines use LUNs 5, 6, ... 12 for the scratch files. Use the task builder device assignment (ASG) command appropriately. The LUN can be overridden by globally patching location $RFIRL. Insure that the LUNs used by the sort subroutines do not conflict with the LUNs assigned to files in the COBOL program that might be open when the sort subroutines are called.

F.6 COMPARISON WITH ANS COBOL SORT VERB

Readers familiar with the ANS COBOL SORT verb will recognize that a substantial portion of that capability has been described in this chapter. The following points of comparison will be helpful in converting from such usage to the described facility:

1. INPUT PROCEDURES are available thru the CALL RELES usage.

2. OUTPUT PROCEDURES are available thru the CALL RETRN usage.

3. Only ASCENDING keys are supported. The programmer can get the effect of DESCENDING key fields by simply complementing them when he stores them in KEYLOC. Note that the data record itself is unaffected by this procedure, so restoration of such fields after the sort is unnecessary.

4. The COLLATING-SEQUENCE option is not directly available. Again, however, the programmer could transform key fields when storing them in KEYLOC to achieve the desired effect.

5. There is no MERGE feature.

6. Multiple usages of the sort may occur within a given COBOL program provided that "RSORT" and "END" bracket each usage.

7. There is no restriction on the presence of COBOL code in addition to INPUT and OUTPUT PROCEDURES.

F.7 ERROR CODES

Whenever the sort detects an error, it returns a non-zero code to the location specified by the programmer (IERROR in discussion above). The error codes (octal representation) and their meanings are:

DEC	OCTAL	
	00	No errors
	01	Device input error
	02	Device output error
	03	OPEN INPUT failure
	04	OPEN OUTPUT failure
	05	Size of current record is greater than maximum size
	06	Not enough work area
	07	"RETRN" was called after it had exited with a negative error code (end of sort).
8	10	SORT routine called out of order. The order of the calls must be RSORT, RELES, MERGE, RETRN, ENDS.
9	11	Sort already in progress. To do a second sort, ENDS must be called to clean up the first sort.
10	12	Key size is not positive, SORTS detected a zero or negative key size in its calling parameter.
11	13	Record size not positive.
12	14	Key address not even. The keys must start at an even address (SORT uses word moves).
13	15	Record address not even.

DEC	OCTAL	
14	16	Scratch records will be too large. The size of the keys plus the size of the largest record must be less than 377776 (octal).
15	17	Too few scratch files. A minimum of 3 scratch files must be specified.
16	20	Too many scratch files. A maximum of 10 scratch files may be specified.
17	21	End-of-string record was detected where none was expected.
18	22	Like 21, but for End-of-File.
19	23	SORT found a record larger than it expected.
20	24	Record length is non-standard for SORTT, SORTA, SORTI.
		[COMP items are displayed in DECIMAL!]

APPENDIX G

DIAGNOSTIC ERROR MESSAGES

This Appendix contains a numerical listing of the diagnostic messages generated by the TRAX COBOL compiler. The general format of presentation is to give the error message number and the text of the diagnostic message to the left. On the right, a detailed explanation of the diagnostic is given indicating the reason(s) for which the diagnostic message is issued and the recovery action taken by the compiler.

NOTE

In many explanations, the word "Fatal." appears as the very last sentence of the explanation. This means that this is a fatal diagnostic issued in the Procedure Division. If the /ACC:2 switch is specified in the command string input to the compiler, the associated diagnostic message will cause the generation of the special error trap coding discussed previously.

001	CONTINUE PUNCH WITH BLANK STATEMENT. IGNORED.	A blank line has a continue punch. The continue punch is ignored.
002	QUOTE OR CONTINUE PUNCH MISSING. QUOTE ASSUMED.	A non-numeric literal has no quote and the following line has no continue punch. A terminal quote is assumed at the end of the line.
003	VIOLATION OF AREA A. ASSUMED CORRECT.	The first non-blank character on a continued line occurs in Area A. The error is ignored.
004	LINE LENGTH EXCEEDS INPUT BUFFER. TRUNCATED.	Continuation lines cause a COBOL word to exceed the capacity of the input buffer. The word is truncated on the right; the number of characters retained depends on the type of word being processed.

005	.IO CONTROL. WITHOUT .FILE CONTROL. IGNORED.	An I-O-CONTROL paragraph appears when no FILE-CONTROL paragraph was present. The I-O-CONTROL paragraph is ignored.
006	.STRING. DATA ITEM MUST HAVE DISPLAY USAGE.	A data item in a STRING statement has been given a COMP or INDEX usage. Fatal.
007	NAME EXCEEDS 30 CHARACTERS. TRUNCATED TO 30.	A character string which appears to be a name exceeds 30 characters in length. The string is truncated on the right to 30 characters.
010	NUMERIC LITERAL OVER 18 DIGITS. TRUNCATED TO 18.	A numeric literal exceeds 18 digits in length. The literal is truncated on the right, with any necessary adjustment to scaling. The sign is retained.
011	NUMERIC LITERAL HAS MULTIPLE DECIMAL POINTS.	A numeric literal has more than one decimal point.
012	PICTURE CLAUSE ILLEGAL ON GROUP LEVEL. IGNORED.	A group level item has a PICTURE clause. The clause is ignored.
013	.SELECT. NOT FOUND. SENTENCE IGNORED.	A FILE-CONTROL statement should begin with the word SELECT, but does not. All words up to the next period are ignored.
014	JUST.SYNC.BLANK CLAUSES WRONG AT GROUP. IGNORED.	A group level item may not contain JUSTIFIED, SYNCHRONIZED, or BLANK WHEN ZERO clauses. The clause is ignored.
015	FILENAME MISSING OR INVALID. SELECT IGNORED.	A SELECT statement either contains no user name or the the user name is invalid. The SELECT statement is ignored.
016	USAGE CONFLICTS WITH GROUP USAGE. USES GROUP.	The usage specified for this item differs from the usage stated at a higher group level. The group level usage is used.
017	ILLEGAL NUMERIC DATANAME IN .STRING.	A numeric data item in a STRING statement has an illegal description. Fatal.
020	.ALL. ILLEGAL IN CONTEXT OF .STRING. STATEMENT.	An ALL literal has been used in a STRING statement. Fatal.

021	SYNTAX ERROR OR NO TERMINATOR. CLAUSES SKIPPED.	A SELECT statement is missing its terminating period or an error causes the statement to be processed before all clauses were found. The SELECT statement is ignored.
022	NUMERIC LITERAL ILLEGAL IN THIS STATEMENT.	A STRING, UNSTRING, or INSPECT statement contains a numeric literal. Fatal.
023	SENDING LIST OMITTED IN .STRING. STATEMENT.	A STRING statement contains no sending fields before a DELIMITED BY phrase. Fatal.
024	MORE THAN ONE FILENAME IN .ASSIGN.	The non-numeric literal of an ASSIGN clause contains more than one file specification. Only the first specification is used.
025	ILLEGAL DATANAME FOLLOWS .INTO. IN .STRING.	The receiving field of a STRING statement is invalid. Fatal.
026	SUBSCRIPTING DEPTH EXCEEDS 3. OVER 3 IGNORED.	This OCCURS clause is nested more than three deep. The OCCURS clause is ignored.
027	VALUE ILLEGAL IN OCCURS ITEM. IGNORED.	A VALUE clause appears in an item with an OCCURS clause or in an item subordinate to an OCCURS clause. The VALUE clause is ignored.
030	VALUE ILLEGAL IN REDEFINES ITEM. IGNORED.	A VALUE clause appears in an item which either contains a REDEFINES clause, or is subordinate to an item with a REDEFINES clause.
031	NO TERMINATOR FOR .IO CONTROL. PARAGRAPH.	The I-O-CONTROL paragraph is not terminated by a period. The terminator is assumed present.
032	.MAP. NO LONGER APPLICABLE. IGNORED.	An APPLY clause with the MAP option is not applicable for this version and future versions of TRAX COBOL. The APPLY clause is ignored.
033	AN IO CONTROL CLAUSE WITHOUT FILES.	A file-name is missing in a clause of the I-O-CONTROL paragraph. The clause is ignored.
034	SYNTAX ERROR IN .APPLY..	An APPLY clause has illegal syntax. The clause is ignored.

035	INVALID ACCESS MODE. TREAT AS SEQUENTIAL.	The SELECT statement contains an invalid ACCESS mode. SEQUENTIAL ACCESS mode is assumed.
036	INVALID FILE ORGANIZATION. TREAT AS SEQUENTIAL.	THE SELECT statement contains an invalid ORGANIZATION specification. SEQUENTIAL organization is assumed.
037	NO SELECT STATEMENTS.	A FILE-CONTROL paragraph either contains no SELECT statements or none of those present are valid. The FILE-CONTROL paragraph is ignored.
040	.ASSIGN. OMITTED FROM SELECT. SELECT IGNORED.	A SELECT statement contains no ASSIGN clause. The SELECT statement is ignored.
041	DECIMAL PLACES TRUNCATED.	Decimal places have been truncated from a numeric literal during conversion for use as an integer. The integer positions are used.
042	INTEGER EXPECTED, ZERO ASSUMED.	An integer literal was expected but fractional positions were found. The literal is ignored and a value of zero is assumed.
043	INTEGER VALUE TOO BIG. LARGEST VALUE USED.	A numeric literal is too big for conversion as an integer in the given context. A value of 32,767 is used.
044	ERROR IN DATA RECORDS CLAUSE. CLAUSE SKIPPED.	The word DATA is not followed by RECORD or RECORDS in the DATA RECORDS clause. The DATA RECORDS clause is ignored.
045	ERROR IN LABEL RECORDS CLAUSE. CLAUSE SKIPPED.	The word LABEL is not followed by RECORD or RECORDS in the LABEL RECORDS clause. The LABEL RECORDS clause is ignored.
046	NO INTEGER IN BLOCK CLAUSE. CLAUSE SKIPPED.	The BLOCK clause does not contain a numeric literal. The BLOCK clause is ignored.
047	BAD VALUE IN BLOCK CLAUSE. CLAUSE SKIPPED.	The numeric literal in the BLOCK clause causes an illegal block size. The block size in bytes must be greater than 0 and less than 32768. The BLOCK clause is ignored.
050	NO INTEGER IN RECORD CLAUSE. CLAUSE SKIPPED.	The RECORD CONTAINS clause does not contain a numeric literal. The RECORD CONTAINS clause is ignored.

051	INVALID VALUE IN RECORD CLAUSE. CLAUSE SKIPPED.	The numeric literal in the RECORD CONTAINS clause is not greater than zero. The RECORD CONTAINS clause is ignored.
052	INVALID FILENAME. FD SKIPPED.	The word following FD is not valid as a file-name. The FD entry is ignored.
053	FD TERMINATOR MISSING. ASSUMED PRESENT.	The file description entry contains no period terminator. The error is ignored.
054	KEY WORD EXPECTED. REMAINING CLAUSES SKIPPED.	A keyword, which begins a clause, such as BLOCK, LABEL, DATA, etc. is missing. The remainder of the FD entry is ignored.
055	NO LABEL CLAUSE IN FD. .STANDARD. ASSUMED.	The FD entry contains no LABEL RECORD clause. LABEL RECORD IS STANDARD is assumed.
056	NO SELECT. FILE DELETED.	The FD entry's file-name has no corresponding SELECT statement. The FD entry is ignored. All references to the filename will be diagnosed as undefined.
057	ALLOCATED SPACE EXCEEDS LARGEST RECORD.	The maximum record size specified by the RECORD CONTAINS clause exceeds the space required for any 01 entry under the same file. The value specified by the RECORD CONTAINS clause is used.
060	RECORD AREA EXTENDED TO CONTAIN LARGEST RECORD.	The space required by the largest 01 record under a file description exceeds the space required by the RECORD CONTAINS clause in the FD entry. The value derived from the 01 record description is used.
061	NO RECORD AREA. FILE DELETED.	No record area is allocated for a file description. The file description is ignored. All references to the file will be diagnosed as undefined.
062	ILLEGAL DATANAME FOLLOWS .WITH POINTER. PHRASE.	The data item used as a pointer in a STRING or UNSTRING statement is illegal. Fatal.
063	ILLEGAL SYNTAX IN .STRING. STATEMENT.	A STRING statement contains illegal syntax. Fatal.

064	77 ILLEGAL IN FILESECTION. CHANGED TO 01.	A 77 level item description has been found in the FILE SECTION. The 77 level is treated as an 01 level.
065	ILLEGAL WORD FOLLOWS .DELIMITED BY. PHRASE.	A data-name or literal is expected following a DELIMITED BY phrase in a STRING or UNSTRING statement. Fatal.
066	ILLEGAL USE OF .ALL.. IGNORED.	In the VALUE clause, an ALL numeric literal is detected. This is illegal. ALL is ignored by the compiler.
067	CONDITION NAME MISSING OR INVALID. 88 IGNORED.	The condition-name in an 88 level entry is either missing or invalid. The entire entry is ignored.
070	TWO INDEXED KEYS START AT SAME OFFSET IN RECORD	The leftmost character position of the RECORD KEY or ALTERNATE RECORD KEY dataname corresponds to the leftmost character position of some other RECORD KEY or ALTERNATE RECORD KEY data-name. The clause is ignored.
071	.REDEFINES. ON 01 LEVEL IN FILE SECTION INVALID.	The REDEFINES clause is present on the 01 level in the FILE SECTION, where redefinition is implicit. REDEFINES clause is ignored.
072	PICTURE IGNORED FOR INDEX ITEM.	An item defined as USAGE INDEX has a PICTURE clause. The PICTURE clause is is ignored.
073	NONNUMERIC PIC ON COMP ITEM. TREATED AS DISPLAY.	An item defined as USAGE COMP has a picture-string with non-numeric characters. The stated usage is ignored. The item is treated as USAGE DISPLAY.
074	SUBSCRIPT OUT OF RANGE. ASSUME 1.	A literal subscript is either less than 1 or greater than the maximum allowable value. A value of 1 is used.
075	.STATUS. OMITTED FROM .FILE STATUS.. ASSUMED.	The FILE STATUS clause has incorrect syntax. The error is ignored.
076	SOME FILES WITHOUT POSIT. NO. IN MUL. FILE TAPE.	A MULTIPLE FILE TAPE clause contains file-names with POSITION Clauses. Not all the file-names contain POSITION clauses. The error is ignored. File searching during OPEN will find the file.

077	.MULTIPLE FILE TAPE. SYNTAX ERROR.	A MULTIPLE FILE TAPE clause contains a syntax error. The clause is ignored.
100	OPERAND CLASSES IN CONFLICT.	One or more operands in a statement have invalid class. Fatal.
101	POSSIBLE RECEIVING FIELD TRUNCATION.	A MOVE statement results in right hand truncation of the receiving field value. This is not an error and is ignored.
102	TOO FEW SOURCE FIELDS FOR ADD .GIVING..	At least two valid source operands must appear in an ADD...GIVING statement. Fatal.
103	.EXIT. WAS NOT THE ONLY VERB IN PARAGRAPH.	An EXIT statement is not the only statement in a paragraph. The EXIT statement is ignored.
104	SENDING ITEM INVALID OR OMITTED.	A MOVE statement contains an invalid or missing sending operand. Fatal.
105	SENDING ITEM NOT FOLLOWED BY .TO..	A MOVE statement does not have a TO following the sending operand. Fatal.
106	RECEIVING ITEM INVALID OR OMITTED.	A MOVE statement has no valid receiving operand. Fatal.
107	INVALID CLASS FOR DESTINATION FIELD.	The receiving operand of an ADD or SUBTRACT statement is not numeric or numeric-edited. Fatal.
110	RELATIVE OR RECORD KEY OR STATUS NAME INVALID.	The name referenced in a RELATIVE KEY, RECORD KEY, ALTERNATE RECORD KEY or FILE STATUS clause is invalid. The clause is ignored.
111	.STOP. SYNTAX ERROR.	The STOP statement is not followed by a literal or the word RUN. Fatal.
112	.SIZE ERROR. STATEMENT INCORRECT.	The word ERROR is not found in ON SIZE clause. Fatal.
113	.PROCEDURE DIVISION. OMITTED.	The source program does not contain a PROCEDURE DIVISION. Fatal.
114	INTERMEDIATE RESULT TOO LARGE. HIGH ORDER TRUNC.	An arithmetic statement calls for an intermediate result in excess of 18 digits. The intermediate result is truncated on the left to 18 digits with a possible loss of high order non-zero digits at execution time.

115	INTERMEDIATE RESULT TOO LARGE. LOW ORDER TRUNC.	An arithmetic expression calls for an intermediate result in excess of 18 digits. The intermediate result is truncated on the right to 18 digits with a possible loss of low order non-zero digits at execution time.
116	.DIVISION. OMITTED AFTER .PROCEDURE..	The word DIVISION is missing in the PROCEDURE DIVISION header. The error is ignored.
117	TERMINATOR MISSING AFTER DIVISION HEADER.	The period terminator is missing from a division header. The error is ignored.
120	LITERAL INCOMPATIBLE WITH ATTEMPTED USAGE.	Conversion of a literal from one form to another has failed. Fatal.
121	DATANAME MUST FOLLOW .INTO. IN THIS STATEMENT.	A valid data-name is not present following INTO in a STRING or UNSTRING statement. Fatal.
122	NUMERIC SUBJECT OR OBJECT MUST BE INTEGER.	A numeric, non-integer subject or object is invalid in the context of this relation condition. Fatal.
123	OPERANDS CONFLICT IN .SET...	A SET...TO statement TO. STATEMENT. references invalid operands. Fatal.
124	OPERANDS CONFLICT IN .SET ... BY. STATEMENT.	A SET...BY statement references invalid operands. Fatal.
125	ILLEGAL FILENAME LITERAL OR FILENAME DATANAME.	An ASSIGN statement or a VALUE OF ID statement contains an invalid file specification or data-name. The statement is ignored.
126	INVALID SUBJECT OF SIGN CONDITION.	The subject of a sign condition is not a valid arithmetic expression. Fatal.
127	ITEM IN TABLE MAY NOT BE USED AS A SUBSCRIPT.	A data item used as a subscript is itself a table element. Fatal.
130	.POINTER. MUST FOLLOW .WITH. IN THIS STATEMENT.	A STRING or UNSTRING statement has an invalid WITH POINTER phrase. Fatal.
131	RELATIVE KEY INVALID FOR THIS FILE. IGNORED.	A RELATIVE KEY clause has been applied to a file which

		does not have RELATIVE organization. The RELATIVE KEY clause is ignored.
132	SUBJECT OR OBJECT OMITTED IN RELATION CONDITION.	The subject or object is omitted in a COBOL relation condition. The condition expression is considered syntactically invalid. Fatal.
133	UNIDENTIFIABLE WORD FOUND IN SUBSCRIPT.	A subscript list contains a word which is neither a data-name or numeric literal. The remainder of the list or sentence is ignored. Fatal.
134	INVALID SUBJECT OR OBJECT IN RELATION CONDITION.	The subject or object of a relation condition is an invalid operand. Fatal.
135	SUBSCRIPTS OMITTED. ASSUME VALUE OF 1.	A reference to a table item contains no subscript list. Literal subscripts of 1 are supplied as defaults.
136	RELATIVE INDEX LITERAL OUT OF RANGE. INDEX USED.	The literal value of a relative index causes an out of range reference to the table. The literal value is ignored, and the index-name only is used.
137	SUBSCRIPTS GIVEN WHERE NOT REQUIRED. IGNORED.	A reference is made to a non-table item, and a subscript list follows the reference. The subscript list is ignored.
140	TOO FEW SUBSCRIPTS GIVEN. ASSUME 1 FOR REST.	A reference to a table item contains a subscript list with too few subscripts. Default literal subscripts of 1 are supplied for missing subscripts.
141	TOO MANY SUBSCRIPTS GIVEN. IGNORE EXCESS.	A reference to a table item contains too many subscripts in the subscript list. Extra subscripts are ignored.
142	SUBJECT AND OBJECT USAGE MUST MATCH.	A relation condition between non-numeric operands requires the same usage for both operands. Fatal.
143	ARITHMETIC EXPRESSION REQUIRED IN THIS CONTEXT.	An arithmetic expression is required in the context of the COBOL statement being compiled. The compiler has failed to recognize the arithmetic expression in this context. Fatal.

144	CONDITION EXPRESSION REQUIRED IN THIS CONTEXT.	A condition expression is required in the context of the COBOL statement being compiled. The compiler has failed to recognize the condition expression in this context. Fatal.
145	ILLEGAL OPERAND FOUND IN COBOL EXPRESSION.	An invalid data-name or literal has been found in the COBOL statement being compiled. The class or USAGE of the data item may be invalid in the context as a reference in an expression. Fatal.
146	OPERATOR IS MISSING IN COBOL EXPRESSION.	An operator is omitted in the specification of this COBOL expression. The compiler cannot recognize this expression as a syntactically valid COBOL expression. Fatal.
147	ABSOLUTE VALUE STORED.	A negative value has been supplied for an unsigned numeric item. The absolute value of the numeric literal is stored in the item.
150	ILLEGAL WORD FOUND AFTER .NOT. IN EXPRESSION.	The compiler has detected an illegal expression operator following a NOT keyword in the COBOL expression being compiled. The COBOL expression is considered syntactically invalid. Fatal.
151	VERB FOUND IN AREA A. ALLOWED.	A statement begins in Area A. The error is ignored.
152	EXPECTED .RELATIVE KEY. DATANAME NOT DEFINED.	The data-name given in a RELATIVE KEY clause has not been defined in the Data Division.
153	.LINAGE. CLAUSE DATAITEM IS TOO LONG.	A data item named in a LINAGE clause is declared in the Data Division with more than four decimal integer positions of precision.
154	PROCEDURE NAME DUPLICATES DATA NAME. ALLOWED.	A procedure name is identical to a data-name. The error is ignored, since there can be no ambiguity in legal references.
155	STATEMENTS FOLLOWING .GO. CAN NEVER BE EXECUTED.	A statement follows an unconditional GO statement. The statements following the GO are compiled, but can not be executed.

156	NONSEQUENTIAL FILE MAY NOT BE OPTIONAL.	The SELECT statement may specify OPTIONAL only on files with sequential organization. The word OPTIONAL is ignored.
157	FILE HAS IO CONTROL CLAUSE CONFLICTS.	A file is given conflicting clause specifications in the I-O-CONTROL paragraph of the INPUT-OUTPUT SECTION.
160	FILE REQUIRES REL. KEY. TREATED AS SEQ. ACCESS.	A file with relative organization and random or dynamic access has no RELATIVE KEY clause. The access mode is changed to SEQUENTIAL.
161	INVALID INDEX DATAITEM USE IN RELATIONAL.	The compiler detects the invalid use of an index data item reference as the subject or object of a relation condition. Fatal.
162	UNKNOWN WORD. SCAN TO NEXT CLAUSE.	An unknown word is encountered when a clause keyword is expected. All words are ignored up to the next valid clause.
163	CLAUSE DUPLICATED. SECOND OCCURRENCE USED.	A SELECT statement contains two occurrences of the same clause. The second occurrence is used.
164	NO FD FOR THIS SELECT.	The file-name supplied in a SELECT statement is not further described in an FD in the Data Division. The SELECT statement is ignored, causing the filename to become undefined.
165	DIFFERENT SAME REC. AREAS FOR SAME AREA.	The compiler detects a conflict between the SAME RECORD AREA clause and the SAME AREA clause.
166	.READ. WITHOUT .INVALID KEY. .AT END. OR .USE.	A READ statement contains no conditional clauses and the file being read has no USE procedure applied to it. Fatal.
167	IO CONTROL CLAUSE HAS FILE WITH NO .SELECT.	An I-O-CONTROL clause references a file-name which was not named in a SELECT statement. The file-name is ignored in the I-O-CONTROL statement.
170	INTEGER OMITTED IN .RESERVE.. DEFAULT ASSUMED.	A RESERVE clause fails to specify the number of buffer areas to reserve. The

		clause is ignored, and a default of one area for SEQUENTIAL and RELATIVE or two areas for INDEXED is supplied.
171	INVALID SUBJECT OF CLASS CONDITION.	The subject of a class condition is not a data item with acceptable class. Fatal.
172	VALUE EXCEEDS FIELD CAPACITY. TRUNCATED.	A numeric literal supplied by a VALUE clause exceeds the length of the field. The value is right truncated and stored in the field.
173	NO DATA DIVISION STATEMENTS PROCESSED.	The Data Division contains no valid entries. This is an observation only.
174	INVALID GRP LEV NUM. REST OF RECORD IGNORED.	A level-number is encountered which terminates a previous group item, but does not match any previous group item's level-number. All data entries are skipped until the next 01 level, level indicator or header.
175	INVALID PROCEDURE NAME DEFINITION IN AREA A.	The compiler detects source text in Area A of the Procedure Division which does not conform to the rules for the definition of a legitimate paragraph or section name. Source text found in Area A of the Procedure Division is interpreted by the compiler as a user attempt to define a new paragraph or section name. The compiler supplies a system-defined procedure name and proceeds with the processing of the source line text containing the invalid Area A text. The system-defined procedure name is transparent and, thus, inaccessible to the user.
176	MISSING QUOTE ON CONTINUE LINE. QUOTE ASSUMED.	A non-numeric literal is continued, but the first non-space character is not a quote. The error is ignored by assuming a quote in front of the first non-space character.
177	COMPARISON OF LITERALS IS NOT PERMITTED.	A relation condition has a literal as both subject and object. Fatal.

200	COPY IGNORED WITHIN LIBRARY TEXT.	A COPY statement is encountered within library text. The COPY statement is ignored.
201	INVALID FILENAME ON COPY. COPY IGNORED.	A COPY statement supplies a file specification which is invalid. The COPY statement is ignored.
202	COPY FILENAME NOT FOUND.	A COPY statement supplies a valid file specification, but the file cannot be found on the specified device. The COPY statement is ignored.
203	PERIOD OMITTED AFTER .DECLARATIVES..	The word DECLARATIVES is not followed by a period. The error is ignored.
204	.DECLARATIVES. OMITTED FROM .END. STATEMENT.	The word END is not followed by DECLARATIVES. END DECLARATIVES is assumed.
205	PERIOD OMITTED AFTER .END DECLARATIVES..	The words END DECLARATIVES are not followed by a period. The error is ignored.
206	SOURCE PROGRAM ENDS IN DECLARATIVES.	The end of the source program occurs in the Declaratives area. Fatal.
207	DATANAME MUST FOLLOW .WITH POINTER. PHRASE.	A STRING or UNSTRING statement contains an invalid WITH POINTER phrase. Fatal.
210	.OVERFLOW. MUST FOLLOW .ON. IN THIS STATEMENT.	A STRING or UNSTRING statement contains an invalid ON OVERFLOW phrase. Fatal.
211	ILLEGAL SENDING FIELD DATANAME IN .UNSTRING.	The sending field of an UNSTRING statement has invalid class. Fatal.
212	ILLEGAL SYNTAX IN .UNSTRING. STATEMENT.	An UNSTRING statement has invalid syntax. Fatal.
213	MULTIPLE SIGN CLAUSES ON THIS ITEM.	More than one SIGN clause appears in a data description. (SEPARATE must follow LEADING or TRAILING.) The second clause is used.
214	ILLEGAL SYNTAX IN COBOL EXPRESSION.	The compiler detects a syntax error of a general nature in the COBOL expression being compiled. Fatal.
215	SIGN CLAUSE ON NONNUMERIC ITEM.	A SIGN clause appears in a non-numeric data description. The SIGN clause is ignored.

216	SIGN CLAUSE APPLIED TO NONDISPLAY ITEM.	A SIGN clause appears in a numeric data description with usage other than DISPLAY. The SIGN clause is ignored.
217	SIGN CLAUSE APPLIED TO UNSIGNED DATAITEM.	A SIGN clause appears in a numeric data description which has no "S" in its PICTURE string. The SIGN clause is ignored.
220	ILLEGAL DELIMITING DATA ITEM IN .UNSTRING.	An UNSTRING statement references an invalid delimiter. Fatal.
221	.ALL. FIGURATIVE CONSTANT ILLEGAL IN .UNSTRING.	An UNSTRING statement contains an ALL literal reference. Fatal.
222	ILLEGAL RECEIVING DATANAME IN .UNSTRING.	An UNSTRING statement references a receiving data item which is invalid. Fatal.
223	.DELIMITED. CLAUSE REQUIRED IN THIS .UNSTRING.	An UNSTRING statement contains no DELIMITED BY clause. Fatal.
224	DATANAME MUST FOLLOW .DELIMITER IN. PHRASE.	An UNSTRING statement contains a DELIMITER IN phrase with an illegal reference. Fatal.
225	ILLEGAL DATANAME FOLLOWS .DELIMITER IN. PHRASE.	An UNSTRING statement contains a DELIMITER IN phrase referencing a data item which is invalid. Fatal.
226	DATANAME MUST FOLLOW .COUNT IN. PHRASE.	An UNSTRING statement contains a COUNT IN phrase with an illegal reference. Fatal.
227	ILLEGAL DATANAME FOLLOWS .COUNT IN. PHRASE.	An UNSTRING statement contains a COUNT IN phrase which references a data item which is invalid. Fatal.
230	DATANAME MUST FOLLOW .TALLYING IN. PHRASE.	An UNSTRING statement contains a TALLYING phrase with an illegal reference. Fatal.
231	ILLEGAL DATANAME FOLLOWS .TALLYING IN. PHRASE.	An UNSTRING statement contains a TALLYING phrase referencing a data item which is invalid. Fatal.
232	DATANAME MUST FOLLOW .INSPECT. VERB.	A valid data-name reference does not follow the INSPECT keyword. Fatal.

233	ILLEGAL DATANAME FOLLOWS .INSPECT. VERB.	An INSPECT statement references a data item which is invalid. Fatal.
234	ILLEGAL DATANAME PRECEDES .FOR. IN .INSPECT.	An INSPECT...TALLYING statement references a tally data item which is invalid. Fatal.
235	.FOR. OMITTED IN .INSPECT. STATEMENT	An INSPECT...TALLYING statement has invalid syntax. Fatal.
236	DATANAME MUST FOLLOW .TALLYING. PHRASE.	An INSPECT...TALLYING statement does not reference a tally data-name. Fatal.
237	ILLEGAL WORD FOLLOWS .FOR. IN .INSPECT.	An INSPECT...TALLYING statement does not state a valid search condition. Fatal.
240	DATAITEM OMITTED AFTER .ALL. .LEADING. OR .FIRST.	An INSPECT statement does not reference a valid search argument. Fatal.
241	.ALL. FIGURATIVE CONSTANT ILLEGAL IN .INSPECT.	An ALL literal appears in an INSPECT statement. Fatal.
242	ILLEGAL DATANAME FOLLOWS .ALL. OR .LEADING.	An INSPECT statement does not reference a valid search argument. Fatal.
243	ILLEGAL DATANAME FOLLOWS .BEFORE. OR .AFTER.	An INSPECT statement does not reference a valid delimiter in the BEFORE/ AFTER phrase. Fatal.
244	ILLEGAL DATANAME FOLLOWS .BY.	An INSPECT statement does not reference a valid replacement argument. Fatal.
245	ILLEGAL DATANAME PRECEDES .BY.	An INSPECT statement does not reference a legal data-name or literal preceding the BY phrase. Fatal.
246	DATAITEM OMITTED IN .BEFORE. OR .AFTER. PHRASE.	An INSPECT statement does not reference a legal data-name or literal after the BEFORE or AFTER phrase. Fatal.
247	ILLEGAL SYNTAX IN .INSPECT. STATEMENT.	Both the TALLYING and REPLACING keywords are missing in the INSPECT statement. Fatal.
250	.BY. MUST FOLLOW .CHARACTERS. IN REPLACING LIST.	The INSPECT...REPLACING statement must have CHARACTERS BY phrase completely specified. Fatal.

251	DATAITEM OMITTED AFTER .BY. IN .INSPECT.	The INSPECT...REPLACING statement does not reference a legal data-name or literal after BY. Fatal.
252	DATAITEM FOLLOWING .BY. EXCEEDS 1 CHARACTER.	In an INSPECT...REPLACING statement, either when the CHARACTERS BY phrase is specified or when a figurative constant preceding the BY keyword of the ALL, LEADING, or FIRST phrase is specified, the data-name or literal after the BY keyword must be defined as one character in length. Fatal.
253	DATAITEMS BEFORE AND AFTER .BY. UNEQUAL IN SIZE.	In an INSPECT...REPLACING statement, the data items before and after the BY keyword of the ALL, LEADING, or FIRST phrase must be equal in length. Fatal.
254	.BEFORE. OR .AFTER. OPERAND EXCEEDS 1 CHARACTER.	In an INSPECT...REPLACING CHARACTERS BY statement, the data-name or literal following the BEFORE or AFTER keyword must be one character in length. Fatal.
255	ILLEGAL WORD FOLLOWS .REPLACING. IN INSPECT..	A legal keyword was not recognized following REPLACING in the INSPECT statement. Fatal.
256	.BY. OMITTED AFTER REPLACING COMPARISON OPERAND.	The keyword BY is omitted in the ALL, LEADING, or FIRST phrase where it separates operands to be compared. Fatal.
257	TOO MANY RIGHT PARENTHESES IN COBOL EXPRESSION.	The compiler detects an excess of right parentheses in the COBOL expression being compiled. Parentheses must be specified in balanced pairs i.e., a left parenthesis for each right parenthesis specified. This COBOL expression is considered syntactically incorrect. Fatal.
260	TOO MANY LEFT PARENTHESES IN COBOL EXPRESSION.	The compiler detects an excess of left parentheses in the COBOL expression being compiled. Parentheses must be specified in balanced pairs i.e., a right parenthesis for each left parenthesis specified. This COBOL expression is considered syntactically incorrect. Fatal.

261	MISSING OPERAND IN ARITHMETIC EXPRESSION.	An operand is omitted in a COBOL arithmetic expression. The COBOL expression is considered syntactically invalid. Fatal.
262	ILLEGAL OPERAND IN ARITHMETIC EXPRESSION.	The compiler detects an illegal operand in a COBOL arithmetic expression. The class or usage of the operand may be invalid in the context as a reference in an arithmetic expression. Fatal.
263	NONINTEGER EXPONENT FOUND IN COBOL EXPRESSION.	The compiler detects a non-integer, numeric exponent in a COBOL arithmetic expression. The arithmetic expression is considered invalid. Fatal.
264	SUBJECT OMITTED IN CLASS CONDITION.	The compiler detects the omission of the subject in a NUMERIC or ALPHABETIC class condition. The class condition is considered syntactically invalid. Fatal.
265	SUBJECT OMITTED IN SIGN CONDITION.	The compiler detects the omission of the subject in a sign condition. The sign condition is considered syntactically invalid. Fatal.
266	OPERAND MISSING IN COMPLEX CONDITION.	The compiler detects the omission of an operand in an AND or OR complex condition. The COBOL condition expression is considered syntactically invalid. Fatal.
267	INVALID OPERAND IN COMPLEX EXPRESSION.	The compiler detects a complex condition operand which, in turn, is neither a simple condition, combined condition, nor a complex condition. Fatal.
270	ILLEGAL SYNTAX IN NEGATED SIMPLE CONDITION.	The compiler detects illegal syntax in a COBOL negated simple condition. Fatal.
271	INVALID NEGATED SIMPLE CONDITION.	The compiler detects the application of the NOT keyword to an invalid simple condition. Fatal.
272	ILLEGAL SYNTAX IN COMPUTE. STATEMENT.	The compiler detects illegal syntax in a COMPUTE statement. The left side of the assignment symbol, or the assignment symbol itself may have been omitted. Fatal.

273	.AT END. ILLEGAL FOR RANDOM .READ	Either the file has ACCESS RANDOM or DYNAMIC without the word NEXT being included in the READ statement. In either case, the AT END clause is illegal and is treated as an INVALID KEY clause.
274	INVALID KEY ILLEGAL FOR SEQUENTIAL .READ.	Either the file has ACCESS SEQUENTIAL or the READ statement contains the word NEXT. In either case, the INVALID KEY clause is illegal. It is treated as an AT END clause.
275	INDEX DATA ITEM ILLEGAL AS INDEX ON TABLE.	An index data item is used as an index on a table. The index data item reference is ignored. A literal subscript of 1 replaces the index data item reference.
276	INDEX NAME NOT DEFINED FOR THIS TABLE.	An index-name used in a subscript list either is not defined for this table or appears in the wrong logical position of the subscript list for this table. The index-name is ignored and a default value of 1 is assumed as the subscript.
277	RELATIVE INDEX IS INVALID.	The literal component of a relative index is zero or less in value or is an invalid word. Relative indexing is ignored and the index-name only is used.
300	PROGRAM NAME OMITTED AFTER .CALL. VERB	The program-name is omitted after the key word CALL in a CALL statement. This is syntactically invalid. Fatal.
301	LINAGE 0 OR LESS THAN FOOTING.	The LINAGE clause must specify a page body of at least one line and that page body size must be equal to or greater than the footing size specified in the FOOTING phrase.
302	FILE CLOSED BUT NOT OPENED.	A CLOSE statement was seen for a file that was not OPENed in this program. Fatal.
303	PRINT CONTROL ON NON SEQUENTIAL FILE. IGNORED.	An APPLY PRINT-CONTROL clause references a file which does not have SEQUENTIAL organization. The file-name is ignored in the APPLY clause.

304	DATANAME OMITTED IN .KEY IS. PHRASE.	The KEY IS phrase of the START statement is not followed by a data-name. The prime RECORD KEY data-name is assumed present.
305	SECTION OR PARAGRAPH NAME MISSING.	The Procedure Division does not start with a section or paragraph name or a section header is not followed by a paragraph name. Fatal.
306	.PROCEDURE. MISSING IN .USE. STATEMENT. ASSUMED.	The keyword PROCEDURE is missing in the USE statement. It is assumed and processing is continued.
307	.START. WITHOUT .INVALID KEY. OR .USE.	The INVALID KEY option is missing from the START statement or no USE procedure is declared for the referenced file. Fatal.
310	.WRITE. WITHOUT .INVALID KEY. OR .USE.	THE INVALID KEY option is missing from the WRITE statement or no USE procedure is declared for the referenced file. Fatal.
311	DATA DIVISION MUCH TOO LARGE.	Too much buffer space is being used for the files in this program. Too many files are declared to be OPEN simultaneously. Fatal.
312	.REDEFINES. SPECIFIES INVALID REDEFINITION.	The compiler detects the invalid application of REDEFINES to a data description entry which contributes new character positions between the data description entry containing the REDEFINES clause and the item being redefined. Also, the source of error may be the definition of another data description entry with a lower level number appearing between the data description entry containing the REDEFINES clause and the item being redefined. The compiler ignores the REDEFINES clause and continues processing the data description entry.
313	ILLEGAL TO REDEFINE ANOTHER REDEFINITION.	The REDEFINES clause specifies the redefinition of a data item whose data description entry contains a REDEFINES clause itself. This is syntactically invalid. The compiler ignores the REDEFINES clause and continues

		processing of the data description entry.
314	ILLEGAL TO REDEFINE A COBOL TABLE.	The REDEFINES clause specifies the redefinition of a data item whose data description entry contains an OCCURS clause. This is syntactically invalid. The compiler ignores the REDEFINES clause and continues processing of the data description entry.
315	.REDEFINES. APPLIED TO VARIABLE LENGTH DATAITEM.	The compiler detects an application of the REDEFINES clause to a data item whose length is variable at run-time. This data item is variable in length because it has a subordinate data item whose data description entry contains an OCCURS DEPENDING ON clause. The application of the REDEFINES clause to such a data item is syntactically invalid. The compiler ignores the REDEFINES clause and continues processing of the data description entry.
316	.OCCURS DEPENDING ON. ILLEGAL IN REDEFINITION.	The compiler detects a redefinition which contains a data description entry declared with an OCCURS DEPENDING ON clause. The OCCURS DEPENDING ON clause causes the redefinition to contain a data item whose length is variable at run-time. This is syntactically invalid. The DEPENDING ON phrase is ignored and processing continues.
317	PICTURE EXCEEDS 30 CHARACTERS. PIC X ASSUMED.	The unexpanded PICTURE string exceeds 30 characters in length. This is syntactically invalid. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
320	FILENAME MUST FOLLOW .CLOSE VERB.	The data item following the CLOSE verb was not a file-name. Fatal.
321	.NO. MUST FOLLOW .WITH. IT IS ASSUMED.	The keyword NO is missing in the WITH NO REWIND phrase of the CLOSE statement. NO is assumed present.
322	.REWIND. MUST FOLLOW .NO. IT IS ASSUMED.	The WITH NO REWIND phrase of the CLOSE statement must be

		completely specified. It is assumed present.
323	.REMOVAL. MUST FOLLOW .FOR. IT IS ASSUMED.	The FOR REMOVAL phrase of the CLOSE statement must be completely specified. It is assumed present.
324	.LOCK. OMITTED AFTER .WITH. IT IS ASSUMED.	The keyword WITH in a CLOSE statement is recognized but is not followed by one of the keywords NO or LOCK. The WITH LOCK phrase is assumed present.
325	DATANAME SPECIFIED WHERE FILENAME EXPECTED.	The name used in an I/O verb to reference a file was not a file name but was some other data-name. Fatal.
326	FILENAME MUST FOLLOW MODE SPEC. IN .OPEN..	The OPEN statement does not reference a valid file name where a file-name reference is expected. Fatal.
327	ILLEGAL MODE SPECIFIED AFTER .OPEN. VERB.	One of the OPEN mode keywords INPUT, OUTPUT, I-O, or EXTEND is required immediately after the OPEN verb. None of these four keywords was recognized. Fatal.
330	.END. MUST FOLLOW .AT.. IT IS ASSUMED.	The keyword END was omitted in the AT END phrase of the READ statement. The AT END phrase is assumed present.
331	FILENAME MUST FOLLOW .READ. VERB.	Either the file-name was omitted following the READ verb or the data item following the READ verb is not a valid file-name reference. Fatal.
332	DATANAME OMITTED AFTER .INTO. IN .READ.	The data-name reference following the INTO keyword of the READ statement was omitted. Fatal.
333	RECORDNAME MUST FOLLOW .WRITE. OR .REWRITE.	The 01 record-name reference immediately following the WRITE or REWRITE verb was omitted. Fatal.
334	STATEMENT IGNORED DUE TO ILLEGAL RECORDNAME.	The data-name immediately following the WRITE or REWRITE verb is not a valid 01 record-name reference. Fatal.
335	.ADVANCING. OPTION OMITTED IN .WRITE. 1 ASSUMED.	A data-name reference, numeric integer literal reference, or the keyword PAGE was not recognized in the BEFORE/

		AFTER ADVANCING phrase of the WRITE statement. A numeric integer literal value of 1 is assumed.
336	.EOP. MUST FOLLOW .AT.. IT IS ASSUMED.	The keyword EOP was omitted in the AT EOP phrase of the WRITE statement. The AT EOP phrase is assumed present.
337	DATANAME OMITTED AFTER .FROM.	The data-name reference following the FROM keyword of the WRITE or REWRITE statement was omitted. Fatal.
340	.ADVANCING. INTEGER TOO BIG. TRUNCATED TO 63.	The numeric integer in the BEFORE/AFTER ADVANCING phrase of the WRITE statement is greater than 63. 63 is assumed.
341	.NO REWIND. ILLEGAL WITH .IO. OR .EXTEND. MODE.	An OPEN statement with the I-O or EXTEND mode specified cannot have the NO REWIND phrase also specified. Fatal.
342	ILLEGAL .ADVANCING. DATANAME. 1 IS ASSUMED.	The data-name in the BEFORE/ AFTER ADVANCING phrase of the WRITE statement is not an elementary numeric integer data-name reference. A numeric integer literal value of 1 is assumed.
343	FILENAME MUST FOLLOW .DELETE. VERB.	Either the file-name was omitted following the DELETE verb or the data item following the DELETE verb is not a valid file-name reference. Fatal.
344	FILENAME MUST FOLLOW .START. VERB.	Either the file name was omitted following the START verb or the data item following the START verb is not a valid file name reference. Fatal.
345	.LESS. OMITTED AFTER .NOT. IN .START. ASSUMED.	The keyword LESS is omitted after NOT in the relational condition of the START statement. LESS is assumed present.
346	DATANAME OMITTED IN .KEY IS. PHRASE. ASSUMED.	The RELATIVE KEY data-name for the referenced file was omitted in the KEY IS phrase of the START statement. The RELATIVE KEY data-name is assumed present.

347	RELATIONAL WORD OMITTED AFER .KEY IS. PHRASE.	None of the relational keywords EQUAL, GREATER, or NOT was recognized following the KEY IS phrase of the START statement. Fatal.
350	TERMINATOR IGNORED IN .IO CONTROL. PARAGRAPH.	A clause is terminated by a period, but a header does not follow in Area A. The period is ignored. The compiler assumes it is still in the I-O-CONTROL paragraph.
351	TERMINATOR IGNORED IN .SPECIAL NAMES. PARAGRAPH.	A clause is terminated by a period, but is not followed by a header in Area A. The period is ignored, and the compiler continues processing the SPECIAL-NAMES paragraph.
352	.NATIVE. MISSING IN SPECIALNAMES CLAUSE.	The alphabet-name clause does not contain NATIVE or STANDARD-1. The alphabet-name clause is ignored.
353	SYNTAX ERROR IN .OBJECT COMPUTER. PARAGRAPH.	The OBJECT-COMPUTER paragraph contains an unrecognizable word. Recovery is made by scanning over all words until a word is found in area A.
354	TERMINATOR OMITTED IN .OBJECT COMPUTER. PARA.	The OBJECT-COMPUTER paragraph is not terminated by a period. Recovery is made by scanning over all words until a word is found in area A.
355	DATANAME FOLLOWING .KEY IS. PHRASE IS ILLEGAL	The data-name following the KEY IS phrase of the START statement is not a RECORD KEY associated with the referenced indexed file, nor is it subordinate to a RECORD KEY whose left-most character position corresponds to its own left-most character position. FATAL.
356	INVALID USAGE ON CONDITIONAL VARIABLE.	The level 88 condition variable does not have DISPLAY or COMPUTATIONAL usage.
357	ILLEGAL SEPARATOR IN COBOL STATEMENT. IGNORED.	An illegal character was detected between two consecutive words of a COBOL statement. The illegal character is ignored.
360	ILLEGAL CHARACTER FOUND WITHIN A COBOL WORD.	Illegal characters were found in an alphanumeric COBOL word, not within an alphanumeric literal. The illegal characters are

		replaced by dollar signs in the internal representation of the COBOL word.
361	UNRECOGNIZABLE TEXT FOUND IN COBOL STATEMENT.	In scanning the source text, the compiler was unable to recognize an alphanumeric COBOL word (i.e., a keyword or user-defined word), an alphanumeric literal, or a numeric literal. The error is not internally corrected and usually will propagate further error messages.
362	COBOL WORD BEGINS WITH OR ENDS IN HYPHEN.	In attempting to recognize a keyword or user-defined word, the compiler has detected that the COBOL word begins or ends with a hyphen character.
363	NONNUMERIC LITERAL TOO LONG. TRUNCATED TO MAX.	An alphanumeric literal greater than 132 characters in length is detected. The literal is truncated on right, retaining the first 132 characters as the literal.
364	COBOL SOURCE LINE TOO LONG. TRUNCATED TO MAX.	The indicated COBOL source line contains more than 65 characters in terminal format. The excess characters are ignored and only those characters in the printed COBOL source line are retained.
365	.BY. OMITTED IN REPLACING OPTION. COPY IGNORED.	The keyword BY was not found in this COPY...REPLACING statement. The statement will be ignored.
366	TERMINATOR OMITTED IN .COPY. IT IS ASSUMED.	The required period terminating the COPY statement is omitted. It is assumed present.
367	.LINAGE. CLAUSE DATANAME MUST BE AN INTEGER.	A data-name referenced in the LINAGE clause of the FILE SECTION is defined in the WORKING-STORAGE SECTION with decimal places.
370	.LINAGE.CLAUSE DATANAME MUST BE UNSIGNED.	A numeric data-name referenced in the LINAGE clause of the FILE SECTION is defined in the WORKING-STORAGE SECTION as a signed data item.
371	POSSIBLE HIGH ORDER RECEIVING FIELD TRUNCATION.	Truncation of high order information during a MOVE or an arithmetic operation upon a receiving field is

		possible. This is an observation only.
372	POSSIBLE LOW ORDER RECEIVING FIELD TRUNCATION.	Truncation of low order information during a MOVE or an arithmetic operation upon a receiving field is possible. This is an observation only.
373	PD HEADER NOT FOLLOWED BY AN AREA A WORD.	The word following the PROCEDURE DIVISION header does not begin in Area A. A scan is made over all words until a word is found in Area A.
374	OPEN OPTIONAL FILES ONLY IN .INPUT. MODE.	An OPTIONAL file can be OPENed in INPUT mode only. The compiler assumes that the OPTIONAL file is OPENed in INPUT mode.
375	EXPECTED .FILE STATUS. DATANAME NOT DEFINED.	A data-name referenced in a FILE STATUS phrase of a SELECT clause in the FILE-CONTROL paragraph is not defined in the WORKING-STORAGE SECTION of the DATA DIVISION.
376	EXPECTED .VALUE OF ID. DATANAME NOT DEFINED.	The data-name referenced in a VALUE OF ID clause of an FD is not defined in the WORKING-STORAGE SECTION of the DATA DIVISION. Fatal.
377	EXPECTED .LINAGE. CLAUSE DATANAME NOT DEFINED.	A data-name referenced in the LINAGE clause of the FILE SECTION is not defined in the WORKING-STORAGE SECTION of the DATA DIVISION.
400	.RELATIVE KEY. DATANAME HAS INVALID CLASS.	A data-name referenced in a RELATIVE KEY phrase of a SELECT clause in the FILE-CONTROL paragraph is defined in the WORKING-STORAGE SECTION with non-numeric class.
401	.RELATIVE KEY. DATANAME HAS INVALID USAGE.	A data-name referenced in a RELATIVE KEY phrase of a SELECT clause must be defined with COMPUTATIONAL or DISPLAY usage in the WORKING-STORAGE SECTION.
402	.RELATIVE KEY. DATAITEM IS TOO LONG.	A numeric integer data-name referenced in a RELATIVE KEY phrase is defined with more than eight digits of precision in the WORKING-STORAGE SECTION.

403	.RELATIVE KEY. DATANAME MUST BE AN INTEGER.	A numeric data-name referenced in a RELATIVE KEY phrase is defined in the WORKING-STORAGE SECTION with decimal places.
404	.FILE STATUS. DATANAME HAS INVALID CLASS.	A data-name referenced in a the FILE STATUS phrase of a SELECT clause must be defined in with DISPLAY usage in the WORKING-STORAGE SECTION.
405	.FILE STATUS. DATA NAME HAS INVALID USAGE.	A data-name referenced in a FILE STATUS phrase of a SELECT clause is defined with DISPLAY USAGE in the WORKING-STORAGE SECTION.
406	LENGTH OF .FILE STATUS. DATAITEM IS ILLEGAL.	An alphanumeric data-name referenced in a FILE STATUS phrase of a SELECT clause must be defined as an alphanumeric variable consisting of two characters in the WORKING-STORAGE SECTION.
407	.VALUE OF ID. DATANAME HAS INVALID CLASS.	A data-name referenced in a VALUE OF ID clause of an FD is defined in the WORKING-STORAGE SECTION with non-alphanumeric class.
410	.VALUE OF ID. DATANAME HAS INVALID USAGE.	A data-name referenced in a VALUE OF ID clause of an FD must be defined with DISPLAY usage in the WORKING-STORAGE SECTION.
411	LENGTH OF .VALUE OF ID. DATAITEM IS ILLEGAL.	An alphanumeric data-name referenced in a VALUE OF ID clause of an FD must be defined in the WORKING-STORAGE section as alphanumeric variable whose length L falls in the range 9<=L<=40 characters.
412	.LINAGE. CLAUSE DATANAME HAS INVALID CLASS.	A data-name referenced in the LINAGE clause of the FILE SECTION is defined in the WORKING-STORAGE SECTION with non-numeric class.
413	.LINAGE. CLAUSE DATANAME HAS INVALID USAGE.	A data-name referenced in the LINAGE clause of the FILE SECTION must be defined with COMPUTATIONAL USAGE in the WORKING-STORAGE SECTION.
414	INVALID RECEIVING OPERAND IN .SET.. IGNORED.	A receiving operand of a SET statement is invalid. Fatal.

415	NO RECEIVING OPERAND SPECIFIED IN .SET..	No receiving operands are specified in a SET statement. Fatal.
416	OMITTED OR ILLEGAL OPERAND AFTER .TO. IN .SET..	A SET statement has no valid sending operand. Fatal.
417	ILLEGAL SYNTAX IN .SET. STATEMENT.	The words TO, UP or DOWN do not follow the receiving operands of a SET statement. Fatal.
420	.BY. MUST FOLLOW .UP. OR .DOWN.. ASSUMED.	The keyword BY does not follow the word UP or DOWN in a SET statement. BY is assumed present.
421	OMITTED OR ILLEGAL OPERAND AFTER .BY. IN .SET..	The operand following the UP BY or DOWN BY phrase in a SET statement is invalid or omitted. Fatal.
422	NO OPERANDS SPECIFIED IN .DISPLAY.	No operands to be displayed were recognized by the compiler in this DISPLAY statement. Fatal.
423	SETTING INDEX NAME OUT OF RANGE. .SET. IGNORED.	A SET statement is attempting to set an index name using a literal that is too large. Fatal.
424	.IF. TRUE PATH OMITTED. ASSUME .NEXT SENTENCE.	The true path code is omitted from the IF statement. NEXT SENTENCE is assumed as the true path of the IF statement.
425	CONFLICTING SIGN SYMBOLS IN PICTURE STRING.	The compiler recognizes both the + and - sign symbols in this PICTURE string. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration
426	ZERO SUPPRESSION CONFLICTS IN PICTURE STRING.	The compiler recognizes both the Z and * zero suppression symbols in this PICTURE string. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
427	ILLEGAL CHARACTER IN THE PICTURE STRING.	A character which is not in the PICTURE string character set is recognized in this PICTURE by the compiler. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.

430	.BLANK WHEN ZERO. CONFLICTS WITH ZERO SUPPRESS.	A BLANK WHEN ZERO clause is recognized with a zero suppression field specified in the PICTURE string. The compiler ignores the BLANK WHEN ZERO clause and continues with its processing.
431	PARENTHESIZED SPECIFIER EXCEEDS 18 DIGITS	The specification contained inside parentheses of a PICTURE string exceeds 18 digits in length. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
432	SPECIFIER MISSING INSIDE PARENTHESES.	The specification contained inside parentheses of a PICTURE string is missing. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
433	ILLEGAL SYMBOL PRECEDES LEFT PAREN. IN PICTURE.	The compiler recognizes an S, V, CR, DB, or "." character preceding a left parenthesis in a PICTURE string. The error is ignored and processing continues.
434	TERMINATOR OMITTED IN .NOTE. PARAGRAPH	A NOTE paragraph that does not end with a period was detected.
435	INVALID OPERAND IN .VARYING. OR .AFTER. PHRASE.	The expected operand is not a valid name reference in the VARYING or AFTER phrase of this PERFORM VARYING statement. Fatal.
436	INVALID OPERAND IN .FROM. OR .BY. PHRASE.	The FROM or BY phrase of this PERFORM VARYING statement does not contain a valid operand reference. Fatal.
437	TOO MANY .AFTER. PHRASES IN .PERFORM. STATEMENT.	The compiler detects more than two AFTER phrases in the PERFORM VARYING statement being compiled. This is syntactically invalid. Fatal.
440	.FROM. OR .BY. OR .UNTIL. MISSING IN PERFORM.	The compiler detects the omission of the keywords FROM, BY, or UNTIL in the PERFORM VARYING statement. Fatal.

441	ILLEGAL CONDITION EXPRESSION IN THE PERFORM.	The compiler detects an invalid condition expression in the PERFORM statement. Fatal.
442	NONPOSITIVE LITERAL IN .FROM. OR .BY. PHRASE.	The compiler detects a non-positive, numeric integer literal in this PERFORM statement. This is syntactically invalid. Fatal.
443	INVALID RELATION CONDITION IN .SEARCH ALL.	The compiler detects either a syntax error or an invalid operand in the restricted form of a relation condition in the SEARCH ALL statement. Fatal.
444	NONINTEGER DATA CONFLICTS WITH INDEXNAME USAGE.	The compiler detects a non-integer data item reference in a PERFORM VARYING statement in which the VARYING, AFTER, and/or FROM phrase contains an index-name reference. This is syntactically invalid. Fatal.
445	IMPLICIT REFERENCE TO BAD CONDITION VALUES.	Through a reference to a condition-name, the compiler detects a reference to an associated condition-value which is improperly declared in the Data Division. The compiler considers this to be syntactically invalid. Fatal.
446	IMPLICIT REFERENCE TO BAD CONDITION VARIABLE.	Through a reference to a condition-name, the compiler detects that the associated condition-variable is improperly declared in the Data Division. The compiler considers this to be syntactically invalid. Fatal.
447	TOO MANY NAMES IN COBOL PROGRAM. RECOMPILE.	The COBOL program being compiled has too many data-names or procedure-names. This condition has caused a compiler table to overflow with the resultant action of aborting the compilation. The user is advised to recompile the program using the "/SYM:N" switch to get more space for the compiler symbol tables.
450	REFERENCE TO UNDEFINED DATANAME. IGNORED.	The COBOL statement being compiled contains a reference to an undefined data-name. The compiler considers this

		to be syntactically invalid and ignores the reference. This diagnostic may be issued in conjunction with other diagnostics for the erroneous statement.
451	QUALIFIED REFERENCE ILLEGAL IN THIS CONTEXT.	The compiler detects a qualified reference in a context in which an unqualified reference is required. The compiler permits the qualified reference in this context and continues with the compilation of the statement containing the reference.
452	QUALIFIER OMITTED IN QUALIFIED REFERENCE.	A data-name is omitted after the keyword OF or IN in a qualified reference in the COBOL statement being compiled. The reference is ignored. This diagnostic may be issued in conjunction with other diagnostics for the statement in error.
453	TOO MANY QUALIFIERS IN QUALIFIED REFERENCE.	The compiler detects more than 48 qualifiers in a qualified reference. The excess qualifiers are ignored in the reference.
454	UNDEFINED QUALIFIER IN QUALIFIED REFERENCE.	The compiler detects a qualified reference one of whose qualifiers is a reference to an undefined data-name. The compiler considers this to be syntactically invalid and ignores the entire qualified reference. This diagnostic may be issued in conjunction with other diagnostics for the erroneous statement containing the reference.
455	COBOL STATEMENT CONTAINS AMBIGUOUS REFERENCE.	The compiler detects a reference to COBOL data which is not uniquely referenceable through qualification. The compiler uses a reference to COBOL datum which satisfies the reference in the text of the COBOL program. This diagnostic may be issued in conjunction with other diagnostics for the statement in error.
456	DATANAME REFERENCE EXPECTED IN THIS CONTEXT.	The compiler detects a reference to a COBOL datum

		which is not alphabetic, numeric, alphanumeric, alphanumeric-edited, or numeric-edited. The context of this reference requires that the reference be to one of these classes of data items. The compiler considers the referenced item to be syntactically invalid. This diagnostic may be issued in conjunction with other diagnostics for the statement in error.
457	ILLEGAL REFERENCE DETECTED IN THIS CONTEXT.	The compiler detects a reference to a COBOL datum which is invalid in the context of its usage. The compiler considers the referenced item to be syntactically invalid. This diagnostic may be issued in conjunction with other diagnostics for the statement in error. Fatal.
460	PARENTHESIZED SPECIFIER LARGER THAN 4095.	The specification contained inside parentheses of a PICTURE string is larger than 4095 in value. The specifier exceeds an implementation limitation of 4095. The compiler assumes 4095 and continues with the processing of the PICTURE string.
461	EXTRA OPENING QUOTE ON LITERAL IS IGNORED.	The compiler detects a superfluous quote at the beginning of a non-numeric literal specification. The compiler ignores the extra quote and continues with the processing of the non-numeric literal.
462	PROGRAM NAME MUST BE A NONNUMERIC LITERAL	The program-name literal following the key word CALL is not a nonnumeric literal. This is syntactically invalid. Fatal.
464	LITERALS ARE ILLEGAL IN ARGUMENT LIST OF .CALL..	Literals are not allowed in the argument list of a CALL statement. Fatal.
465	ARGUMENT LIST OMITTED AFTER .USING. IN .CALL..	The required argument list is missing after the key word USING in the CALL statement. Fatal.
470	ILLEGAL SYNTAX IN .CODE SET. CLAUSE. IGNORED.	A valid alphabet-name reference is omitted in the

		CODE-SET clause. The compiler ignores the CODE-SET clause and continues to process the remainder of the FD.
471	DATANAME IN .KEY IS. PHRASE NOT ALPHANUMERIC.	The data-name following the KEY IS phrase in a START statement referencing an indexed file must be alphanumeric. FATAL.
472	.RECORD KEY. DATAITEM LENGTH GREATER THAN 255.	A data-name referenced in a RECORD KEY or ALTERNATE RECORD KEY phrase of a SELECT clause in the FILE-CONTROL paragraph must be defined in the FILE SECTION as an item whose length is less than or equal to 255.
473	DATANAME IN .KEY IS PHRASE IS SUBSCRIPTED OR INDEX	The data-name following the KEY IS phrase in a READ or START statement referencing an indexed file must not be subscripted or index. Fatal.
474	.RECORD KEY. DATAITEM MUST NOT BE A COBOL TABLE	A data-name referenced in a RECORD KEY or ALTERNATE RECORD KEY phrase of a SELECT clause in the FILE-CONTROL paragraph must not be defined in the FILE SECTION with an OCCURS clause or subordinate to an item with an OCCURS clause.
475	.RECORD. OMITTED FROM .ALTERNATE RECORD. ASSUMED.	The reserved word RECORD is missing from the ALTERNATE RECORD KEY clause. The error is ignored.
476	UNDEFINED .ALTERNATE RECORD KEY. DATANAME.	The data-name given in an ALTERNATE RECORD KEY clause has not been defined in the Data Division.
477	.ALTERNATE RECORD KEY. CLAUSES ARE SEPARATED	In the SELECT statement the ALTERNATE RECORD KEY clauses are interleaved among the other clauses. The ALTERNATE RECORD KEY clauses should follow one another with no intervening clauses. This error is ignored.
500	LINKAGE SECTION ITEM APPEARS TWICE IN .USING.	A LINKAGE SECTION data item must not appear more than once in the USING phrase of a PROCEDURE DIVISION USING header. FATAL.
501	ILLEGAL .SEGMENT-LIMIT. VALUE. IGNORED	The segment-limit is either not a numeric literal or a numeric literal whose value is outside of allowed segment-limit range.

502	INTEGER 1 BEYOND AREA A TREATED AS LEVEL NUMBER.	An 01 level item was detected beyond Area A and accepted as if in Area A.
503	MULTIPLE PICTURES FOR SAME ITEM. LAST USED.	A data item has more than 1 PICTURE clause. The compiler used the last PICTURE clause specified.
504	CLOSING PARENTHESIS MISSING IN PICTURE.	The right parenthesis is missing in the PICTURE string. The compiler uses the last four digits of the PICTURE string.
505	OT A SUBPROGRAM .PROGRAM. IGNORED.	An EXIT PROGRAM has been detected, but the COBOL program being compiled is not a subprogram. Because EXIT PROGRAM is meaningful only in a subprogram, the word PROGRAM is ignored, and the statement is treated as if it were a simple EXIT statement.
506	EXPANDED PICTURE STRING TOO LONG. PIC X ASSUMED.	The process of expanding a PICTURE string specification produces a string which exceeds implementation limitation. The compiler ignores the user-supplied PICTURE and declares the data-name with a "PICTURE X" declaration.
507	SPECIFIER OMITTED BEFORE LEFT PAREN. IN PIC.	The first character of a PICTURE string is a left parenthesis. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
510	SECTION NO. GREATER THAN 49 TREATED AS 49.	A segment number greater than 49 follows the word SECTION. The segment is treated as if it were 49.
511	INVALID ITEM LENGTH IN PARENTHESES OF PICTURE.	The parenthesized length specifier in a PICTURE contains non-numeric characters. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
512	VALUE CLAUSE NOT ALLOWED IN LINKAGE SECTION.	The VALUE clause cannot appear in data items in the LINKAGE SECTION. The only place the VALUE clause can appear in the LINKAGE SECTION is in a condition name definition.

513	OPERAND IN .USING. MUST BE LINKAGE SECTION ITEM.	Only level 01 or 77 LINKAGE SECTION items may appear in the USING phrase of a PROCEDURE DIVISION header. FATAL.
514	MULTIPLE FLOATING FIELDS IN NUMERIC EDIT ITEM.	The PICTURE string contains multiple floating fields. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaraton.
515	MULTIPLE ZERO SUPPRESS FIELDS IN PICTURE STRING.	Multiple zero suppression fields are detected in PICTURE string. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
516	ZERO SUPPRESSION ILLEGAL WITH FLOATING FIELD.	The PICTURE string contains both floating and zero suppression fields. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
517	ILLEGAL SYNTAX IN PICTURE STRING.	The PICTURE string is not specified correctly according to the rules of PICTURE string syntax. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
520	MULTIPLE DECIMAL POINTS IN PICTURE.	The PICTURE string contains multiple decimal point specifications (V's, P's, or periods). The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
521	OPERAND IN USING MUST BE LEVEL 01 OR 77	Only level 01 or 77 LINKAGE SECTION items may appear in the USING phrase of a PROCEDURE DIVISION header. FATAL.
522	INVALID USAGE. IGNORED.	The USAGE clause contains an invalid word. The compiler ignores the entire USAGE clause.
523	MULTIPLE USAGE CLAUSES. LAST USED.	The defined data-name has multiple USAGE clauses specified. The last USAGE clause specified is used by the compiler.

524	MULTIPLE OCCURS CLAUSES. LAST USED.	The defined data-name has multiple OCCURS clauses specified. The compiler uses the last OCCURS clause specified.
525	OCCURS SPECIFICATION ERROR. 1 ASSUMED.	The integer entry of the OCCURS clause is either non-numeric or non-integer or does not lie in the range 1 to 4095. The compiler assumes an integer value of 1.
526	DATANAME OMITTED IN DATA DESCRIPTION ENTRY.	The data-name declaration is omitted after a level-number in the data description entry. The compiler supplies a system-defined name and proceeds with the processing of the data description entry. The system-defined name is transparent and, thus, inaccessible to the user.
527	INVALID INDEX NAME. IGNORED.	The compiler did not recognize a valid index name in the INDEXED BY phrase. The compiler ignores the INDEXED BY phrase.
530	USAGE OPTION NOT YET IMPLEMENTED. IGNORED.	The compiler detected COMP-1 in the USAGE clause. This option is not implemented and is ignored. The default USAGE of DISPLAY is used by the compiler.
531	TERMINATOR OMITTED AFTER DATAITEM DESCRIPTION.	A data item description entry in the DATA DIVISION is not terminated by a period. The compiler assumes the period is present and continues processing.
532	INVALID SIGN IN NUMERIC PICTURE.	The sign character S is detected in a position other than the leading character position of a numeric PICTURE string. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
533	PICTURE CLAUSE OMITTED ON ELEMENTARY ITEM.	An elementary item is recognized with its PICTURE clause omitted in the description. The compiler declares the data-name alphanumeric with a PICTURE X declaration.

534	NUMERIC ITEM EXCEEDS 18 DIGIT MAX. TRUNCATED.	A numeric field is defined in this PICTURE with more than 18 digits of precision. The numeric field is truncated to 18 digits.
535	COMP ITEM EXCEEDS 18 DIGITS. ASSIGN 4 WORDS.	A COMPUTATIONAL data item exceeds 18 digits in its specification. The compiler truncates it and allocates four words for its run-time storage.
536	INDEX ITEM HAS ILLEGAL CLAUSE.	The compiler recognized a JUSTIFIED, SYNCHRONIZED, VALUE, PICTURE, or SIGN clause on a data-item description which has INDEX USAGE. This is illegal. The compiler ignores the offensive clause.
537	NUMERIC VALUE FOR DISPLAY ITEM. IGNORED.	The VALUE clause specifies numeric value initialization for a non-numeric data-item which is defined with DISPLAY USAGE. This is illegal. The VALUE clause is ignored.
540	VALUE TOO LONG. TRUNCATED.	The length of the non-numeric literal in the VALUE clause is longer than the associated data-item. The literal is truncated on the right to fit in the storage allocated to the data-item.
541	CLAUSE DUPLICATION. IGNORED.	This clause has been previously recognized for this item. The duplicate clause is ignored.
542	INVALID WORD IN .BLANK WHEN ZERO.. IGNORED.	The keyword ZERO was not recognized in the BLANK WHEN ZERO clause. The entire clause is ignored.
543	LEVEL NUMS UNEQUAL IN .REDEFINES. CLAUSE IGNORED.	A REDEFINES clause attempts to redefine two items of different level numbers. The REDEFINES clause is ignored.
544	POSSIBLE OVERLAP OF DEPENDING ON ITEM AND TABLE	The depending on item and variable length table are both defined in the LINKAGE SECTION. Because LINKAGE SECTION items are associated with data items appearing in a CALL statement, there is no way at compile time to insure that the depending on items and table do not overlap. The COBOL run-time OTS does not check for overlap

		of the depending on item and the table during execution. It is, therefore, your responsibility to insure that overlap does not occur.
545	LEVEL ILLEGAL AFTER 77. TREATED AS 01.	An invalid level number (02-49) follows a 77 level item. The 77 level item is treated as an 01 level item. This action may propagate further diagnostics if it is not a valid group item.
546	PERIOD OMITTED AFTER .EXIT PROGRAM.	The words EXIT PROGRAM are not followed by a period. The error is ignored.
547	.EXIT PROGRAM. NOT LAST STMT OF SENTENCE.	An EXIT PROGRAM statement appears in a sequence of statements within a sentence. But, it is not the last statement. All of the statements following it are compiled, but can never be reached during execution.
550	REDEFINING LENGTH SHOULD MATCH ORIGINAL LENGTH.	The length of a non-01 level redefines item is not the same as the length of the item it REDEFINES. The new length is used.
551	REDEFINITION OF .OCCURS. ITEM. IGNORED	Items with OCCURS cannot be redefined. REDEFINES is ignored.
552	PROCESSING RESUMES AFTER BAD FD.	Prior to issuing this message, the compiler had discovered bad syntax in the FD of the FILE SECTION. The compiler at that time issued an error message identifying the syntax error. Then the compiler went into recovery mode attempting to recognize another FD, the WORKING-STORAGE SECTION header or the PROCEDURE DIVISION. Upon recognizing one of these three language elements, the compiler issues this diagnostic indicating that normal processing resumes.
553	INVALID CLAUSE KEYWORD. OTHER CLAUSES SKIPPED.	A reserved clause keyword was expected at this point in a data item description entry of the DATA DIVISION, but was not recognized by the compiler. The compiler skips to the next level number data item description.

554	INVALID WORD FOLLOWING .VALUE.. IGNORED.	The VALUE clause contains an invalid word for this data description. The entire VALUE clause is ignored.
555	VALUE CONFLICT. GROUP VALUE USED.	This VALUE clause assigns a value to an item subordinate to a group item that also has a VALUE clause. The subordinate VALUE clause is ignored.
556	LEVEL NUMBER OMITTED. ITEM IGNORED.	The level number has been omitted in a data-item description. All the source text is ignored up to and including the next period.
557	NO VALUE AFTER CONDITION NAME. 88 IGNORED.	An 88 level condition-name has no VALUE clause specified. The entire 88 level data-item is ignored.
560	SYNTAX ERROR IN SWITCH CLAUSE. CLAUSE IGNORED.	The SWITCH clause has a syntax error in its specification. The compiler ignores the entire clause.
561	.NO. MISSING IN ADVANCING PHRASE. ASSUMED.	The keyword NO is missing in the ADVANCING phrase of the DISPLAY statement. NO is assumed present.
562	.ADVANCING. MISSING AFTER .NO.. ASSUMED.	The keyword ADVANCING is missing in the ADVANCING phrase of the DISPLAY statement. ADVANCING is assumed present.
563	DUPLICATE DATANAME DECLARATION DETECTED.	In the ENVIRONMENT and/or DATA DIVISION, a data-name is defined which, if referenced, is not uniquely referenceable even with complete qualification.
564	ILLEGAL PARAGRAPH HEADER ID DIV. PAR IGNORED.	An illegal paragraph header appears in the IDENTIFICATION DIVISION. The paragraph is ignored.
565	ILLEGAL PARAGRAPH HEADER ENV DIV. PAR IGNORED.	An illegal paragraph header appears in the ENVIRONMENT DIVISION. The paragraph is ignored.
566	NUMERIC LITERAL ILLEGAL ON GROUP ITEM. IGNORED.	A numeric literal is illegal in the VALUE clause of a group item. The VALUE clause is ignored.

567	.ENVIRONMENT. NOT FOLLOWED BY .DIVISION..	The word ENVIRONMENT is not followed by the word DIVISION. DIVISION is assumed present.
570	TERMINATOR MISSING AFTER .DATA DIVISION. HEADER.	The DATA DIVISION header is not followed by a period. The period is assumed present and processing continues.
571	TERMINATOR MISSING AFTER PARAGRAPH HEADER.	A paragraph header in the IDENTIFICATION or ENVIRONMENT DIVISION is not terminated by a period. The period is assumed present and processing continues.
572	.RENAMES. SPECIFIES STORAGE OVERLAP ON RIGHT.	In processing the RENAMES clause, the compiler detects the condition in which the end of the storage allocated to the data-name after the THRU keyword is not positionally to the right of the end of the storage allocated to the data-name after the RENAMES keyword. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
573	.SECTION. OMITTED FROM SECTION HEADER.	An ENVIRONMENT DIVISION section name is not followed by the word SECTION. The error is ignored.
574	TERMINATOR MISSING AFTER SECTION HEADER.	An ENVIRONMENT DIVISION section header is not terminated by a period. The error is ignored.
600	ILLEGAL LEVEL NUMBER. TREAT AS 01.	This level number is not an 01-49, 66, 77, or 88 level number. The level number is assumed to be 01.
601	TERMINATOR MISSING AFTER ENV DIV HEADER.	The ENVIRONMENT DIVISION header is not terminated by a period. The period is assumed present and processing continues.
602	.DATA. NOT FOLLOWED BY .DIVISION.	The word DATA is not followed by the word DIVISION. DIVISION is assumed present.
603	ENVIRONMENT DIVISION HEADER OMITTED.	The program contains no ENVIRONMENT DIVISION header. The compiler resumes processing at the next paragraph header.

604	UNRECOGNIZABLE COBOL PROGRAM FORMAT. ABORT.	The compiler is unable to recognize the reserved word IDENTIFICATION as the first word required in a COBOL source program. Failure to recognize this required reserved word may be due to one of the following reasons: (1) IDENTIFICATION is, in fact, omitted as the first word of the source file, (2) the user is attempting to compile a COBOL source program in conventional format without specifying the "/CVF" switch, or (3) the user is attempting to compile a file which is not a COBOL source program. The compiler issues a string of diagnostics to the printer, informs the user on the system console, and then aborts the compilation.
605	.IDENTIFICATION. NOT FOLLOWED BY .DIVISION..	The word IDENTIFICATION is not followed by the word DIVISION. DIVISION is assumed present.
606	TERMINATOR OMITTED AFTER .ID DIVISION. HEADER.	The IDENTIFICATION DIVISION header is not terminated by a period. The period is assumed present and processing continues.
607	.PROGRAMID. EXPECTED AFTER DIVISION HEADER.	The IDENTIFICATION DIVISION header is not followed by the PROGRAM-ID paragraph. The error is ignored and processing continues.
610	TERMINATOR OMITTED AFTER .PROGID. PARA HEADER.	The PROGRAM-ID paragraph-name is not terminated by a period. The period is assumed present and processing continues.
611	INVALID PROGRAM NAME IN .PROGRAM ID. PARAGRAPH.	The program name of the PROGRAM-ID paragraph contains an invalid character or exceeds nine characters in length. The error is ignored and processing continues.

612	TOO MANY FILES FOR LUNS OR TEMPORARY SPACE.	The compiler has discovered either that more than 30 files are declared in the program or that more than 30 SAME RECORD AREA clauses are specified in the program. The compiler imposes a limit of 30 in both cases, because the associated compiler and/ or object time table space is exhausted.
613	INVALID WORD SUSPENDS PROCESSING. SCAN FORWARD.	An unidentifiable word is found where a verb is expected. A scan is made to a verb, or period, or word in Area A.
614	PROCESSING RESTARTS ON VERB.	Due to a previous syntax error, the compiler went into recovery mode looking for the next verb, period, or Area A word upon which to resume compilation. The compiler has recognized a verb and resumes normal compilation at this point. This message is an observation only.
615	PROCESSING RESTARTS ON PROCEDURE NAME.	Due to a previous syntax error, the compiler went into recovery mode looking for the next verb, period, or Area A word upon which to resume compilation. The compiler has recognized an Area A word and resumes compilation at this point. This message is an observation only.
616	PROCESSING RESTARTS AFTER TERMINATOR.	Due to a previous syntax error, the compiler went into recovery mode looking for the next verb, period, or Area A word upon which to resume compilation. The compiler has recognized a period and resumes normal compilation on the word following the period. This is an observation only.
617	.IDENTIFICATION. KEYWORD NOT IN AREA A.	The compiler detects that the IDENTIFICATION keyword is not in Area A. The compiler ignores the error and continues processing.
620	PARAGRAPH TERMINATOR ASSUMED OMITTED.	A paragraph was terminated without a period. The period is assumed and processing continues.

621	.LINAGE. INVALID FOR THIS FILE. CLAUSE IGNORED.	The LINAGE clause must not be specified for a file which has RELATIVE or INDEXED organization. The LINAGE clause is ignored.
622	TERMINATOR MISSING AFTER PROCEDURE NAME.	A section or paragraph name is not terminated by a period. The period is assumed present and processing continues.
623	.ELSE DOES NOT HAVE ASSOCIATED .IF.. IGNORED.	The word ELSE has no associated IF statement. The ELSE is ignored.
624	VERB EXPECTED TO FOLLOW ELSE.. .ELSE. IGNORED.	A SENTENCE ENDS WITH THE word ELSE. The ELSE is ignored.
625	.JUSTIFY. WITH NUMERIC OR EDITED ITEM. IGNORED.	The JUSTIFIED clause must not be specified for a numeric or numeric-edited dataitem. The JUSTIFIED clause is ignored.
626	.BLANK WHEN ZERO. ILLEGALLY SPECIFIED. IGNORED.	The BLANK WHEN ZERO clause must be specified only for a numeric or numeric-edited data-item. The clause is ignored.
627	INVALID OR MISSING DATANAME AFTER .REDEFINES..	The compiler detects the omission of a valid data-name reference following the keyword REDEFINES. The compiler ignores the REDEFINES clause and continues with the processing of the data description entry.
630	.REDEFINES. MUST FOLLOW DATA NAME. IGNORED.	The REDEFINES keyword appears in the wrong position of a data description entry. The REDEFINES clause is ignored.
631	DEPTH OF NESTED .IF. EXCEEDS LIMIT.	A nested IF statement has exceeded the maximum depth of 30 levels. The compiler ignores nesting beyond this depth of nesting.
632	DUPLICATE PROCEDURE NAME DETECTED.	In the Procedure Division, a paragraph or section-name is defined which, if referenced, is not uniquely reference-able, even with qualification.
633	REFERENCE TO UNDEFINED PARAGRAPH NAME.	In the Procedure Division, an explicit qualified reference is made to a paragraph-name which is undefined in the section specified by the qualifier.

634	FILENAME LITERAL TOO LONG. TRUNCATED.	A file specification in the ASSIGN clause exceeds 40 characters in length. It is truncated to 40 characters.
635	ILLEGAL SYNTAX IN .GO TO. STATEMENT.	The compiler detects illegal syntax in the GO TO statement. Fatal.
636	INVALID INTEGER OR DATANAME.	In the LINAGE clause, the compiler failed to recognize a non-negative integer literal or a numeric integer data-name. This phrase of the LINAGE clause is ignored.
637	.GO TO. HAS MULTIPLE PROCEDURE NAMES.	A simple GO TO statement (i.e., without the DEPENDING ON phrase) has more than one procedure-name. Fatal.
640	INVALID WORD FOLLOWS .DATA DIVISION.	The word following the DATA DIVISION header either does not start in Area A or is not one of the reserved words FILE, WORKING-STORAGE, LINKAGE, or PROCEDURE. The compiler goes into recovery mode skipping all source text until one of the keywords FILE, WORKING-STORAGE, LINKAGE, or PROCEDURE is recognized.
641	INVALID WORD IN FILE SECTION. SCAN FORWARD.	An invalid word was detected in the FILE SECTION where the keyword FD is expected. The compiler goes into recovery mode skipping all source text until one of the keywords FD, WORKING-STORAGE, LINKAGE, or PROCEDURE is recognized.
642	.OMITTED LABELS IGNORED WITH .VALUE OF ID.	The LABEL RECORDS ARE OMITTED clause is ignored if VALUE OF ID is specified for a file. STANDARD labels are assumed. WARNING.
643	.SECTION. EXPECTED AFTER HEADER WORD.	The keyword SECTION is omitted after the word FILE, WORKING-STORAGE, OR LINKAGE SECTION is assumed present and processing continues.
644	TERMINATOR EXPECTED AFTER SECTION HEADER.	The FILE SECTION, WORKING-STORAGE SECTION, or LINKAGE header is not terminated by a period. The period is assumed and processing continues.

646	.OF. OR .ID. MISSING IN .VALUE OF ID..	One or both of the keywords OF or ID is omitted in the VALUE OF ID clause. Their presence is assumed and processing continues.
647	ILLEGAL WORD IN AREA A. SCAN FORWARD.	In the WORKING-STORAGE SECTION, an 01 or 77 level number or the PROCEDURE keyword was expected in Area A, but was not recognized. The compiler goes into recovery mode skipping source text until one of the three language elements aforementioned is recognized in Area A.
650	GROUP LEVEL .VALUE. DISALLOWED.	The VALUE clause on this group item is not permitted because a subordinate elementary item has a non-DISPLAY usage specified or has a SYNCHRONIZED clause specified. The group VALUE clause is ignored.
651	REFERENCED LINKAGE SECTION ITEM NOT IN .PD. USING..	This LINKAGE SECTION item has been referenced in the PROCEDURE DIVISION. However, neither this item nor the level 01 to which it is subordinate, appeared in the PROCEDURE DIVISION USING phrase. Only those LINKAGE SECTION items appearing in the PROCEDURE DIVISION USING phrase, or items subordinate to them may be referenced in the PROCEDURE DIVISION of a COBOL program. FATAL.
652	NON-SEQ FILE IN .MULTIPLE. FILE TAPE. CLAUSE.	In the I-O CONTROL paragraph, the MULTIPLE FILE TAPE clause is specified for a file whose organization is not SEQUENTIAL. This is illegal. The MULTIPLE FILE TAPE clause is ignored for this file.
653	.VALUE. CLAUSE ILLEGAL IN FILE SECTION.	A VALUE clause is specified for a data description entry given in the FILE SECTION. This is illegal. The VALUE clause is ignored.
654	SYNTAX ERROR IN CURRENCY CLAUSE.	The alphanumeric literal expected in the CURRENCY SIGN clause of the SPECIAL-NAMES paragraph is omitted. The clause is ignored and the currency sign defaults to the dollar sign.

655	ILLEGAL CURRENCY SIGN.	The alphanumeric literal in the CURRENCY SIGN clause is not allowed as the currency sign either because the literal is longer than one character or because it is an invalid COBOL currency sign. The CURRENCY SIGN clause is ignored and the currency sign defaults to the dollar sign.
656	SPECIALNAMES CLAUSE INVALID.	An unrecognizable word appears in a position where a SPECIAL-NAMES paragraph clause keyword is expected. All source text is skipped up to the next recognizable keyword.
657	SYNTAX ERROR IN DECIMALPOINT CLAUSE.	The keyword COMMA is omitted in the DECIMAL-POINT IS COMMA clause of the SPECIAL-NAMES paragraph. The clause is ignored.
660	.AFTER. MISSING IN .USE. STATEMENT. ASSUMED.	The keyword AFTER is omitted in the USE statement. AFTER is assumed present and processing continues.
661	NO .ERROR. OR .EXCEPTION. IN .USE. ASSUMED.	One of the keywords ERROR or EXCEPTION is omitted in the USE statement. The missing keyword is assumed present and processing continues.
662	NO KNOWN CLAUSES IN SPECIALNAMES.	The SPECIAL-NAMES paragraph contains no valid clauses. This is an observation only.
663	REDUNDANT .USE. COVERAGE. PREV. .USE. IGNORED.	Multiple USE statements have referenced the same file. The last USE statement specified is then applied to the referenced file. Fatal.
664	UNKNOWN OPEN MODE IN .USE. STATEMENT.	An unrecognizable OPEN mode option was specified in the USE statement. Fatal.
665	GROUP ITEM HAS BEEN CALLED FILLER.	A FILLER item cannot have any elementary items subordinate to it. The compiler replaces the FILLER declaration with a system-defined name and proceeds with the processing of the newly named group item. The system-defined name is transparent and inaccessible to the user.

666	MISSING ENVIRONMENT DIVISION.	The program does not contain an ENVIRONMENT DIVISION. The compiler skips to the DATA DIVISION and continues processing.
667	DIVISION BY ZERO.	The divisor of a DIVIDE statement is a literal of zero value. The error is ignored.
670	VALUE NOT PERMITTED WITH THIS ITEM.	A VALUE clause is recognized in a data description entry which contains a REDEFINES or an OCCURS clause. This is illegal. The VALUE clause is ignored.
671	INVALID CONSTANT OR LITERAL FOLLOWING .ALL..	The reserved word ALL is not followed by a non-numeric literal or a figurative constant. Thus, this is not a valid ALL literal. ALL is ignored and processing continues.
672	BAD FILENAME IN .USE. STATEMENT.	An unrecognizable word appears where a filename is expected in the USE statement. Fatal.
673	FILE NOT CLOSED.	The referenced file was OPENed but there was no CLOSE statement detected for this file in the program.
674	SUBJECT OF .ALTER. IS SECTION NAME.	The ALTER statement references a section name. Only paragraph names may be altered. If this statement is reached during execution, the program will be aborted.
675	FILE COVERED BY CONFLICTING USE PROCEDURE.	There was more than one conflicting USE procedure specified for the referenced file. Fatal.
676	DATAITEM LENGTH EXCEEDS 4095 CHARACTERS.	An elementary or group item is longer than the implementation limit of 4095 characters. The compiler declares the data item with a length of 4095 characters and proceeds with the processing of the data item.
677	SUPPLIED VALUE INVALID FOR NUM ITEM. IGNORED.	The VALUE clause specifies invalid value initialization for a numeric data item. The compiler ignores the VALUE clause.

700	FILE ACCESSED BY VERB REQUIRING REL. OR IDX ORG.	A file whose organization is SEQUENTIAL is referenced by the START or DELETE verbs or by an I/O verb which has the INVALID KEY clause specified. This is illegal. In all these cases, the referenced file must have RELATIVE or INDEXED organization. Fatal.
701	FILE ACCESSED BY VERB REQ. SEQUENTIAL ORG.	A file whose organization is RELATIVE or INDEXED is referenced by an I/O verb which has the AT EOP or ADVANCING clauses specified. This is illegal. The referenced file must have SEQUENTIAL organization. Fatal.
702	VERB NOT IMPLEMENTED.	An ANS 1974 COBOL verb appears that is not implemented in this release of the compiler. The compiler scans to another verb, period, or word in Area A.
704	OCCURS ILLEGAL FOR 01 OR 77 ITEM. IGNORE.	An OCCURS clause is specified for an 01 or 77 level data-name. The compiler ignores the OCCURS clause.
705	.ACCEPT FROM. OBJECT NOT IN SPECIALNAMES.	The mnemonic name used in the ACCEPT statement was not defined in the SPECIAL-NAMES paragraph. Fatal.
706	ACCEPT IDENTIFIER INVALID.	The word following the ACCEPT verb is not a data-name or is a data-name which has non-DISPLAY usage or invalid class. Fatal.
707	VERB OR COND. CLAUSE CONFLICTS WITH FILE ACCESS.	There is a conflict between the ACCESS MODE of the referenced file and the I/O verbs and/or condition clauses which reference this file. Fatal.
710	DATANAME AFTER .GO DEPENDING. INVALID.	The word following the DEPENDING ON phrase of the GO TO statement is not a data-name or is a data-name which has INDEX usage. This is illegal. Fatal.
711	INVALID CLASS OF DATANAME AFTER .GO DEPENDING.	The data-name following the DEPENDING ON phrase of the GO TO statement is not a numeric data-name or is a numeric, non-integer data-name. This is illegal. Fatal.

712	.DISPLAY UPON. OBJECT NOT IN SPECIALNAMES.	The mnemonic name used in the DISPLAY statement was not defined in the SPECIAL-NAMES paragraph. Fatal.
713	.DISPLAY. OPERAND IS INVALID.	A data item in the DISPLAY statement has invalid class or USAGE.
714	MISSING OR INVALID OPERAND. OF .MULTIPLY..	One of the operands of the MULTIPLY statement either is missing or is invalid. Fatal.
715	ILLEGAL .MULTIPLY. DUE TO MISSING .BY..	The keyword BY is omitted in the MULTIPLY statement. Fatal.
716	MISSING OR INVALID OPERAND OF .DIVIDE..	One of the operands of the DIVIDE statement either is missing or is invalid. Fatal.
717	ILLEGAL .DIVIDE. DUE TO MISSING .BY. OR .INTO..	One of the keywords BY or INTO is omitted in the DIVIDE statement. Fatal.
720	.GIVING. OPTION OF .DIVIDE. MISSING.	The GIVING option must be specified in a DIVIDE statement when one of the following syntactic elements is present in the DIVIDE statement:(1) a numeric literal follows the keyword INTO or (2)the keyword BY is specified. In this DIVIDE statement, the GIVING option was omitted while one of the two aforementioned syntactic elements was present. Fatal.
721	MISSING OR INVALID OPERAND OF .ADD. OR .COMPUTE.	One of the operands of an ADD or COMPUTE statement is either missing or is invalid. Fatal.
722	.TO. OR .GIVING. MISSING FROM .ADD..	One of the keywords TO or GIVING is omitted in the ADD statement. Fatal.
723	MISSING OR INVALID OPERAND OF SUBTRACT.	One of the operands in the SUBTRACT statement either is missing or is invalid. Fatal.
724	FILE NEEDS DYNAMIC ACCESS FOR .READ NEXT..	In a READ NEXT statement, the referenced file must have ACCESS MODE IS DYNAMIC specified in the FILE-CONTROL paragraph. Fatal.

725	BAD PROCEDURE NAME IN .PERFORM..	A missing or invalid procedure-name is recognized in the PERFORM statement. Fatal.
726	ILLEGAL OPERAND OF .TIMES. OPTION OF .PERFORM..	The TIMES operand of the PERFORM statement is not a numeric integer data-name or numeric integer literal. The compiler assumes a value of 1 for the TIMES operand.
727	.TIMES. MISSING FROM .PERFORM.. ASSUMED.	The PERFORM statement does not contain the keyword TIMES but does contain the iteration value required to execute the PERFORM correctly. The keyword TIMES is assumed present.
730	PROCEDURE NAME OMITTED IN .ALTER..	A valid procedure-name was not recognized in the ALTER statement. Fatal.
731	ILLEGAL .ALTER. DUE TO MISSING .TO..	The keyword TO was not recognized in the ALTER statement. Fatal.
732	FILE HAS VAR. SIZE RECS. .READ INTO. ILLEGAL.	It is illegal for the READ INTO statement to reference a file which has multiple record descriptions of different lengths. Fatal.
733	FILE ACCESSED BY VERB REQUIRING .LINAGE.	A file is accessed by an I/O verb which did not have a LINAGE clause in its specification. Fatal.
734	.DELETE. OR .REWRITE. WITHOUT INV. KEY OR USE.	A DELETE or REWRITE statement references a file for which there was no USE procedure specified and for which the INVALID KEY option was not specified in that DELETE or REWRITE statement. Fatal.
735	OPEN MODE OR NO READ PROHIBITS REWRITE OR DELETE.	A DELETE or REWRITE statement references a file which was not OPENed in the proper mode or which has no READ statement referencing it in the program. Fatal.
736	.START. CONFLICTS WITH OPEN MODE.	A START statement references a file which was not opened in the proper mode. Fatal.
737	.WRITE. CONFLICTS WITH OPEN MODE.	A WRITE statement references a file which was not opened in the proper mode. Fatal.

740	.READ. CONFLICTS WITH OPEN MODE.	A READ statement references a file which is only opened in OUTPUT or EXTEND mode. Fatal.
741	USE NOT IN DECLAR. OR NOT FOLLOWING SECTION NAME.	The USE statement is not in the DECLARATIVES section of the PROCEDURE DIVISION or is not immediately following a section name inside the DECLARATIVES. Fatal.
742	MORE THAN 255 ALTERNATE KEYS. IGNORED.	The maximum of 255 ALTERNATE KEYS has been exceeded. The clause is ignored.
743	INTEGER IN SWITCH CLAUSE INVALID OR OMITTED.	A SWITCH clause of the SPECIAL-NAMES paragraph either contains an invalid numeric integer or has omitted the integer in its specification. A SWITCH clause integer, for example, n must fall in the decimal range 1<=n<=16. The SWITCH clause is ignored.
744	.IS. OMITTED IN SPECIALNAMES. ASSUMED PRESENT.	The required keyword IS is omitted in a clause of the SPECIAL-NAMES paragraph. IS is assumed present and processing continues.
745	DEVICE MNEMONIC OMITTED IN SPECIALNAMES.	A valid device mnemonic-name is not recognized in one of the CONSOLE, LINE-PRINTER, CARD-READER, PAPER-TAPE-READER, or PAPER-TAPE-PUNCH clauses of the SPECIAL-NAMES paragraph. All source text is skipped up to the next recognizable keyword.
746	TERMINATOR OMITTED IN SPECIALNAMES.	The SPECIAL-NAMES paragraph is not terminated by a period. The period is assumed present and processing continues.
747	SUBJECT OF .ALTER. NOT .GO TO.. ALTER IGNORED.	The paragraph referenced by this ALTER statement does not contain a GO TO statement as its first statement. The ALTER statement is ignored.
750	KEYWORD OMITTED IN .SWITCH. CLAUSE.	One of the keywords OFF or ON is omitted in the SWITCH clause of the SPECIAL-NAMES paragraph. The SWITCH clause is ignored.

751	CONDITION NAME MISSING IN .SWITCH. CLAUSE.	A valid condition-name is not recognized in the SWITCH clause of the SPECIAL-NAMES paragraph. The SWITCH clause is ignored.
752	.CR. OR .DB. NOT AT RIGHT END OF PICTURE.	The PICTURE symbol CR or DB does not appear at the right end of the PICTURE string. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" DECLARATION.
753	.CR. OR .DB. USED WITH SIGNED ITEM.	Both the PICTURE symbols, CR or DB, and a sign, + or -, appear in the same PICTURE. The compiler ignores the user-supplied PICTURE and declares the data-name alphanumeric with a "PICTURE X" declaration.
754	MULTIPLE DEFINITION OF SWITCH. FIRST USED.	Multiple definitions of a COBOL switch are detected in the SPECIAL-NAMES paragraph. All but the first definition of SWITCH are ignored.
755	.SENTENCE. ASSUMED AFTER .NEXT..	The keyword NEXT is not followed by the keyword SENTENCE. SENTENCE is assumed present and processing continues.
756	SUBSCRIPT NOT NUMERIC INTEGER.	A data-name used as a subscript is not numeric in class. A default value of 1 is assumed as the subscript.
760	ILLEGAL SYNTAX IN .DIVIDE. STATEMENT.	The compiler detects illegal syntax in the DIVIDE statement. Fatal.
761	INDEXED FILE REQUIRES .RECORD KEY. PHRASE.	Self explanatory.
762	RECORD KEY INVALID FOR THIS FILE.	The RECORD KEY clause is only valid for indexed files.
763	.ALT RECORD KEY. INVALID FOR FILE. IGNORED.	The ALTERNATE RECORD KEY clause is only valid for indexed files.
764	READ-AHEAD. OR. WRITE-BEHIND. NOT SUPPORTED.	The APPLY READ-AHEAD or APPLY WRITE-BEHIND clauses are not supported in this version of the compiler. The APPLY clause is ignored.

765	INTEGER INVALID IN. RESERVE AREA. CLAUSE.	The number of buffer areas reserved by the RESERVE clause is invalid. The clause is ignored and a default of one area for SEQUENTIAL and RELATIVE or two areas for INDEXED is supplied.
766	BAD VALUE IN BLOCK CONTAINS CLAUSE.	The numeric literal in the BLOCK clause is less than the sum of the record size, the record header size, and the bucket header size. The BLOCK CONTAINS clause is ignored.
767	VALUE IN. BLOCK CONTAINS. CLAUSE IS ROUNDED UP	The numeric literal in the BLOCK clause is not a multiple of 512. The value is rounded up to the next even multiple of 512.
770	EXPECTED .RECORD KEY. DATANAME NOT DEFINED.	The data-name given in a RECORD KEY clause has not been defined in the DATA DIVISION.
771	.RECORD KEY. DATANAME HAS INVALID CLASS.	A data-name referenced in a RECORD KEY or ALTERNATE RECORD KEY phrase of a SELECT clause in the FILE-CONTROL paragraph is defined in the FILE SECTION with non-alphanumeric class.
772	.RECORD KEY. DATA ITEM CANNOT BE VARIABLE LENGTH.	A data-name referenced in a RECORD KEY or ALTERNATE RECORD KEY phrase of a SELECT clause in the FILE-CONTROL paragraph is defined in the FILE SECTION as an item whose size is variable.
773	.RECORD KEY. ITEM NOT DEFINED IN RECORD OF FILE	A data-name referenced in a RECORD KEY or an ALTERNATE RECORD KEY phrase of a SELECT clause is not defined in the record description of the associated file.
774	FILE ACCESSED BY VERB REQUIRING INDEXED ORG.	A file whose organization is SEQUENTIAL or RELATIVE is referenced by the READ verb which has the KEY IS data-name phrase specified. This is illegal. The referenced file must have INDEXED organization. FATAL.
775	.KEY IS. PHRASE INVALID FOR SEQUENTIAL .READ.	Either the file has ACCESS SEQUENTIAL or the READ statement contains the word NEXT. In either case the KEY IS data-name phrase is illegal. FATAL.

776	INVALID DATANAME IN .KEY IS. PHRASE.	The KEY IS phrase of the READ statement was not followed by a data-name. FATAL.
777	.KEY IS. PHRASE NOT FOLLOWED BY RECORD KEY.	The data-name following the KEY IS phrase of the READ statement is not a RECORD KEY or ALTERNATE RECORD KEY for the referenced file. The RECORD KEY data-name is assumed.
1000	VARIABLE OCCURRENCES TABLE MUST END RECORD.	A COBOL table declared with the DEPENDING ON phrase may only be followed, within the record, by data description entries whose level-numbers are strictly greater than the level-number of this table entry. The compiler ignores the remainder of the record descriptor from the point where the error is detected. Fatal.
1001	.ASCENDING. OR .DESCENDING. DATANAME EXPECTED.	A user-defined data-name was expected, but not found, in the ASCENDING KEY IS or DESCENDING KEY IS phrase.
1002	RENAMED DATAITEMS NOT IN CURRENT RECORD.	The data items specified after the RENAMES keyword (i.e., the data items being renamed) are defined outside of the current record description. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1003	MAXIMUM OCCURRENCES NOT GREATER THAN MINIMUM.	In a variable occurrence table declaration, the integer following the keyword TO (i.e., the maximum) must be strictly greater than the integer following the keyword OCCURS (i.e., the minimum). The compiler assumes the maximum value to be equal to the minimum value plus one.
1004	.DEPENDING. IS OMITTED IN THE .OCCURS. CLAUSE.	In a variable occurrence table declaration, the keyword DEPENDING has been omitted. The compiler ignores the remainder of the OCCURS clause and treats the table declaration as an ordinary COBOL table.
1005	A DATANAME MUST FOLLOW THE .DEPENDING. KEYWORD.	In a variable occurrence table declaration, a valid data-name is not found

	following the keyword DEPENDING. The compiler ignores the remainder of the OCCURS clause and treats the table declaration as an ordinary COBOL table.
1006 .OCCURS DEPENDING. SUBORDINATE TO AN .OCCURS.	The compiler detects a table declaration with a DEPENDING ON phrase subordinate to a group item which has an OCCURS clause. This is syntactically illegal. The compiler ignores the DEPENDING ON phrase and treats the declaration as an ordinary COBOL table.
1007 MAXIMUM NO. TABLE OCCURRENCES MUST BE POSITIVE.	In a variable occurrence table declaration, the integer following the keyword TO (i.e., the maximum) must be greater than zero. The compiler assumes the maximum value to be equal to the integer value following the keyword OCCURS (i.e., the minimum) plus one.
1010 EXPECTED .DEPENDING ON. DATANAME NOT DEFINED.	The data-name referenced in a DEPENDING ON phrase was not defined in the DATA DIVISION. Fatal.
1011 EXPECTED .ASCENDING KEY. DATANAME NOT DEFINED.	The data-name referenced in an ASCENDING KEY phrase was not defined in the DATA DIVISION. Fatal.
1012 EXPECTED .DESCENDING KEY. DATANAME NOT DEFINED.	The data-name referenced in a DESCENDING KEY phrase was not defined in the DATA DIVISION. Fatal.
1013 .DEPENDING ON. DATANAME NOT A NUMERIC INTEGER.	The data-name referenced in a DEPENDING ON phrase was not declared as a numeric integer in the DATA DIVISION. Fatal.
1014 .RENAMES. APPLIED TO AN INVALID LEVEL OF DATA.	The RENAMES clause specifies the renaming of data items whose level number is an 01, 66, 77, or 88. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1015 .DEPENDING ON. DATANAME DETECTED WITHIN TABLE.	The compiler detects a data-name, which follows a DEPENDING ON phrase and which defines the current number of occurrences in a variable occurrence table, to have its

	storage allocated within the range of the table. This is syntactically illegal. Fatal.
1016 .OCCURS. CLAUSE ON A TABLE KEY DATANAME.	The compiler detects the presence of an OCCURS clause on a data item which has been declared as an ASCENDING or DESCENDING KEY. This is syntactically illegal. Fatal.
1017 .SEARCH ALL. TABLE DOES NOT HAVE KEYS.	The table being searched by by SEARCH ALL statement must have the ASCENDING KEY or DESCENDING KEY phrase specified in its declaration. Fatal.
1020 IMPERATIVE STATEMENT EXPECTED DURING .SEARCH.	A period or a non-imperative statement was found where the SEARCH statement environment is expecting an imperative statement. Fatal.
1021 KEYS SPECIFIED FOR .SEARCH ALL. NOT DENSE.	When a key is referenced for the SEARCH ALL statement, all preceding keys in the KEY clause of the table declaration must also be referenced. Fatal.
1022 .WHEN. EXPECTED BUT NOT FOUND IN .SEARCH.	The compiler expected but failed to recognize the WHEN keyword while compiling the SEARCH statement. This SEARCH statement is considered syntactically invalid. Fatal.
1023 THE KEYWORD .WHEN. ILLEGAL IN THIS CONTEXT.	The compiler detects the presence of the keyword WHEN outside the environment of the SEARCH statement. This is syntactically invalid. Fatal.
1024 THE KEYWORD .SEARCH. ILLEGAL IN THIS CONTEXT.	While compiling a SEARCH statement, the compiler detects the presence of another SEARCH statement in the environment of the original SEARCH statement. The second SEARCH statement is detected at a point where an imperative statement is expected. This is syntactically invalid. Fatal.
1025 KEY MUST BE SUBSCRIPTED BY FIRST INDEX OF TABLE.	The SEARCH ALL statement requires that the key referenced on the left side of the simple condition must be subscripted by the first index-name of the table being searched. Fatal.

1026 THE KEYWORD .SENTENCE. EXPECTED AFTER .NEXT..	The keyword SENTENCE was not detected after the NEXT keyword during the compilation of a SEARCH statement. Fatal.
1027 TABLE NAME NOT FOUND AFTER .SEARCH. VERB.	The compiler failed to recognize a valid table data item after the keyword SEARCH or SEARCH ALL. Fatal.
1030 INVALID TABLE REFERENCE IN .SEARCH. STATEMENT.	The table data item reference following the SEARCH or SEARCH ALL verbs must have both the INDEXED BY and the OCCURS clauses specified in its declaration. Fatal.
1031 DATANAME EXPECTED AFTER .VARYING. IN .SEARCH.	No data-name reference was found after the VARYING keyword in the SEARCH statement being compiled. Fatal.
1032 .VARYING. ITEM MUST BE INDEX OR INTEGER.	The data-name reference following the VARYING keyword must be an index data item, an index-name, or an elementary numeric integer data-name reference. Fatal.
1033 .SEARCH ALL. DATA ITEM IS NOT A KEY.	The data item referenced on the left side of the SEARCH ALL simple condition must be declared as an ASCENDING or DESCENDING KEY. Fatal.
1034 DATA ITEM NOT A KEY FOR THIS .SEARCH. TABLE.	The data item referenced on the left side of the SEARCH ALL simple condition is not a key for the table being searched. This is considered illegal. Fatal.
1035 .RENAMES. SPECIFIES RENAMING OF A COBOL TABLE.	The RENAMES clause specifies the renaming of a datum which has an OCCURS clause in its declaration or is subordinate to another datum having an OCCURS clause. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1036 .RENAMES. APPLIED TO VARIABLE LENGTH DATAITEM.	The compiler detects an application of the RENAMES clause to a range of data items which contains a data item whose length is variable at run-time. This data item is variable in length because is has a subordinate data item whose data description entry contains an OCCURS

	DEPENDING ON clause. The application of the RENAMES clause to such a range of data items is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1037 DATANAME OMITTED AFTER 66 LEVEL NUMBER.	The data-name declaration is omitted after a 66 level number. The compiler ignores the entire RENAMES data description entry.
1040 .RENAMES. OMITTED IN LEVEL 66 DESCRIPTION ENTRY.	The RENAMES keyword is omitted in a level 66 data description entry. The compiler ignores the entire level 66 data description entry.
1041 SEARCH KEY NOT SUBORDINATE TO TABLE.	The compiler detects an ASCENDING or DESCENDING data-name key which is not defined as a data item subordinate to the associated SEARCH table. This is syntactically invalid.
1042 INVALID OR MISSING DATANAME AFTER .RENAMES..	The data-name is missing after the RENAMES keyword or, if present, is not recognized as a valid data item previously defined. The compiler ignores the entire RENAMES data description entry.
1043 .OCCURS. ITEM NOT ALLOWED BETWEEN TABLE AND KEY.	The compiler detects a data item declared with an OCCURS clause "sandwiched" between the declaration of another COBOL table and its associated SEARCH key. This is syntactically invalid.
1044 .RENAMES. SPECIFIES INVALID NOMENCLATURE RANGE.	In processing the RENAMES clause, the compiler detects an invalid nomenclature range specified by identical data-names following the RENAMES and THRU keywords, respectively. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1045 .RENAMES. SPECIFIES STORAGE OVERLAP ON LEFT END.	In processing the RENAMES clause, the compiler detects the condition in which the beginning of the storage allocated to the data-name

	after the THRU keyword is positionally to the left of the beginning of the storage allocated to the data-name after the RENAMES keyword. This is syntactically invalid. The compiler ignores the entire RENAMES data description entry.
1046 INVALID OR MISSING DATANAME AFTER .THRU..	In specifying the RENAMES clause, a data-name is missing after the THRU keyword or, if present, is not recognized as a valid data item previously defined. The compiler ignores the entire RENAMES data description entry.
1047 INVALID OR MISSING DATANAME AFTER CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler detects the omission of a valid data-name reference after the CORRESPONDING keyword. Fatal.
1050 .TO. OR .FROM. OMITTED IN .CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler detects the omission of the TO or FROM keyword. Fatal.
1051 INVALID OR MISSING DATANAME AFTER .TO. OR .FROM.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler detects the omission of a valid data-name reference after the keyword TO or FROM. Fatal.
1052 NO OBJECT CODE PRODUCED FOR .CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler produced no object code. No object code is produced because no "correspondence" was found between the two group items referenced in the COBOL statement containing the CORRESPONDING option. This diagnostic is informational only.

1053 GROUP ITEM NOT REFERENCED IN .CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler discovers that one of the references is a reference to an elementary item. This is syntactically invalid. Fatal.
1054 LEVEL 66 REFERENCE DISALLOWED IN .CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler detects a reference to a data-name declared at level 66. This is an invalid reference. Fatal.
1055 .FILE STATUS. ITEM DEFINED IN .FILE SECTION.	A data-name referenced in a FILE STATUS phrase of a SELECT clause is defined in the FILE SECTION of the COBOL program. The compiler ignores this error and continues to process the FILE STATUS data-name.
1056 INCOMPATIBLE OPERANDS FOUND IN .CORRESPONDING.	In the processing of an ADD, SUBTRACT, or MOVE CORRESPONDING statement, the compiler detects a pair of CORRESPONDING data items which are incompatible. This diagnostic is informational only.
1057 EMPTY .GO TO. WAS NOT THE SUBJECT OF AN .ALTER..	A GO TO statement without a procedure reference was detected. The empty GO TO is not the subject of an ALTER statement. FATAL.
1060 QUALIFIER OMITTED IN PROCEDURE REFERENCE.	A section name is omitted after the keyword OF or IN in a qualified procedure reference of the COBOL statement being compiled. Fatal.
1061 INCONSISTENT NUMBER OF ARGUMENTS IN .CALL..	The subprogram referenced in this CALL statement has been referenced before. The number of arguments in the earlier CALL differs from the number in the current CALL.
1062 PARAGRAPH WITHOUT SECTION PRECEDES THIS SECTION.	In a COBOL program, if one paragraph is in a section, then all paragraphs must be in sections. In this source program, a paragraph not within a section has been detected, preceding this section in the source program.

1063 DUPLICATE PARAGRAPH NAME DETECTED.	In a section of the Procedure Division, a paragraph name is defined more than once which, if referenced, is not uniquely referenceable, even with qualification.
1064 REFERENCE TO UNDEFINED PROCEDURE NAME.	The compiler detects a reference to an undefined procedure name in the PROCEDURE DIVISION. This is syntactically invalid.
1065 UNDEFINED PROCEDURE QUALIFIER REFERENCE.	The compiler detects a qualified procedure reference which contains an undefined qualifier in the PROCEDURE DIVISION. This is syntactically invalid.
1066 ILLEGAL PROCEDURE NAME REFERENCE.	The compiler detects an invalid procedure name reference in the PROCEDURE DIVISION. This is syntactically invalid.
1067 AMBIGUOUS PROCEDURE NAME REFERENCE.	The compiler detects a reference in the PROCEDURE DIVISION to a procedure name which is not uniquely referenceable, even through qualification. This is syntactically invalid.
1070 PARAGRAPH NAME DISALLOWED AS QUALIFIER.	The compiler detects a qualified procedure reference in the PROCEDURE DIVISION in which the qualifier is a paragraph name. This is syntactically invalid.
1071 SECTION NAME REFERENCE MAY NOT BE QUALIFIED.	The compiler detects a qualified procedure reference in the PROCEDURE DIVISION in which a section name is qualified by another section name. This is syntactically invalid.
1072 AMBIGUOUS PARAGRAPH NAME REFERENCE.	The compiler detects a reference in the PROCEDURE DIVISION to a paragraph name which is not uniquely referenceable, even through qualification.

1073 POSSIBLE .PERFORM. RANGE VIOLATION.	The compiler detects a PERFORM THRU statement in which the procedure name following the THRU keyword is defined in the text of the Procedure Division before the procedure name following the PERFORM keyword. This condition may potentially represent a logic problem in the COBOL program being compiled, although not necessarily so.
1074 NUMERIC PROCEDURE NAME EXCEEDS 30 CHARACTERS.	A numeric string which appears to be a numeric procedure name exceeds 30 characters in length. The string is truncated on the right to 30 characters and processing of the numeric procedure name continues.
1075 NUMERIC PROCEDURE NAME CONTAINS DECIMAL POINT.	A numeric string which appears to be a numeric procedure name contains a decimal point. This is syntactically invalid. The compiler ignores the presence of the decimal point and proceeds with the processing of the numeric procedure name.
1076 .RELATIVE KEY. ITEM DEFINED IN RECORD OF FILE.	A data-name referenced in a RELATIVE KEY phrase of a SELECT clause is defined in the record description of the associated file. The compiler ignores this error and continues to process the RELATIVE KEY data-name.
1077 NO. OF AREAS DEFAULTS TO MAX. FOR FILE TYPE	The number of buffer areas reserved by the RESERVE clause is greater than the maximum allowed for the file organization. Instead, the clause will cause two areas to be allocated for a sequential file and one for a relative file.

APPENDIX H

RECORD MANAGEMENT SERVICES ERROR CODES

Any of the following I/O error conditions could occur during COBOL program execution. The codes appear in a COBOL message in the form shown below:

"RECORD MANAGEMENT SERVICES ERROR - nn"

(nn represents the Record Management Services error code).

These error codes are listed in Table H-1.

Table H-1
RMS System Standard Error Codes

Value	Meaning
-16	OPERATION ABORTED(STV=ER$STK/MAP)
-32	F11ACP COULD NOT ACCESS FILE(STV=SYS ERROR CODE)
-48	"FILE" ACTIVITY PRECLUDES OPERATION
-64	BAD AREA ID(STV=@XAB)
-80	ALIGNMENT OPTIONS ERROR(STV=@XAB)
-96	ALLOCATION QUANTITY TOO LARGE
-112	NOT ANSI "D" FORMAT
-128	ALLOCATION OPTIONS ERROR(STV=@XAB)
-144	INVALID(I.E. SYNCH) OPERATION AT AST LEVEL
-160	ATTRIBUTE READ ERROR(STV=SYS ERR CODE)
-176	ATTRIBUTE WRITE ERROR(STV=SYS ERR CODE)
-192	BUCKET SIZE TOO LARGE(FAB)
-208	BUCKET SIZE TOO LARGE(STV=@XAB)
-224	"BLN" LENGTH ERROR(RAB/FAB)
-232	BEGINNING OF FILE DETECTED
-240	PRIVATE POOL ADDRESS NOT MULTIPLE OF "4"
-256	PRIVATE POOL SIZE NOT MULTIPLE OF "4"
-272	INTERNAL RMS ERROR CONDITION DETECTED
-288	CAN'T CONNECT RAB
-304	$UPDATE-KEY CHANGE A KEY WITHOUT HAVING ATTRIBUTE OF XB$CHG SET
-320	BUCKET FORMAT CHECK-BYTE FAILURE
-352	INVALID OR UNSUPPORTED "COD" FIELD(STV=@XAB)
-368	F11-ACP COULD NOT CREATE FILE(STV=SYS ERR CODE)
-384	NO CURRENT RECORD(OPERATION NOT PRECEDED BY GET/FIND)
-400	F11-ACP DEACCESS ERROR DURING "CLOSE"(STV=SYS ERR CODE)
-416	DATA "AREA" NUMBER INVALID(STV=@XAB)
-432	RFA-ACCESSED RECORD WAS DELETED
-448	BAD DEVICE, OR INAPPROPRIATE DEVICE TYPE
-464	ERROR IN DIRECTORY NAME

Table H-1 (Cont.)
RMS System Standard Error Codes

Value	Meaning
-480	DYNAMIC MEMORY EXHAUSTED
-496	DIRECTORY NOT FOUND
-512	DEVICE NOT READY
-520	DEVICE POSITIONING ERROR(STV=SYS ERR CODE)
-528	"DTP" FIELD INVALID(STV=@XAB)
-544	DUPLICATE KEY DETECTED, XB$DUP ATTRIBUTE NOT SET
-560	RSX-F11ACP ENTER FUNCTION FAILED(STV=SYS ERR CODE)
-576	OPERATION NOT SELECTED IN "ORG$" MACRO
-592	END-OF-FILE
-608	EXPANDED STRING AREA TOO SHORT
-616	FILE EXPIRATION DATE NOT YET REACHED
-624	FILE EXTEND FAILURE(STV=SYS ERR CODE)
-640	NOT A VALID FAB("BID" NOT=FB$BID)
-656	ILLEGAL FAC FOR REC-OP,0, OR FB$PUT NOT SET FOR "CREATE"
-672	FILE ALREADY EXISTS
-680	INVALID FILE-ID
-688	INVALID FLAG-BITS COMBINATION(STV=@XAB)
-704	FILE IS LOCKED BY OTHER USER
-720	PSX-F11ACP "FIND" FUNCTION FAILED(STV=SYS ERR CODE)
-736	FILE NOT FOUND
-752	ERROR IN FILENAME
-768	INVALID FILE OPTIONS
-784	DEVICE/FILE FULL
-800	INDEX "AREA" NUMBER INVALID(STV=@XAB)
-816	INDEX NOT INITIALIZED(STV ONLY,STS=ER$RNF)
-832	INVALID IFI VALUE
-848	MAX NUM(254) AREAS/KEY XABS EXCEEDED(STV=@XAB)
-864	$INIT MACRO NEVER ISSUED
-880	OPERATION ILLEGAL, OR INVALID FOR FILE ORG.
-896	ILLEGAL RECORD ENCOUNTERED(SEQ. FILES ONLY)
-912	INVALID ISI VALUE, ON UNCONNECTED RAB
-928	BAD KEY BUFFER ADDRESS(KBF=0)
-944	INVALID KEY FIELD(KEY=0/NEG)
-960	INVALID KEY-OF-REFERENCE($GET/$FIND)
-976	KEY SIZE TOO LARGE(IDX)/NOT=4(REL)
-992	LOWEST-LEVEL-INDEX "AREA" NUMBER INVALID(STV=@XAB)
-1008	NOT ANSI LABELED TAPE
-1024	LOGICAL CHANNEL BUSY
-1040	LOGICAL CHANNEL NUMBER TOO LARGE
-1048	LOGICAL EXTEND ERROR, PRIOR EXTEND STILL VALID(STV=@XAB)
-1056	"LOC" FIELD INVALID(STV=@XAB)
-1072	BUFFER MAPPING ERROR
-1088	F11ACP COULD NOT MARK FILE FOR DELETION(STV=SYS ERR CODE)
-1104	MRN VALUE=NEG/REL.KEY>MRN
-1120	MRS VALUE=0 FOR FIXED LENGTH RECS/=0 FOR REL. FILES
-1136	"NAM" BLOCK ADDRESS INVALID(NAM=0, OR NOT ACCESSIBLE)
-1152	NOT POSITIONED TO EOF(SEG. FILES ONLY)
-1168	CAN'T ALLOCATE INTERNAL INDEX DESCRIPTOR
-1184	INDEXED FILE-NO PRIMARY KEY DEFINED
-1216	XAB'S NOT IN CORRECT ORDER(STV=@XAB)
-1232	INVALID FILE ORGANIZATION VALUE
-1248	ERROR IN FILE'S PROLOGUE(RECONSTRUCT FILE)
-1264	"POS" FIELD INVALID(POS>MRS,STV=@XAB)
-1280	BAD FILE DATE FIELD RETRIEVED(STV=@XAB)
-1296	PRIVILEGE VIOLATION(OS DENYS ACCESS)

Table H-1 (Cont.)
RMS System Standard Error Codes

Value	Meaning
-1312	NOT A VALID RAB("BID" NOT=RB$BID)
-1328	ILLEGAL RAC VALUE
-1344	ILLEGAL RECORD ATTRIBUTES
-1360	INVALID RECORD BUFFER ADDR("ODD", OR NOT WORD-ALIGNED IF BLK-IO)
-1376	FILE READ ERROR(STV=SYS ERR CODE)
-1392	RECORD ALREADY EXISTS
-1408	BAD RFA VALUE(RFA=0)
-1424	INVALID RECORD FORMAT
-1440	TARGET BUCKET LOCKED BY ANOTHER STREAM
-1456	RSX-F11ACP REMOVE FUNCTION FAILED(STV=SYS ERR CODE)
-1472	RECORD NOT FOUND(STV=0/ER$IDX) RECORD NEVER WAS IN FILE, OR HAS BEEN DELETED
-1488	RECORD NOT LOCKED
-1504	INVALID RECORD OPTIONS
-1520	ERROR WHILE READING PROLOGUE(STV=SYS ERR CODE)
-1536	INVALID RRV RECORD ENCOUNTERED
-1552	RAB STREAM CURRENTLY ACTIVE
-1568	BAD RECORD SIZE(RSZ>MRS, OR NOT=MRS IF FIXED LENGTH RECS RSZ NOT=CURRENT REC.SIZE FOR $UPDATE TO SEQ.FILE
-1584	RECORD TOO BIG FOR USER'S BUFFER(STV=ACTUAL REC SIZE)
-1600	PRIMARY KEY OUT OF SEQUENCE(RAC=RB$SEQ FOR $PUT)
-1616	"SHR" FIELD INVALID FOR FILE(CAN'T SHARE SEQ FILES)
-1632	"SIZ" FIELD INVALID(STV=@XAB)
-1648	STACK TOO BIG FOR SAVE AREA
-1664	SYSTEM DIRECTIVE ERROR(STV=SYS ERR CODE)
-1680	INDEX TREE ERROR
-1696	ERROR IN FILE TYPE
-1712	INVALID USER BUFFER ADDR(0,ODD, OR IF BLK-IO NOT WORD ALIGNED)
-1728	INVALID USER BUFFER SIZE(USZ=0)
-1744	ERROR IN VERSION NUMBER
-1760	INVALID VOLUME NUMBER(STV=@XAB)
-1776	FILE WRITE ERROR(STV=SYS ERR CODE)
-1784	DEVICE IS WRITE-LOCKED
-1792	ERROR WHILE WRITING PROLOGUE(STV=SYS ERR CODE)
-1808	NOT A VALID XAB(@XAB=ODD,STV=@XAB)

APPENDIX I

OBJECT TIME SYSTEM ERROR MESSAGES

Table I-1
COBOL Object Time System Error Messages

Number	Message	Meaning
1	NON EXISTENT OTS ROUTINE INVOKED	The COBOL compiler has generated reference to a nonexistent OTS routine. This should never occur; (COBOL compiler error - notify your DEC Software Specialist).
3	DEPENDING DATA NAME OUT OF RANGE	The data item which defines the current number of elements in the table does not fall within the defined table size range.
4	ILLEGAL SUBROUTINE REENTRY	A COBOL subprogram may not be called while it is still processing a previous call.
5	INCORRECT NUMBER OF SUBROUTINE ARGUMENTS	The number of arguments expected by a COBOL subprogram does not agree with the number actually received.
6	FILE: NN... ATTEMPT TO OPEN 2 'MULTIPLE SAME AREA' FILES SIMULTANEOUSLY	The program tried to open a file that uses the same buffer area of another file that is still open. (NN... represents the file-name.)
7	FILE: NN... NOT OPEN	The program attempted to perform an I/O operation on a file that was not open. (NN... represents the file-name.)

Table I-1 (Cont.)
COBOL Object Time System Error Messages

Number	Message	Meaning
10	FILE: NN... ALREADY OPEN	The program attempted to open a file that was already open. (NN... represents the file-name.)
11	SUBSCRIPT TOO BIG	A subscript value used in a subscripted data item reference has exceeded the upper bounds of the number of items in the table.
12	PERFORM STACK OVERFLOW	The perform stack is used to process nested performs. The size of this stack is fixed at compile time. To increase the default size, specify the /PFM switch at compile time.
13	NULL ALTERABLE GO TO	An alterable GOTO statement has been reached, and no procedure name was assigned to it.
14	STOP, CR TO CONTINUE	The program executed a STOP statement. The OTS waits indefinitely. To continue, type carriage return.
15	STOP RUN	The program executed a STOP RUN statement. The program stops all activity and closes all open files.
16	SUBSCRIPT TOO SMALL	The subscript value of a data item is less than or equal to zero.
17	PERFORM END OF RANGE VIOLATION	The end-point of an active perform range has occurred. However, the perform range in question is not the most recent.
20	FILE: NN... OPTIONAL FILE MOUNTED? Y OR N?	The OTS is asking the operator to specify whether the file NN... is available to the running program. (NN... represents the file-name.) Type a Y for yes, or N (or some other character) for no.

Table I-1 (Cont.)
COBOL Object Time System Error Messages

Number	Message	Meaning
22	INDEX VALUE TOO SMALL OR TOO LARGE AT SOURCE LINE NNNNN	A value for an index name is being used in a SET statement that is outside the bounds of the table. (NNNNN represents the source program's page-line number.)
24	WRITE ERROR IN DISPLAY	A DISPLAY statement encountered a bad device or a record length of more than 132 characters.
25	ILLEGAL NESTED PERFORM	An attempt was made to invoke a perform range whose end-point is that of an active perform range.
26	UNKNOWN PROCEDURE	Self-explanatory; an appropriate diagnostic error message was produced by the compiler. See the compiler listing.
27	SPECIFY "ON" SWITCHES	See Section 2.4
30	ACCEPT-INPUT TOO LONG	A single ACCEPT statement has attempted to read more than 80 characters. The OTS currently imposes a limit of 80 characters on the ACCEPT statement.
31	FILE: NN... OPEN ERROR-XX	The program attempted to open file NN... but the open failed. The Record Management services error code specifies the kind of error. (See Appendix H for the RMS error codes.) (NNN.. represents the file-name. XX represents the error code.)
32	FILE: NN... CLOSE ERROR-XX	The program attempted to close file NN... but the close operation failed. The RMS error code specifies the kind of error. (See Appendix H for the RMS error codes.) (NN... represents the file-name. XX represents the error code.)
33	FILE: NN... NOT OPEN	The program attempted to close file NN... but file NN... is not open. (NN... represents the file-name.)

Table I-1 (Cont.)
COBOL Object Time System Error Messages

Number	Message	Meaning
34	FILE: NN... INVALID LINAGE	The LINAGE clause specified a page body size that has been calculated to be zero. (NN... represents the file-name.)
36	FILE: NN... REWRITE/ DELETE NOT LEGAL WITHOUT PRIOR READ	The program requested a REWRITE or a DELETE operation on a sequential file and the last I/O operation in the file was not a READ.
37	FILE: NN... NO USE PROCEDURE FOR I/O ERROR-XX	The OTS detected an I/O error for file NN... and no USE procedure is specified for the file (explicitly or implicitly). The RMS error code XX, specifies the kind of error. (See Appendix H for the RMS error codes.) This message results from a fatal error; the OTS executes a STOP RUN and closes all open files.
40	FILE: NN... LOCKED	The program previously closed the file with lock during this program execution. (NN... represents the file-name.)
41	FILE: NN... INVALID OPERATION	The program attempted to issue one of the following I/O statements on a file open in an incompatible mode: • A READ on a file open for output; • A WRITE on a file open for input or I-O; • A REWRITE or DELETE on a file open for input or output.
42	ABORT EXECUTION	Execution of the task has arrived at a point where a fatal diagnostic was detected by the compiler.

NOTE

The following errors indicate a fault condition within the task.

Table I-1 (Cont.)
COBOL Object Time System Error Messages

Number	Message	Meaning
43	ODD ADDRESS ERROR	
44	MEMORY PROTECTION VIOLATION	
45	T-BIT TRAP OR BPT INSTRUCTION	
46	IOT INSTRUCTION	
47	RESERVED INSTRUCTION	
50	NON-RSX EMT	
51	FLOATING POINT EXCEPTION	

INDEX

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