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Program Product

OS
PL/I Optimizing Compiler Programmer's Guide

Program Numbers 5734-PL1
5734-LM4
5734-LM5

(These program products are available as composite package 5734-PL3)

IBM

First Edition (September 1971)

This edition applies to Release 20.1 of IBM System/360 Operating System and to all subsequent releases until otherwise indicated in new editions or Technical Newsletters. Changes will continually be made to the information herein; before using this publication in connection with the operation of IBM systems, consult the latest IBM System/360 and System/370 Bibliography SRL Newsletter, Order No. GN20-0360, for the editions that are applicable and current.

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Preface

This publication is a guide to the use of the PL/I Optimizing Compiler (Program No. 5734-PL1) in a batch environment of the IBM Operating System. It explains how to use the compiler to execute PL/I programs and describes the operating system features that may be required by a PL/I programmer. It does not describe the language implemented by the compiler, nor does it explain how to use the compiler in an operating system with the Time Sharing Option (TSO); these are the functions of the manuals listed under "Associated Publications," below.

For execution of a PL/I program, the optimizing compiler employs subroutines from the OS PL/I Resident Library (Program No. 5734-LM4) and the OS PL/I Transient Library (Program No. 5734-LM5), and this programmer's guide assumes the availability of these program products.

The first three chapters cover basic topics, and are intended primarily for casual (non-specialist) programmers or for newcomers to IBM System/360 or IBM System/370. The reader is assumed to have only an elementary grasp of PL/I and the basic concepts of data processing. These chapters introduce the reader to the operating system, and explain how to run a PL/I program and how to define a data set.

The rest of the manual contains more detailed information on the optimizing compiler, and provides general guidance and reference information on operating system features that are likely to be required by the PL/I applications programmer. Most of this information is equally relevant to the use of the compiler in a batch or TSO environment.

Chapter 4 describes the optimizing compiler, the data sets it requires, its optional facilities, and the listings it produces. Chapter 5 contains similar information for the linkage editor and loader, one of which is needed in addition to the compiler to prepare a PL/I program for execution.

Chapters 6 through 9 are concerned with the various types of data sets that can be created and accessed by a PL/I program, and explain how to define these data sets.

Chapter 10 describes the standard cataloged procedures provided by IBM for the optimizing compiler, and explains how to modify them.

Chapter 11 deals with the facilities available for debugging PL/I programs.

Chapter 12 explains how to link programs written in PL/I with those written in assembler language. (The optimizing compiler implements language designed to facilitate communication between programs written in PL/I and those written in FORTRAN and COBOL; these facilities are described in the language reference manual listed under "Associated Publications," below.)

Chapters 13 and 14 are concerned with the use of built-in subroutines included in the resident library to provide direct interface between PL/I programs and the operating system sort and checkpoint/restart facilities.

A series of appendixes supply sundry reference information.

ASSOCIATED PUBLICATIONS

The language implemented by the optimizing compiler is described in the following publication:

> OS PL/I Optimizing and Checkout Compilers: Language Reference Manual, Order No. SC33-0009

For information on how to use the compiler in a TSO environment refer to:

> OS Time Sharing Option: PL/I Optimizing Compiler, Order No. SC33-0029

The diagnostic messages issued by the compiler and the transient library are listed in the following publication, together with explanations, where necessary, and suggested programmer response:

> OS PL/I Optimizing Compiler: Messages, Order No. SC33-0027

RECOMMENDED PUBLICATIONS

The following publications are referred to in this programmer's guide. They contain additional details about particular topics discussed in this manual.

OS PL/I Optimizing Compiler: Execution Logic, Order No. SC33-0025

OS Introduction, Order No. GC28-6534

OS Job Control Language User's Guide, Order No. GC28-6703

OS Job Control Language Reference, Order No. GC28-6704

OS Time Sharing Option, Terminal User's Guide, Order No. GC28-6763

OS Linkage Editor and Loader, Order No. GC28-6538

OS System Programmer's Guide, Order No. GC28-6550

OS Utilities, Order No. GC28-6586

OS Sort/Merge, Crder No. SC28-6543

OS Supervisor and Data Management Macro Instructions, Order No. GC28-6647

OS Programmer's Guide to Debugging, Order No. GC28-6670

AVAILABILITY OF PUBLICATIONS

The availability of a publication is indicated by its use key, the first letter in the order number. The use keys are

G - General: available to users of IBM systems, products, and services without charge, in quantities to meet their normal requirements; can also be purchased by anycne through IBM branch offices.

S - Sell: can be purchased by anycne through IBM branch offices.

Contents

Figures

Chapter 1: Introduction

The Optimizing Compiler

The PL/I Optimizing Compiler is a processing program that translates PL/I source programs, diagnosing errors as it does so, into IBM System/360 machine instructions. These machine instructions make up an object program. (See later in this chapter for a description of how an object program is prepared for execution.)

The compiler is designed to produce efficient object programs either with or without optimization. This optimization, which is optional, can be specified by the programmer by means of a compiler option.

If optimization is specified, the machine instructions generated will be optimized if necessary, to produce a very efficient object program.

If optimization is not specified, compilation time will be reduced.

The optimizing compiler also can be used conversationally. It can be invoked from a remote terminal to compile and execute a PL/I source program, and return the results to the terminal or to a printer.

The optimizing compiler requires a minimum of 50K bytes of main storage when used with MFT and a minimum of 52K when used with MVT. In either case it will work more efficiently with larger amounts of main storage.

The Operating System

The optimizing compiler must be executed through the IBM Operating System. This operating system is used with both System/360 and System/370.

The operating system relieves the programmer of routine and time-consuming tasks by controlling the allocation of storage space and input/output devices. The throughput of the system is increased because the operating system can process a stream of jobs without intervention by the operator.

The operating system comprises a control program and a number of processing programs. The control program supervises the execution of all processing programs, and provides services that are required by the processing programs during their execution. The processing programs include such programs as compilers, the linkage editor and the loader (see later in this chapter). The operating system is described in the publication CS Introduction.

The optimizing compiler can be used with two operating system control programs:

MFT (Multiprogramming with a Fixed number of Tasks) permits up to fifteen jobs to be processed concurrently, each job occupying a separate area of main storage termed a partition.

MVT (Multiprogramming with a Variable number of Tasks) permits up to fifteen jobs to be processed concurrently, each job occupying a separate area of main storage termed a region.

TIME SHARING OPTION

An optional facility of the MVT operating system is the Time Sharing Option (TSO). One or more regions can be allocated to TSO and several users can have concurrent access to the system. Each user enters his jobs from a remote terminal and can receive the results at the terminal. (To contrast it with this "conversational" mode of operation, the more conventional method of submitting jobs through the system operator is called batch operation.)

This programmer's guide forms a complete guide to the use of the optimizing compiler in a batch environment. It also provides essential background and reference information for the TSO user; however, instructions on how to use TSO and how to use the optimizing compiler with TSO are contained in the publications TSO Terminal User's Guide and TSO: PL/I Optimizing Compiler.

JOBS AND JOB STEPS

In a batch environment, the order of processing jobs is determined by a user-defined job class and/or priority, although this order might not be the order in which they are entered. Consequently jobs should be independent of each other.

A job comprises one or more job steps, each of which involves the execution of a program. Since job steps are always processed one-by-one in the order in which they appear, they can be interdependent. For example, the output from one job step can be used as the input to a later one, and the processing of a job step can be made dependent on the successful completion of a previous job step.

JOB CONTROL LANGUAGE

Job control language (JCL) is the means by which a programmer defines his jobs and job steps to the operating system; it allows the programmer to describe the work he wants the operating system to do, and to specify the input/output facilities he requires.

Chapter 2, "How to Run a PL/I Program," illustrates the use of JCL statements that are essential for the PL/I programmer. These statements are:

JOB statement, which identifies the start of a job.

EXEC statement, which identifies a job step and, in particular, specifies the program to be executed, either directly or by means of a cataloged procedure (see later in this chapter).

DD (data definition) statement, which defines the input/output facilities required by the program executed in the job step.

/* (delimiter) statement, which separates data in the input stream from the job control statements that follow this data.

JOB, EXEC, and DD statements have the same format, and figure 1.1 shows an example of a JOB statement on a punched card. These three statements are identified by // in columns 1 and 2. Each statement can contain four fields -- name, operation, operand, and comments -- that are separated by one or more blanks. The name field always starts in column 3.

A full description of job control language is given in the publications OS Job Control Language User's Guide and OS Job Control Language Reference.

Cataloged Procedures

Regularly-used sets of job control statements can be prepared once, given a name, stored in a system library and the name entered into the catalog for that library. Such a set of statements is termed a cataloged procedure. A cataloged procedure comprises one or more job steps (though it is not a job, because it must not contain a JOB statement). It is

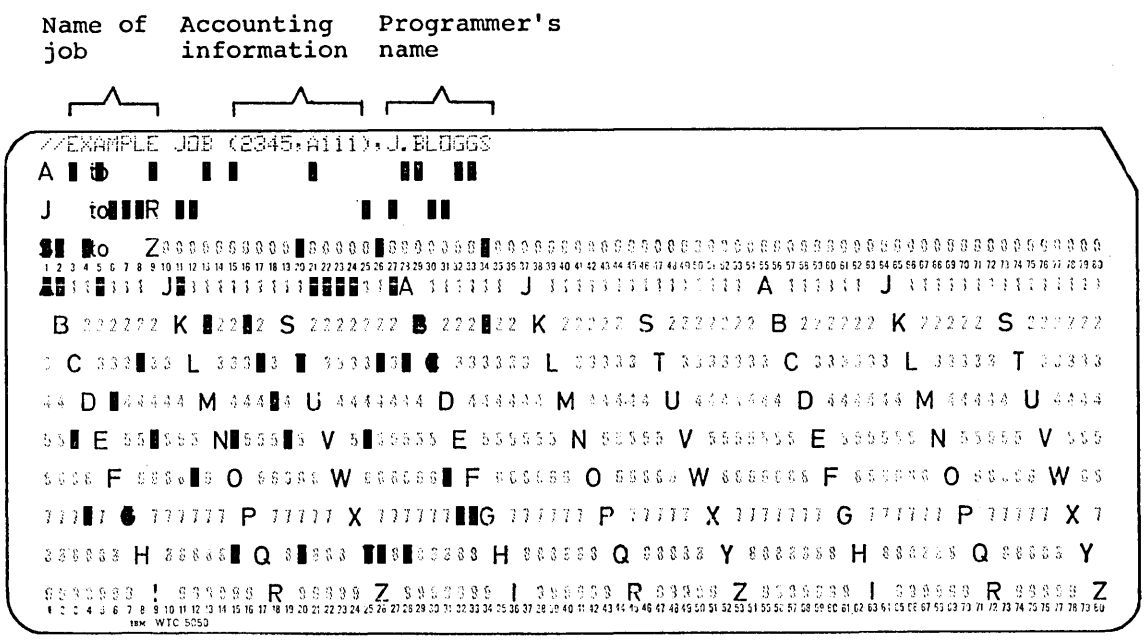


Figure 1.1. A JOB statement

included in a job by specifying its name in an EXEC statement instead of the name of a program.

Several IBM-supplied cataloged procedures are available for use with the optimizing compiler. Chapter 10 describes these procedures and how to use them.

EXECUTING A PL/I PROGRAM

The process of executing a PL/I program requires a minimum of two job steps.

A compilation job step is always required. In this step the optimizing compiler translates the PL/I source program into a set of machine instructions called an object module. This object module does not include all the machine instructions required to represent the source program. In many instances the compiler merely inserts references to subroutines that are stored in the OS PL/I Resident Library.

To include the required subroutines from the resident library, the object module must be processed by one of two processing programs, the linkage editor and the loader. Subroutines from the resident library may contain references to other subroutines stored in the OS PL/I Transient Library. The subroutines from the transient library do not become a permanent part of the compiled program; they are loaded into main storage when needed during execution of the PL/I program, and the storage they occupy is released when they are no longer needed.

When using the linkage editor, two further job steps are required after compilation. In the first of these steps, the linkage editor converts the object module into a form suitable for execution and includes subroutines, referred to by the compiler, from the resident library. The program in this form is called a load module. In the final job step, this load module is loaded into main storage and executed.

When using the loader, only one more job step is required after compilation. The loader processes the object module, includes the appropriate library subroutines, and executes the resultant executable program immediately.

Both the linkage editor and the loader can combine separately produced object modules and previously processed load modules. However, they differ in one important respect: the linkage editor produces a load module, which it always places in a library, where it can be permanently stored and called whenever it is required; the loader creates only temporary executable programs in main storage where they are executed immediately.

The linkage editor also has several facilities that are not provided by the loader; for example, it can divide a program that is too large for the space available in main storage so that it can be loaded and executed segment by segment.

The loader is intended primarily for use when testing programs and for processing programs that will be executed only once.

Chapter 2: How to Run a PL/I Program

The job control statements shown in figure 2.1 are sufficient to compile and execute a PL/I program that comprises only one external procedure.

This program uses only punched-card input and printed output. For other forms of input/output refer to chapter 3. The listing produced includes only the standard default items. Many other items can be included by specifying the appropriate compiler options in the EXEC statement. The compiler listing and all the compiler options are described in chapter 4. The linkage editor listing and the linkage editor options are described in chapter 5. Appendix F is a sample PL/I program that includes most of the listing items discussed in these two chapters.

The example in figure 2.1 uses the cataloged procedure PLIXCLG. Several other cataloged procedures are supplied by IBM for use with the optimizing compiler (for example, for compilation only). The use of these other cataloged procedures is described in chapter 4.

An alternative method of specifying compiler options is by use of the PROCESS statement, which is described in chapter 4. An example of a PROCESS statement is:

```
* PROCESS MACRO,OPT(TIME);
```

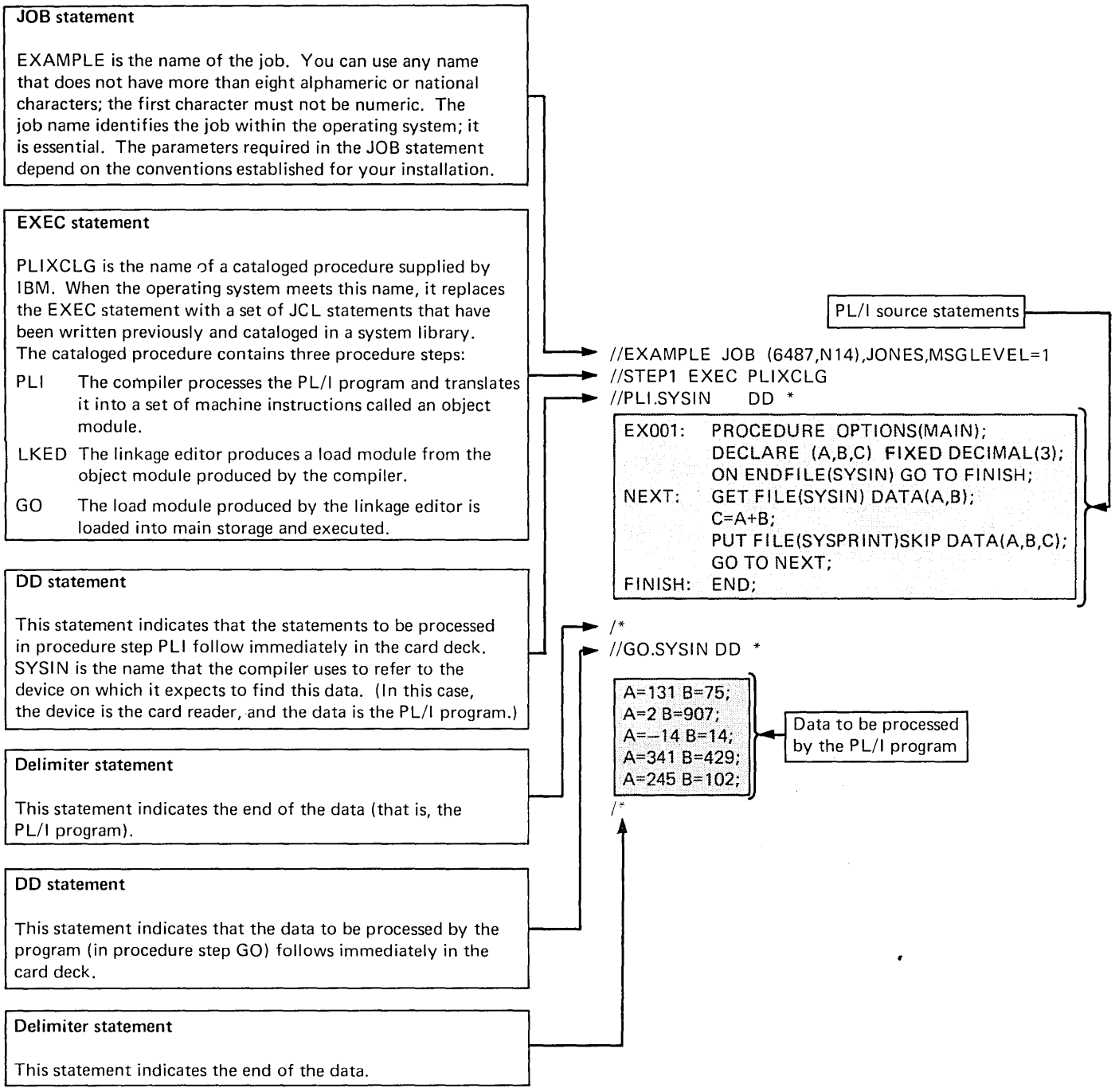


Figure 2.1. How to run a PL/I program

Chapter 3: How to Create and Access a Data Set

A data set is any collection of data in auxiliary storage that can be created or accessed by a program. It can be punched onto cards or a reel of paper tape; or it can be recorded on magnetic tape or on a direct-access device such as a magnetic disk or drum. A printed listing can also be a data set, but it cannot be read by a program.

Data sets that are created or accessed by PL/I programs must have one of the following types of organization:

CONSECUTIVE

INDEXED

REGIONAL

Teleprocessing

The items of data in a CONSECUTIVE data set are recorded in the order in which you present them, and can be accessed only in the order in which they were presented or, in the case of magnetic tape, in the reverse order. The items of data in INDEXED and REGIONAL data sets are arranged according to "keys" that you supply when you create the data sets. Teleprocessing data sets are organized as consecutive groups of data items.

This chapter explains how to create and access CONSECUTIVE data sets stored on magnetic tape or on a direct-access device. It is intended to provide an introduction to the subject of data management, and to meet the needs of those programmers who do not require the full input/output facilities of PL/I and the operating system. Chapters 6 through 9 contain a full explanation of the relationship between the data management facilities provided by PL/I and those provided by the operating system, and they explain how to create and access all the types of data sets referred to above.

Using a Data Set

To create or access a data set, you must not only include the appropriate input and output statements in your PL/I program, but you must also supply certain information to the operating system in a DD statement. A DD statement defines a data set and specifies how it will be handled. The information contained in a DD statement enables the operating system to allocate the necessary auxiliary storage devices, and allows the compiler to use the data management routines of the operating system to transmit data between main storage and auxiliary storage.

The language reference manual for this compiler describes the input and output statements that you will need to use in your PL/I program. Essentially, you must declare a file (explicitly or contextually) and open it (explicitly or implicitly) before you can begin to transmit data. A file is the means provided in PL/I for accessing a data set, and is related to a particular data set only while the file is open; when you close the file, the data set is no longer available to your program. This arrangement allows you to use the same file to access different data sets at different times, and to use different files to access the same data set.

You must provide a DD statement for each data set that you will use in each job step. If you use the same data set in more than one job step, each job step that refers to this data set must include a DD statement for the data set.

If you are using a cataloged procedure, such as PLIXCLG (described in chapters 2 and 10), the DD statement for any data set processed by your program must be associated with the appropriate step of the procedure by qualifying the name of the DD statement with the name of the procedure step. For example:

```
//GO.RESULTS DD ...
```

would indicate a DD statement named RESULTS in procedure step GO, as in the example in figure 3.4. The name of the DD statement is known as its "ddname".

How to Create a Data Set

When you create a data set, you should specify the following information to the operating system:

Information Required	Parameter of DD statement
Type of output device to which the data set will be transmitted.	UNIT=
Serial number of the volume (tape reel, disk pack, etc.) that will contain the data set.	VOLUME=SER= (or VOL=SER=)
Name of the data set.	DSNAME= (or DSN=)
Type of records in the data set.	DCB= (see appendix A)
Amount of auxiliary storage required for the data set (direct-access devices only).	SPACE=
Disposition of the data set on entry to, and at the end of the job step.	DISP=

To give this information in the DD statement, use the parameters listed above. The following paragraphs discuss their use in creating a CONSECUTIVE data set, figure 3.1 summarizes this discussion, figure 3.3 is an example of creating this type of data set, and the subparameters of the DCB parameter are described in appendix A. The job control language reference publication explains how to code a DD statement.

TYPE OF OUTPUT DEVICE (UNIT=)

You must always indicate the type of output device (for example, magnetic tape or disk drive, card punch, or printer) on which you want to create your data set. Usually the simplest way to do this is to use the UNIT parameter, although for a printer or a card punch it is often more convenient to use one of the special forms of DD statement discussed under "Special-purpose Parameters," later in this chapter.

In the UNIT parameter, you can specify either the type number of the unit (for example, 2311 for a disk drive) or the name of a group of devices (for example, SYSDA for any direct-access device). The group names are established for a system during system generation.

VOLUME SERIAL NUMBER (VOLUME=SER=)

A unit of auxiliary storage such as a reel of magnetic tape or a magnetic disk pack is

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSCUT=
		Block size[1]	DCB=(BLKSIZE=...)
Direct access only	Always	Auxiliary storage space required	SPACE=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but only required by this job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSN=
	Data set to be on particular volume	Volume serial number	VOL=SER=

[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Figure 3.1. Creating a CONSECUTIVE data set: essential parameters of DD statement

termed a volume; a volume can contain one or more data sets, and a data set can extend to more than one volume. A volume is identified by a serial number that is recorded within it (and usually printed on the label attached to it). Although a deck of cards, a printed listing, and a reel of paper tape can be considered to be volumes, they do not have serial numbers.

Specify a volume serial number only if you want to place the data set in a particular volume. If you omit the VOLUME parameter, the operating system will print in your program listing the serial number of the volume in which it placed the data set.

The VOLUME parameter has several subparameters. To specify a volume serial number, you need only the SER (serial number) subparameter (for example, VOLUME=SER=12345).

NAME OF DATA SET (DSNAME=)

You must name a new data set if you want to keep it for future jobs. If the data set is temporary (required only for the job in which it is created), you can still name it, but you need not; if you omit the DSNAME parameter, the operating system will assume that the data set is temporary, and will give it a temporary name. Alternatively, you can specify your own temporary name by prefixing it with the characters &&, for example:

```
DSNAME=&&TEMP
```

this is especially useful if you want to use the temporary data set in more than one step of your job. The cataloged procedures supplied with the optimizing compiler contain examples of such use.

RECORD TYPE (DCB=)

You can give record-type information either in your PL/I program (in the ENVIRONMENT attribute or LINESIZE option) or in a DD statement. This discussion refers only to the DD statement, and does not apply if you decide to give the information in your program; refer to the language reference manual for this compiler for a description of the ENVIRONMENT attribute and the LINESIZE option.

The type of record in a data set is defined by its format, its physical length (block size), and the length of the subsections (logical record length) which together can be considered to make up a physical record.

The records in a data set must have one of the following formats:

F fixed length

V variable length (D- or V-format)

U undefined length

F-, D-, and V-format records can be blocked (FB, DB, or VB) or unblocked (F, D, or V); V-format records can be spanned. (A spanned record is a record whose length can exceed the size of a block. If this occurs, the record is divided into segments and accommodated in two or more consecutive blocks.) In most cases, you must specify a block size. If you do not specify a record length, unblocked records of length equal to the block size are assumed. If you are using a PRINT file to produce printed output, you do not need to specify a block size in your DD statement or in your PL/I program; in the absence of other information, the compiler supplies a default line size of 120 characters.

To give record-type information in a DD statement, use the RECFM (record format), BLKSIZE (block size), and LRECL (logical record length) subparameters of the DCB parameter. The DCB parameter passes information to the operating system for inclusion in the data control block, a table maintained by the data management routines of the operating system for each data set in a job step; it contains a description of the data set and how it will be used. If your DCB parameter includes more than one subparameter, you must enclose the list in parentheses. For example:

```
DCB=(RECFM=FB,BLKSIZE=1000,LRECL=50)
```

AUXILIARY STORAGE REQUIRED (SPACE=)

When creating a data set on a direct-access device, you must always specify the amount of auxiliary storage that the data set will need. Use the SPACE parameter to specify the number of cylinders, tracks, or blocks that the data set will need. If you intend to extend the data set in a later job or job step, ensure that your original space allocation is sufficient for future needs; you cannot make a further allocation later. If the SPACE parameter appears in a DD statement for a non-direct-access device, it is ignored.

DISPOSITON OF DATA SET (DISP=)

To keep a data set for use in a later job step or job, you must use the DISP parameter to specify how you want it to be handled. You can pass it to another job step, keep it for use in a later job, or enter its name in the system catalog. If you want to keep the data set, but do not want to include its name in the system catalog, the operating system will request the operator to demount the volume in which it resides and keep it for you. If you omit the DISP parameter, the operating system will assume that the data set is temporary and will delete it at the end of the job step.

The DISP parameter can contain two positional subparameters. The first specifies whether the data set is new or already exists, and the second specifies what is to be done with it at the end of the job step. If you omit the first, you must indicate its absence by a comma. For example:

```
DISP=(,CATLG)
```

specifies that the data set is to be cataloged at the end of the job step. The omission of the first subparameter means that the data set is assumed by default to be new.

How to Access a Data Set

To access (that is, read or update) an existing data set, your DD statement should include information similar to that given when the data set is created. However, for data sets on labeled magnetic tape or on direct-access devices, you can omit several parameters because the information they contain is recorded with the data set by the operating system when the data set is created; figure 3.2 summarizes the essential information and figure 3.4 is an example of accessing this type of data set. The subparameters of the DCB parameter are described in appendix A, and the jcb control language reference publication explains how to code a DD statement.

Except in the special case of data in the input stream (described under "Special-purpose Parameters," later in this chapter), you must always include the name of the data set (DSNAME) and its disposition (DISP).

TYPE OF INPUT DEVICE (UNIT=)

You can omit the UNIT parameter if the data set is cataloged or if it is created with DISP=(NEW,PASS) in a previous job step of the same job. Otherwise, it must always appear. (PASS specifies that the data set is to be passed for use by a subsequent job step in the same job).

VOLUME SERIAL NUMBER (VOLUME=SER=)

You can omit the VOLUME parameter if the data set is cataloged or if it is created with DISP=(,PASS) in a previous job step of the same job. Otherwise it must always appear.

Parameters of DD Statement			
When required		What you must state	Parameters
Always		Name of data set	DSN=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT=
	Magnetic tape and direct access	Volume serial number	VOL=SER=
For punched cards, paper tape, or unlabeled magnetic tape		Block size[1]	DCB=(BLKSIZE=...)
[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.			

Figure 3.2. Accessing a CONSECUTIVE data set: essential parameters of DD statement

NAME OF DATA SET (DSNAME=)

The DSNAME parameter can either refer back to the DD statement that defined the data set in a previous job step, or it can give the actual name of the data set. (You would have to use the former method to refer to an unnamed temporary data set.)

RECORD TYPE (DCB=)

You can omit the DCB parameter if the record information is specified in your PL/I program, using the ENVIRONMENT attribute, or if you are accessing a data set on a direct-access device or standard labeled magnetic tape. Otherwise you must specify the DCB parameter for punched cards, paper tape, or unlabeled magnetic tape.

AUXILIARY STORAGE REQUIRED (SPACE=)

You cannot add to, or otherwise modify, the space allocation made for a data set when it is created. Accordingly, the SPACE parameter is never required in a DD statement for an existing data set.

DISPOSITION OF DATA SET (DISP=)

Except for unit record devices (such as card readers), you must always include the DISP parameter to indicate to the operating system that the data set exists. Code DISP=SHR if you want to read the data set, DISP=OLD if you want to read and/or overwrite it, or DISP=MOD if you want to add records to the end of it.

Special-purpose Parameters

Three parameters of the DD statement have special significance because you can use a very simple form of DD statement; they are:

SYSOUT=

*

DATA

SYSOUT= is particularly useful for printed or punched-card output, and * and DATA allow you to include data in the input stream.

System Output (SYSOUT=)

A system output device is any unit (but usually a printer or a card punch) that is used in common by all jobs. The computer operator allocates all the system output devices to specific classes according to the type of device. The usual convention is for class A to refer to a printer and class B to a card punch; the IBM-supplied cataloged procedures assume that this convention is followed.

To route your output through a system output device, use the SYSOUT parameter in your DD statement. For example, to punch cards, use the DD statement:

```
//GO.PUNCH DD SYSOUT=B
```

Data in the Input Stream (* and DATA)

A convenient way to introduce data to your program is to include it in the input stream with your job control statements. Data in the input stream must, like job control statements, be in the form of 80-byte records (usually punched cards), and must be immediately preceded by a DD statement with the single parameter * in its operand field, for example:

```
//GO.SYSIN DD *
```

To indicate the end of the data, you may optionally include a delimiter job control statement (/*). If you omit the /* delimiter, the end of the data is determined by the next job control statement (commencing // in the first two columns) in the input stream.

If your data includes records that start with // in the first two columns use the parameter DATA, for example:

```
//GO.SYSIN DD DATA
```

In this case, you must always indicate the end of the data by the job control delimiter statement (/*).

Standard Files

PL/I includes two standard files, SYSIN for input and SYSPRINT for output. If your program includes a GET statement without the FILE or STRING option, the compiler uses the file name SYSIN; if it includes a PUT statement without the FILE option, the compiler uses the name SYSPRINT.

If you use one of the IBM-supplied cataloged procedures to execute your program, you will not need to include a DD statement for SYSPRINT; procedure step GO always includes the statement:

```
//SYSPRINT DD SYSOUT=A
```

The block size is normally supplied by the compiler; you need not specify it yourself, unless you want blocked output.

If your program uses SYSIN, either explicitly or implicitly, you must always include a corresponding DD statement.

Examples

Two examples of simple applications for CONSECUTIVE data sets are shown in figures 3.3 and 3.4; both use the cataloged procedure PLIXCLG supplied by IBM.

The first program evaluates the familiar expression for the roots of a quadratic equation and stores the results in a data set on a disk pack and on punched cards. The last DD statement (//GO.DISK...) specifies that the newly created data set is to be given the name ROOTS and is to be stored in a volume with serial number D186 on a 2311 Disk Storage Drive. It specifies that fixed-length records, 40 bytes in length, are to be grouped together in blocks, each 400 bytes long. It specifies that the data set is new and that it is to be kept on the volume at the end of the job step; and it specifies that one track of the disk storage drive is to be allocated to the data set with one additional track to be used if more space is required.

The second program accesses the data set on the disk pack created in the first program and prints the results.

```
//OPT3#3  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CREATE: PROC OPTIONS(MAIN);

         DCL PUNCH FILE STREAM OUTPUT,
             DISK FILE RECORD OUTPUT SEQUENTIAL,
              1 RECORD,
                2(A,B,C,X1,X2) FLOAT DEC(6) COMPLEX;

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(PUNCH), FILE(DISK);
 NEXT:   GET FILE(SYSIN) LIST(A,B,C);
         X1=(-B+SQRT(B**2-4*A*C))/(2*A);
         X2=(-B-SQRT(B**2-4*A*C))/(2*A);
         PUT FILE(PUNCH) EDIT(RECORD) (C(E(16,9)));
         WRITE FILE(DISK) FROM(RECORD);
         GO TO NEXT;
 FINISH: CLOSE FILE(PUNCH), FILE(DISK);
         END CREATE;
/*
//GO.PUNCH DD SYSOUT=B
//GO.DISK  DD DSN=ROOTS,UNIT=2311,VOL=SER=D186,DISP=(NEW,KEEP),
//        SPACE=(TRK,(1,1)),DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
//GO.SYSIN DD *
5 12 4
4 -10 4
5 16 2
4 -12 10
5 12 9
29 -20 4
/*
```

Figure 3.3. Creating a CONSECUTIVE data set

```
//OPT3#4  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 ACCESS: PROC OPTIONS(MAIN);

         DCL RESULTS FILE RECORD INPUT SEQUENTIAL,
              1 RECORD,
                2(A,B,C,X1,X2) FLOAT DEC(6) COMPLEX;

         ON ENDFILE(RESULTS) GO TO FINISH;

         PUT FILE(SYSPRINT) EDIT('A','B','C','X1','X2')
           (X(7),3(A,X(23)),A,X(22),A);
         OPEN FILE(RESULTS);
 NEXT:   READ FILE(RESULTS) INTO(RECORD);
         PUT FILE(SYSPRINT) SKIP EDIT(RECORD) (C(F(12,2)));
         GO TO NEXT;
 FINISH: CLOSE FILE(RESULTS);
         END ACCESS;
/*
//GO.RESULTS DD DSN=ROOTS,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
```

Figure 3.4. Accessing a CONSECUTIVE data set

Chapter 4: The Compiler

This chapter describes the optimizing compiler and the job control statements required to invoke it and defines the data sets it uses. It describes the compiler options, the listing produced by the compiler, batched compilation, and the preprocessor, all of which are introduced briefly below.

The optimizing compiler translates the PL/I statements of the source program into machine instructions. A set of machine instructions such as is produced for an external PL/I procedure by the compiler is termed an object module. If several sets of PL/I statements, each set corresponding to an external procedure and separated by appropriate control statements, are present, the compiler can create two or more object modules in a single job step.

However, the compiler does not generate all the machine instructions required to represent the source program. Instead, for frequently used sets of instructions such as those that allocate main storage or those that transmit data between main storage and auxiliary storage, it inserts into the object module references to standard subroutines. These subroutines are stored in either the OS PL/I Resident Library or in the OS PL/I Transient Library.

An object module produced by the compiler is not ready for execution until the appropriate subroutines from the resident library have been included; this is the task of either one of two processing programs, the linkage editor and the loader, described in chapter 5. An object module that has been processed by the linkage editor is referred to as a load module, an object module that has been processed by the loader is referred to as an executable program.

Subroutines from the transient library do not form a permanent part of the load module or executable program. Instead, they are loaded as required during execution, and the storage they occupy is released when they are no longer needed.

While it is processing a PL/I program, the compiler produces a listing that contains information about the program and the object module derived from it, together with messages relating to errors or other conditions detected during compilation. Much of this information is optional, and is supplied either by default or by specifying appropriate options when the compiler is invoked.

The compiler also includes a preprocessor (or compile-time processor) that enables you to modify source statements or insert additional source statements before compilation commences.

Compiler options, discussed under "Optional Facilities," later in this chapter, can be used for purposes other than to specify the information to be listed. For example, the preprocessor can be used independently to process source programs that are to be compiled later, or the compiler can be used merely to check the syntax of the statements of the source program. Also, continuation of processing through syntax checking and compilation can be made conditional on successful preprocessing.

Description of the Compiler

The compiler consists of a number of load modules, referred to as phases, each of which can be loaded individually into main storage for execution. A simplified flow diagram is shown in figure 4.1. The first phase to be loaded is a resident control phase, which remains in main storage throughout compilation. This phase consists of a number of service routines that provide facilities required during execution of the remaining phases. One of these routines communicates with the supervisor program of the operating system for the sequential loading of the remaining phases, which are referred to as processing phases.

The resident control phase also causes a transient control phase to be loaded, the function of which is to initialize the operating environment in accordance with options specified by the programmer.

Each processing phase performs a single function or a set of related functions. Some of these phases must be loaded and executed for every compilation; the requirement for other phases depends on the content of the source program or on the optional facilities selected. Apart from the phases that provide diagnostic information, each phase is executed once only.

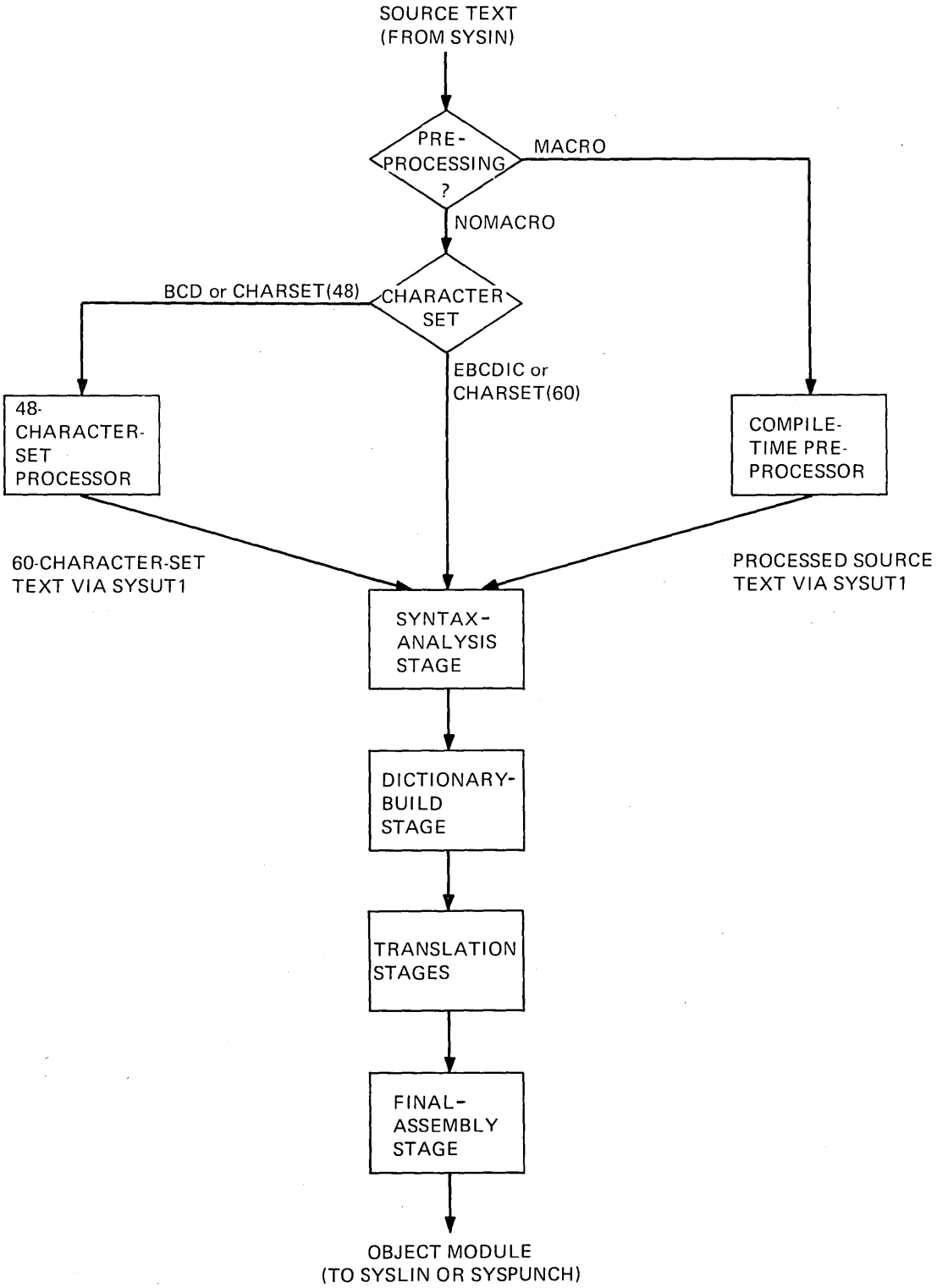


Figure 4.1. Simplified flow diagram of the compiler

Input to the compiler is known throughout all stages of the compilation process as text. Initially, this text comprises the PL/I statements of the source program. At the end of compilation, it comprises the machine instructions substituted by the compiler for the source text, together with the inserted references to resident library subroutines for use by the linkage editor or by the loader.

The source text must be in the form of a data set defined by a DD statement with the name SYSIN; frequently, this data set is a deck of punched cards. The source text is passed to the syntax-analysis stage either directly or after processing by one of the following preprocessor phases:

1. If the source text is in the PL/I 48-character set or in BCD, the 48-character-set preprocessor translates it into the 60-character set. To use the 48-character-set processor, specify the CHARSET(48) or CHARSET(BCD) options.

2. If the source text contains preprocessor statements, the preprocessor executes these statements in order to modify the source text or to introduce additional statements. Also, if the source text is in the PL/I 48-character set or in BCD (as specified by the CHARSET(48) or CHARSET(BCD) options), the preprocessor automatically translates it into the 60-character set. To use the preprocessor, specify the MACRO compiler option.

Both preprocessor phases store the translated source text in the data set defined by the DD statement with the name SYSUT1.

The syntax-analysis stage takes its input either from this data set or from the data set defined by the DD statement with the name SYSIN. This stage analyzes the syntax of the PL/I statements and removes any comments and non-significant blank characters.

After syntax analysis, the dictionary-build stage creates a dictionary containing entries for all identifiers in the source text. The compiler uses this dictionary to communicate descriptions of the elements of the source text and the object module between phases. The dictionary-build stage of the compiler replaces all identifiers and attribute declarations in the source text with references to dictionary entries.

Further processing of the text involves several compiler stages, known as translation stages, which:

1. Translate the text from the PL/I syntactic form into an internal syntactic form.

2. Rearrange the text to facilitate further translation (for example, by replacing array assignments with do-loops that contain element assignments).

3. Map arrays and structures to ensure correct boundary alignment.

4. Translate the text into a series of fixed-length tables, each with a format that can be used to define machine instructions.

5. Allocate main storage for static variables and generate inline code to allow storage to be allocated automatically during execution. (In certain cases resident library subroutines may also be called to allocate storage during execution.)

The final-assembly stage translates the text tables into machine instructions, and creates the external symbol dictionary (ESD) and relocation dictionary (RLD) required by the linkage editor and by the loader.

The external symbol dictionary includes the names of subroutines that are referred to in the object module but are not part of the module and that are to be included by the linkage editor or by the loader; these names, which are termed external references, include the names of all the PL/I resident library subroutines that will be required when the object module is executed. (These resident library subroutines may, in their turn, contain external references to other resident library subroutines required for execution).

The relocation dictionary contains information that enables absolute storage addresses to be assigned to locations within the load module when it is loaded for execution.

The external symbol dictionary and the relocation dictionary are described in chapter 5, which also explains how the linkage editor and the loader use them.

Job Control Statements for Compilation

Although you will probably use cataloged procedures rather than supply all the job control statements required for a job step that invokes the compiler, you should be familiar with these statements so that you can make the best use of the compiler, and if necessary, override the statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a compilation procedure step are as follows:

PLIXC	Compile only.
PLIXCL	Compile and link-edit.
PLIXCLG	Compile, link-edit, and execute.
PLIXCG	Compile, load and execute.

Standard ddname	Contents of data set	Possible device classes	Record format (RECFM)	Record size (LRECL)	Buffers	
					Number allocated by default	Reserved area (bytes)
SYSIN (or SYSCIN)	Input to the compiler	SYSSQ	F,FB,V, VB,U	<101(100)	2	200
SYSLIN	Object module	SYSSQ	F,FB	80(80)	2	160
SYSPUNCH	Preprocessor output, compiler output	SYSSQ SYSCP	F,FB	80(80)	2	160
SYSUT1	Temporary workfile	SYSDA	F	1291 or 2571	-	-
SYSPRINT	Listing, including messages	SYSSQ	V,VA,VB	125(125)	2	258
SYSLIB	Source statements for preprocessor	SYSDA	F,FB	<101(100)	-	-

Notes:

1. The possible device classes are:

   SYSSQ Magnetic-tape or direct-access device.

   SYSDA Direct-access device.

   SYSCP Card-punch device.

2. Any block size can be specified except for SYSLIB and SYSUT1. Block size for SYSLIB must be less than or equal to 2.5K bytes; that for SYSUT1 is always provided by the compiler.

3. If the record format is not specified in a DD statement, the default value (underlined) is provided by the compiler.

4. The compiler will attempt to obtain source input from SYSCIN if a DD statement for this data set is provided. Otherwise it will obtain its input from SYSIN.

5. The numbers in parentheses in the "Record size" column are the defaults.

Figure 4.2. Compiler standard data sets

The following paragraphs describe the essential job control statements for compilation. The IBM-supplied cataloged procedures are described in chapter 10 and include examples of these statements.

EXEC STATEMENT

The basic EXEC statement is:

```
//stepname EXEC PGM=IEL0AA
```

The PARM parameter of the EXEC statement can be used to specify one or more of the optional facilities provided by the compiler. These facilities are described under "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The compiler requires several standard data sets, the number depending on the optional facilities specified. You must define these data sets in DD statements with the standard ddnames which are shown, together with other characteristics of the data sets, in figure 4.2. The DD statements SYSIN, SYSUT1, and SYSPRINT are always required.

You can store any of the standard data sets on a direct-access device, in which case, you must include the SPACE parameter in the DD statement that defines the data set to specify the amount of auxiliary storage required. The amount of auxiliary storage allocated in the IBM-supplied cataloged procedures should suffice for most applications.

Input (SYSIN, or SYSCIN)

Input to the compiler must be a data set defined by a DD statement with the name SYSIN or SYSCIN; this data set must have CONSECUTIVE organization. The input must be one or more external PL/I procedures; if you want to compile more than one external procedure in a single job or job step, precede each procedure, except possibly the first, with a PROCESS statement (described under "Batched Compilation," later in this chapter).

Eighty-column punched cards are commonly used as the input medium for PL/I source programs. However, the input data set may be on a direct-access device, magnetic tape, or paper tape. The input data set may contain either fixed-length records, blocked or unblocked, variable-length records, or undefined-length records; the maximum record size is 100 bytes. The compiler always reserves 200 bytes of main storage (100 bytes each) for two buffers for this data set; however, you may specify a block size of more than 100 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.)

Output (SYSLIN, SYSPUNCH)

Output (that is, one or more object modules) from the compiler can be stored in either the data set defined by the DD statement with the name SYSLIN (if you specify the OBJECT compiler option) or in the data set defined by the DD statement with the name SYSPUNCH (if you specify the DECK compiler option). You may specify both options in one program, when the output will be stored in both data sets.

The object module is always in the form of 80-byte fixed-length records, blocked or unblocked. The compiler always reserves two buffers of 80 bytes each; however, you may specify a block size of more than 80 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.) The data set defined by the DD statement with the name SYSPUNCH is also used to store the output from the preprocessor if you specify the MDECK compiler option.

Temporary Workfile (SYSUT1)

The compiler always requires a data set for use as a temporary workfile. It is defined by a DD statement with the name SYSUT1, and is known as the spill file. It must always be on a direct-access device. The spill file is used as a logical extension to main storage and is always used by the compiler and by the preprocessor to contain text and dictionary information.

Dedicated Data Sets: If a job being run under MVT has several job steps, and each job step requires a data set for use as a temporary workfile, the result is a considerable overhead in time and space. To reduce this as far as possible, you can use dedicated data sets. These are data

sets that are created by the operating system when the job is selected for processing. They can be used by each job step that requires a temporary workfile. Dedicated data sets are normally allocated by the initiator and deleted when it terminates. More information on using dedicated data sets is given in chapter 10.

Listing (SYSPRINT)

The compiler generates a listing that includes all the source statements that it processed, information relating to the object module, and, when necessary, messages. Most of the information included in the listing is optional, and you can specify those parts that you require by including the appropriate compiler options. The information that may appear, and the associated compiler options, are described under "Compiler Listing," later in this chapter.

You must define the data set in which you wish the compiler to store its listing in a DD statement with the name SYSPRINT. This data set must have CONSECUTIVE organization. Although the listing is usually printed, it can be stored on any magnetic-tape or direct-access device. For printed output, the following statement will suffice if your installation follows the convention that output class A refers to a printer:

```
//SYSPRINT DD SYSOUT=A
```

The compiler always reserves 258 bytes of main storage (129 bytes each) for two buffers for this data set; however, you may specify a block size of more than 129 bytes, provided that sufficient main storage is available to the compiler. (See the discussion of the SIZE option under "Optional Facilities," later in this chapter.)

Source Statement Library (SYSLIB)

If you use the preprocessor %INCLUDE statement to introduce source statements into the PL/I program from a library, you can either define the library in a DD statement with the name SYSLIB, or you can choose your own ddname (or ddnames) and specify a ddname in each %INCLUDE statement. (See "Compile-time Processing," later in this chapter.)

EXAMPLE OF COMPILER JCL

A typical sequence of job control statements for compiling a PL/I program is shown in figure 4.3. The DECK and NOOBJECT compiler options, described below, have been specified to obtain an object module as a card deck only. Job control statements for link editing an object module in the form of a card deck are shown in chapter 5.

Optional Facilities

The compiler provides a number of optional facilities that can be obtained either by default, by specifying the options in the PARM parameter of the EXEC statement that invokes the compiler, by specifying the options in a PROCESS statement, or by a combination of all three.

For each compilation, the IBM or installation default for an option will apply, unless overridden by specifying the option either in the PARM parameter of an EXEC statement, or in a PROCESS statement.

An option specified in the PARM parameter overrides the default value, and an option specified in a PROCESS statement

```
//COMP     JOB
//STEP1    EXEC PGM=IEL0AA,PARM='DECK,NOOBJECT'
//SYSPUNCH SYSOUT=B
//SYSUT1   DD UNIT=SYSDA,SPACE=(291,(60,60),,CONTIG)
//SYSPRINT DD SYSOUT=A
//SYSIN    DD *
           .
           .
           .
  (insert here the PL/I program to be compiled)
           .
           .
           .
/*
```

Figure 4.3. Typical job control statements for compiling a PL/I program

overrides both that specified in the PARM parameter and the default value.

All the compiler options, their abbreviated forms, and their defaults (as supplied by IBM) are shown in figure 4.4. An installation can modify or delete the defaults according to local requirements; check for any modified defaults at your installation. Deleted options can be reinstated for a compilation by means of the CONTROL option.

OPTIONS IN EXEC STATEMENT

To specify options in the EXEC statement, code PARM= followed by the list of options, in any order (except that CONTROL, if used, must be first) separating the options with commas and enclosing the list within single quotation marks, for example:

```
//STEP1 EXEC PGM=IEL0AA,PARM='OBJECT,LIST'
```

Any option that has quotation marks, for example MARGINI('c'), must have the quotation marks duplicated. The length of the option list must not exceed 256 characters, including the separating commas (note that only the first 100 characters are printed out on the listing). However, many of the options have an abbreviated form that you can use to save space. If you need to continue the statement onto another line, you must enclose the list of options in parentheses (instead of in quotation marks) enclose the options list on each line in quotation marks, and ensure that the last comma on each line except the last is outside of the quotation marks. An example covering all the above points is as follows:

```
//STEP1 EXEC PGM=IEL0AA,PARM=('AG,A,BI(10),
         C,ESD,F(I),FLOW(10,1)',
// 'M,MI(''X''),NEST,STG,X')
```

If you are using a cataloged procedure, and wish to specify options explicitly, you must include the PARM parameter in the EXEC statement that invokes it, qualifying the keyword PARM with the name of the procedure step that invokes the compiler, for example:

```
//STEP1 EXEC PLIXCLG,PARM.PLI='A,LIST,ESD'
```

PARM Parameter in GO Step

The PARM field of the EXEC statement for the GO step comprises two parts separated by a slash. The first part is passed to the library initialization subroutine, and only the second part is passed to the main procedure. If only the second part appears, it must be preceded by the slash, for example:

```
//GO   EXEC PGM=OPT,PARM='/ARGUMENT'
```

The first part can be used for specifying execution-time options and these must precede the slash, for example:

```
//GO   EXEC PGM=OPT,PARM='ISASIZE(10K),
//    REPORT/ARGUMENT'
```

The execution-time options are as follows:

ISASIZE specifies the amount of main storage initially acquired by the PL/I program at execution time. This storage is known as the initial storage area (ISA). The option has the format:

ISASIZE[([x][,y][,z])]

where "x" is the initial storage allocation for the major task,

where "y" is the initial storage allocation for each subtask within the total storage available to the compiler. This value can be used in a multitasking program to prevent a new storage request (with its accompanying time overhead) each time a block is entered during the execution of the subtasks. If you specify enough storage for a whole subtask, these additional requests are not made,

and where "z" is the maximum number of subtasks that will be active at any one time.

All storage values must be in bytes or K bytes. If "x" is omitted and "y" or "z" is specified, or if "y" is omitted and "z" is specified, then the separating commas must be used to indicate that a value is missing. The default values for this option are ISASIZE(,0,20), and the option keyword may be abbreviated to ISA.

The ISA is used for the dynamic allocation of the main storage required by PL/I blocks as they are entered and by controlled and based variables as they are allocated. If the ISA is large enough to contain these blocks PL/I storage handling will not

acquire any more storage from the system.

If ISASIZE is not specified, a default value is calculated as follows:

(m - n)/2

where "m" is the region or partition size, and "n" is the load module length. This value is rounded up to a 2K boundary.

Note that if this is too large, that is, most variables in STATIC and few controlled and based allocations, there will be a considerable amount of wasted main storage in the ISA. If it is too small, then dynamic main storage requirements will be less efficiently met by individual requests to the system.

The execution-time option REPORT is available to enable the programmer to determine exactly what his storage requirements are, apart from I/O requirements.

REPORT specifies that a report of certain program management activity is to be printed. The report will be automatically output to the dump data set on program termination. This includes, for example, the amount of storage that was specified in the ISASIZE option, the length of the initial storage area, and the amount of PL/I storage required. This option may be abbreviated to R.

NOREPORT specifies that a report is not required. This option may be abbreviated to NR.

STAE specifies that when an ABEND occurs, the STAE macro instruction attemps to raise the PL/I ERROR condition. This is also the default for this option.

NOSTAE specifies that on program initialization, a STAE macro instruction is not to be issued.

SPIE specifies that when a program interrupt occurs, the SPIE macro instruction attempts to enter the PL/I error handler. This is also the default for this option.

NOSPIE specifies that on program initialization, a SPIE macro instruction is not to be issued.

The execution-time options are discussed in greater detail in the publication OS PL/I Optimizing Compiler: Execution Logic.

Execution-time Storage Requirements

At execution time there are three separate areas of main storage.

The first area is the load module. Its length can be obtained from the linkage editor output listing.

The second area is the initial storage area (ISA). Its length can be specified by the ISASIZE execution-time option or supplied by default. If supplied by default, it will be approximately half of the main storage available after the load module has been loaded. The ISA will include:

Dynamic block requirements. These lengths can be obtained from the table produced by the STORAGE compiler option.

Variable data areas, that is, varying-length strings and arrays, whose bounds or dimensions are not known at compile time. The programmer must calculate these lengths himself.

Controlled and based variables. These lengths should be known to the programmer.

The third area consists of the remainder of main storage. It is retained by the system and is made available on specific main storage requests for overflow from the ISA and for I/O requirements, that is, file control blocks, buffers, system I/O modules and also for PL/I transient library modules (that is, storage overflow, program initialization, and I/O transmission modules).

The storage requirements in this third area can only be calculated with difficulty. The simplest way is to use the Storage Management Facilities (SMF) as described in the publication OS Introduction to determine the total main storage requirements for the job. This figure is only meaningful if an accurate figure for the ISA has been supplied.

The length of the ISA can greatly affect the performance of the program. If it is too large there will be wasted storage in the ISA which might result in insufficient main storage being available for I/O requirements and transient library modules requirements.

If it is too small then dynamic main storage requirements will be met by specific requests to the system (that is, from the third area of main storage) resulting in slow execution. The programmer's total ISA requirements can be determined either by calculation or by using the REPORT execution-time option.

This can most easily be done in one of two ways:

1. If sufficient main storage is available, specify an ISASIZE larger than will be required. The report will then give the amount of this ISA used and this figure will be the optimum ISASIZE.

2. If there is a shortage of main storage specify an ISASIZE of 1, which will ensure that the program will run if at all possible and the report will still give the amount of main storage which should be allocated to the ISA.

Note that for optimum efficiency, the ISA should contain all dynamic main storage requirements. If however, certain blocks are entered only occasionally, or controlled or based variables allocated only briefly, these variables could well be permitted to remain outside the ISA. So long as these allocations do not clash with a larger I/O requirement the program may run in a smaller main storage area.

OPTIONS IN PROCESS STATEMENT

To specify options in the PROCESS statement, code as follows:

```
* PROCESS options;
```

where "options" is a list of compiler options. The list of options must be terminated with a semicolon and should not extend beyond the default right-hand source margin. The asterisk must appear in the first byte of the record (card column 1), and the keyword PROCESS may follow in the next byte (column) or after any number of blanks. Option keywords must be separated by a comma and/or at least one blank.

Blanks are permitted before and after any non-blank delimiter in the list, with the exception of strings within quotation marks, for example MARGINI('*'), in which optional blanks should not be inserted.

The number of characters is limited only by the length of the record. If you do not wish to specify any options, code:

```
* PROCESS;
```

Should it be necessary to continue the PROCESS statement onto the next card or record, terminate the first part of the list after any delimiter, up to the default right-hand margin, and continue on the next card or record. Option keywords or keyword arguments may be split, if required, when continuing onto the next record, provided that the keyword or argument string terminates in the right-hand source margin, and the remainder of the string starts in column 1 of the next record. A PROCESS statement may be continued in several statements, or a new PROCESS statement started.

COMPILER OPTIONS

The compiler options are of the following types:

1. Simple pairs of keywords: a positive form (for example, LIST) that requests a facility, and an alternative negative form (for example, NOLIST) that rejects that facility.

2. Keywords that permit you to provide a value-list that qualifies the option (for example, NOCOMPILE(E)).

3. A combination of 1 and 2 above.

The following paragraphs describe the options in alphabetic order. For those options that specify that the compiler is to list information, only a brief description is included; the generated listing is described under "Compiler Listing," later in this chapter.

Figure 4.4 lists all the compiler options with their abbreviated forms and their standard default values.

Compiler Option	Abbreviated Name	IBM Default
AGGREGATE|NOAGGREGATE	AG|NAG	NOAGGREGATE
ATTRIBUTES|NOATTRIBUTES	A|NA	NCATTRIBUTES
CHARSET([48|60][EBCDIC|BCD])	CS([48|60][EB|B])	CHARSET(60 EBCDIC)
COMPILE|NOCOMPILE[(W|E|S)]	C|NC|[(W|E|S])	NOCOMPILE(S)
CONTROL('password')	-	-
DECK|NODECK	D|ND	NODECK
DUMP	-	-
ESD|NOESD	-	NCESD
FLAG[(I|W|E|S)]	F[(I|W|E|S)]	FLAG(I)[1]
FLOW(n,m)|NOFLOW	-	NOFLOW
GONUMBER|NOGONUMBER	GN|NGN	NCGCNUMBER
GOSTMT|NOGSTMT	GS|NGS	NOGOSTMT
IMPRECISE|NOIMPRECISE	IMP|NIMP	NCIMPRECISE
INSOURCE|NOINSOURCE	IS|NIS	INSOURCE
LINECOUNT(n)	LC(n)	LINECOUNT(55)
LIST|NOLIST	-	NOLIST
LMESSAGE|SMESSAGE	LMSG|SMSG	LMESSAGE for batch[2]
MACRO|NOMACRO	M|NM	NOMACRO
MAP|NOMAP	-	NOMAP
MARGINI('c')|NOMARGINI	MI('c')|NMI	NOMARGINI
MARGINS(m,n[,c])	MAR(m,n[,c])	MARGINS(2,72)
MDECK|NOMDECK	MD|NMD	NOMDECK
NAME('name')	N('name')	-
NEST|NONEST	-	NCNEST
NUMBER|NONUMBER	NUM|NNUM	NONUMBER
OBJECT|NOOBJECT	OBJ|NOBJ	CBJECT
OFFSET|NOOFFSET	OF|NOF	NOOFFSET
OPTIMIZE(TIME|0|2)|NOOPTIMIZE	OPT(TIME|0|2)|NOPT	NCOPTIMIZE
OPTIONS|NOOPTIONS	OP|NOP	OPTIONS
SEQUENCE(m,n)	SEQ(m,n)	(see description)
SIZE(YYYYYYYY|YYYYYK|MAX)	SZ(YYYYYYYY|YYYYYK|MAX)	SIZE(MAX)
SOURCE|NOSOURCE	S|NS	SOURCE
STMT|NOSTMT	-	STMT
STORAGE|NOSTORAGE	STG|NSTG	NCSTORAGE
SYNTAX|NOSYNTAX[(W|E|S)]	SYN|NOSYN[(W|E|S)]	NOSYNTAX(S)
TERMINAL[(opt-list)]|NOTERMINAL	TERM[(opt-list)]|NTERM	NOTERMINAL
XREF|NOXREF	X|NX	NOXREF

[1]FLAG(W) for TSO [2]SMESSAGE for TSO.

Figure 4.4. Compiler options, abbreviations, and defaults

AGGREGATE Option

The AGGREGATE option specifies that the compiler is to include in the compiler listing an aggregate length table, giving the lengths of all arrays and major structures in the source program.

ATTRIBUTES Option

The ATTRIBUTES option specifies that the compiler is to include in the compiler listing a table of source-program identifiers and their attributes. If both ATTRIBUTES and XREF apply, the two tables are combined.

CHARSET Option

The CHARSET option specifies the character set and data code that you have used to create the source program. The compiler will accept source programs written in the 60-character set or the 48-character set, and in the Extended Binary Coded Decimal Interchange Code (EBCDIC) or Binary Coded Decimal (BCD).

60- or 48-character Set: If the source program is written in the 60-character set, specify CHARSET(60); if it is written in the 48-character set, specify CHARSET(48). The language reference manual for this compiler lists both of these character sets. (The compiler will accept source programs written in either character set if

CHARSET(48) is specified, however, if the reserved keywords, for example, CAT or LE are used as identifiers, errors may occur.)

BCD or EBCDIC: If the source program is written in BCD, specify CHARSET(BCD); if it is written in EBCDIC, specify CHARSET(EBCDIC). The language reference manual for this compiler lists the EBCDIC representation of both the 48-character set and the 60-character set.

If both arguments (48 or 60, EBCDIC or BCD) are specified, they may be in any order and should be separated by a blank or by a comma.

COMPILE Option

The COMPILE option specifies that the compiler is to compile the source program unless an unrecoverable error was detected during preprocessing or syntax checking. The NOCOMPILE option without an argument causes processing to stop unconditionally after syntax checking. With an argument, continuation depends on the severity of errors detected so far, as follows:

NOCOMPILE(W) No compilation if a warning, error, severe error, or unrecoverable error is detected.

NOCOMPILE(E) No compilation if error, severe error, or unrecoverable error is detected.

NOCOMPILE(S) No compilation if a severe error or unrecoverable error is detected.

CONTROL Option

The CONTROL option specifies that any compiler options deleted for your installation are to be available for this compilation. You must still specify the appropriate keywords to use the options. The CONTROL option must be specified with a password that is established for each installation; use of an incorrect password will cause processing to be terminated. The CONTROL option, if used, must be specified first in the list of options. It has the format:

```
CONTROL('password')
```

where "password" is a character string, not exceeding eight characters.

DECK Option

The DECK option specifies that the compiler is to produce an object module in the form of 80-column card images and store it in the data set defined by the DD statement with the name SYSPUNCH. Columns 73-76 of each card contain a code to identify the object module; this code comprises the first four characters of the first label in the external procedure represented by the object module. Columns 77-80 contain a 4-digit decimal number: the first card is numbered 0001, the second 0002, and so on.

DUMP Option

The DUMP option specifies that the compiler is to produce a formatted dump of main storage if the compilation terminates abnormally (usually due to an I/O error or compiler error). This dump is written on the data set associated with SYSPRINT.

ESD Option

The ESD option specifies that the external symbol dictionary (ESD) is to be listed in the compiler listing.

FLAG Option

The FLAG option specifies the minimum severity of error that requires a message to be listed in the compiler listing. The format of the FLAG option is:

FLAG(I) List all messages.

FLAG(W) List all except informatory messages. If you specify FLAG, FLAG(W) is assumed.

FLAG(E) List all except warning and informatory messages.

FLAG(S) List only severe error and unrecoverable error messages.

FLOW Option

The FLOW option specifies that the compiler is to list the transfers of control most recently executed in the program prior to

the occurrence of an interrupt that results in an execution-time message. The format of the FLOW option is:

```
FLOW(n,m)
```

where "n" is the maximum number of entries to be included in the lists. It should not exceed 32768.

"m" is the maximum number of procedures for which the lists are to be generated. It should not exceed 32768.

The list will start at the latest information and continue, in reverse order of execution, to the point where either limit is exceeded.

GONUMBER Option

The GONUMBER option specifies that the compiler is to produce additional information that will allow line numbers from the source program to be included in execution-time messages. Alternatively, these line numbers can be derived by using the offset address, which is always included in execution-time messages, and the table produced by the OFFSET option. (The NUMBER option must also apply.)

Use of the GONUMBER option implies NUMBER and NOSTMT.

GOSTMT Option

The GOSTMT option specifies that the compiler is to produce additional information that will allow statement numbers from the source program to be included in execution-time messages. Alternatively, these statement numbers can be derived by using the offset address, which is always included in execution-time messages, and the table produced by the OFFSET option. (The STMT option must also apply.)

Use of the GOSTMT option implies STMT and NONUMBER.

IMPRECISE Option

The IMPRECISE option specifies that the compiler is to include extra text in the object module to localize imprecise interrupts when executing the program with an IBM System/360 Model 91 or 195 (see appendix D). This extra text ensures that if interrupts occur, the correct on-units will be entered, and that the correct line or statement numbers will appear in execution-time messages.

INSOURCE Option

The INSOURCE option specifies that the compiler is to include a listing of the source program (including preprocessor statements) in the compiler listing. This option is applicable only when the preprocessor is used, therefore the MACRO option must also apply.

LINECOUNT Option

The LINECOUNT option specifies the number of lines to be included in each page of the compiler listing, including heading lines and blank lines. The format of the LINECOUNT option is:

```
LINECOUNT(n)
```

where "n" is the number of lines. It must be in the range 1 through 32767, but only headings are generated if you specify less than 7.

LIST Option

The LIST option specifies that the compiler is to include a listing of the object module (in a form similar to IBM System/360 assembler language instructions) in the compiler listing.

LMESSAGE Option

The LMESSAGE and SMESSAGE options specify that the compiler is to produce messages in a long form (specify LMESSAGE) or in a short form (specify SMESSAGE). Short messages can have advantages in a TSC environment due to the comparatively slow printing speed of a terminal.

MACRO Option

The MACRO option specifies that the source program is to be processed by the preprocessor.

MAP Option

The MAP option specifies that the compiler is to produce tables showing the organization of the static storage for the object module. These tables consist of a static internal storage map and the static external control sections. The MAP option is normally used with the LIST option.

MARGINI Option

The MARGINI option specifies that the compiler is to include a specified character in the column preceding the left-hand margin, and in the column following the right-hand margin of the listings resulting from the INSOURCE and SOURCE options. Any text in the source input which precedes the left-hand margin will be shifted left one column, and any text that follows the right-hand margin will be shifted right one column. Thus text outside the source margins can be easily detected.

The MARGINI option has the format:

```
MARGINI('c')
```

where "c" is the character to be printed as the margin indicator.

MARGINS Option

The MARGINS option specifies the extent of the part of each input line or record that contains PL/I statements. The compiler will not process data that is outside these limits (but it will include it in the source listings).

The option can also specify the position of an American National Standard (ANS) printer control character to format the listing produced if the SOURCE option applies. This is an alternative to using %PAGE and %SKIP statements (described in the language reference manual for this compiler). If you do not use either method, the input records will be listed without any intervening blank lines. The format of the MARGINS option is:

```
MARGINS(m,n[,c])
```

where "m" is the column number of the left-hand margin. It should not exceed 104.

"n" is the column number of the right-hand margin. It should be greater than m, but not greater than 104.

"c" is the column number of the ANS printer control character. It should not exceed 104 and should be outside the values specified for m and n. Only the following control characters can be used:

(blank)	Skip one line before printing.
0	Skip two lines before printing.
-	Skip three lines before printing.
+	Skip no lines before printing.
1	Start new page.

MDECK Option

The MDECK option specifies that the preprocessor is to produce a copy of its output (see MACRO option) and store it in the data set defined by the DD statement with the name SYSPUNCH. The last four bytes of each record in SYSUT1 are not copied, thus this option allows you to retain the output from the preprocessor as a deck of 80-column punched cards.

NAME Option

The NAME option specifies that the compiler is to place a linkage editor NAME statement as the last statement of the object module. When processed by the linkage editor, this NAME statement indicates that primary input is complete and causes the specified name to be assigned to the load module created from the preceding input (since the last NAME statement).

It is required if you want the linkage editor to create more than one load module from the object modules produced by batched compilation (see later in this chapter).

If you do not use this option, the linkage editor will use the member name specified in the DD statement defining the load module data set. You can also use the

NAME option to cause the linkage editor to substitute a new load module for an existing load module with the same name in the library. The format of the NAME option is:

```
NAME('name')
```

where "name" has from one through eight characters, and begins with an alphabetic character. The linkage editor NAME statement is described in chapter 5.

NEST Option

The NEST option specifies that the listing resulting from the SOURCE option will indicate, for each statement, the begin-block level and the do-group level.

NUMBER Option

The NUMBER option specifies that the numbers specified in the sequence fields in the source input records are to be used to derive the statement numbers in the listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE and XREF options.

The position of the sequence field can be specified in the SEQUENCE option. Alternatively the following default positions are assumed:

- First 8 columns for undefined-length or variable-length source input records. In this case, 8 is added to the values used in the MARGINS option.
- Last 8 columns for fixed-length source input records.

These defaults are the positions used for line-numbers generated by TSO; thus it is not necessary to specify the SEQUENCE option, or change the MARGINS defaults, when using line numbers generated by TSO. Note that the preprocessor output has fixed-length records irrespective of the original primary input. Any sequence numbers in the primary input are repositioned in columns 73-80.

The line number is calculated from the five right-hand characters of the sequence number (or the number specified, if less than five). These characters are converted to decimal digits if necessary. Each time a line-number is found which is not greater than the preceding one, 100000 is added to this and all following line numbers.

If there is more than one statement on a line, a suffix is used to identify the actual statement in the messages. For example, the second statement beginning on the line numbered 40 will be identified by the number 40.2. The maximum value for this suffix is 31. Thus the thirty-first and subsequent statements on a line have the same number.

OBJECT Option

The OBJECT option specifies that the compiler is to store the object module that it creates in the data set defined by the DD statement with the name SYSLIN.

OFFSET Option

The OFFSET option specifies that the compiler is to print a table of statement or line numbers for each procedure with their offset addresses relative to the primary entry point of the procedure. This information is of use in identifying the statement being executed when an error occurs and a listing of the object module (obtained by using the LIST option) is available. If GOSTMT applies, statement numbers, as well as offset addresses, will be included in execution-time messages. If GONUMBER applies, line numbers, as well as offset addresses, will be included in execution-time messages.

OPTIMIZE Option

The OPTIMIZE option specifies the type of optimization required:

NOOPTIMIZE	specifies fast compilation speed, but inhibits optimization for faster execution and reduced main storage requirements.
OPTIMIZE (TIME)	specifies that the compiler is to optimize the machine instructions generated to produce a very efficient object program. A secondary effect of this type of optimization can be a reduction in the amount of main storage required for the object module. The use

of OPTIMIZE(TIME) could result in a substantial increase in compile time over NOOPTIMIZE.

OPTIMIZE(0) is the equivalent of NOOPTIMIZE.

OPTIMIZE(2) is the equivalent of OPTIMIZE(TIME).

The language reference manual for this compiler includes a full discussion of optimization.

OPTIONS Option

The OPTIONS option specifies that the compiler is to include in the compiler listing, a list showing the compiler options, to be used during this compilation. This list includes all those applied by default, those specified in the PARM parameter of an EXEC statement, and those specified in a PROCESS statement.

SEQUENCE Option

The SEQUENCE option specifies the extent of the part of each input line or record that contains a sequence number. This number is included in the source listings produced by the INSOURCE and SOURCE option. Also, if the NUMBER option applies, line numbers will be derived from these sequence numbers and will be included in the source listings in place of statement numbers. No attempt is made to sort the input lines or records into the specified sequence. The SEQUENCE option has the format:

SEQUENCE(m,n)

where "m" specifies the column number of the left-hand margin.

"n" specifies the column number of the right-hand margin.

The extent specified should not overlap with the source program (as specified in the MARGINS option).

There is no NOSEQUENCE option and no default. If SEQUENCE is not specified but the NUMBER option applies, the position of the sequence number is assumed (see "NUMBER Option").

SIZE Option

This option can be used to limit the amount of main storage used by the compiler. This is of value, for example, when dynamically invoking the compiler, to ensure that space is left for other purposes. The SIZE option can be expressed in three forms:

SIZE(yyyyyyyy) specifies the yyyyyyyy bytes of main storage are to be requested. Leading zeros are not required.

SIZE(yyyyyK) specifies that yyyyyK bytes of main storage are to be requested (1K=1024). Leading zeros are not required.

SIZE(MAX) specifies that the compiler is to obtain as much main storage as it can.

The IBM default, and the most usual value to be used, is SIZE(MAX), which permits the compiler to use as much main storage in the partition or region as it can.

When a limit is specified, the amount of main storage used by the compiler depends on how the operating system has been generated, and the method used for storage allocation. The compiler assumes that buffers, data management routines, and processing phases take up a fixed amount of main storage, but this amount can vary unknown to the compiler.

Under MFT the compiler will operate in a partition of 50K bytes or more of main storage, using its default values for file specifications. Under MVT a region of 52K bytes or more is required.

After the compiler has loaded its initial phases and opened all files, it attempts to allocate space for working storage.

If SIZE(MAX) is specified it obtains all space remaining in the region or partition (after allowance for subsequent data management storage areas). If a limit is specified then this amount is requested. If the amount available is less than specified, but is more than the minimum workspace required, compilation proceeds. If insufficient storage is available, compilation is terminated. This latter situation should arise only if the region or partition is too small, that is, less than 50K, or if too much space for buffers has been requested. The value cannot exceed the main storage available for the

job step and cannot be changed after processing has begun.

This means, that in a batched compilation, the value established when the compiler is invoked cannot be changed for later programs in the batch. Thus it is ignored if specified in a PROCESS statement.

In a TSO environment, an additional 10K to 30K bytes must be allowed for TSO. The actual size required for TSO depends on which routines are placed in the link-pack area (a common main storage pool available to all regions).

SMESSAGE Option

See LMESSAGE option.

SOURCE Option

The SOURCE option specifies that the compiler is to include in the compiler listing a listing of the source program. The source program listed is either the original source input or, if the MACRO option applies, the output from the preprocessor.

STMT Option

The STMT option specifies that statements in the source program are to be counted, and that this "statement number" is used to identify statements in the compiler listings resulting from the AGGREGATE, ATTRIBUTES, LIST, OFFSET, SOURCE, and XREF options. If NOSTMT is specified, NUMBER is implied. STMT is implied by NONUMBER or GOSTMT.

STORAGE Option

The STORAGE option specifies that the compiler is to include in the compiler listing a table giving the main storage requirements for the object module.

SYNTAX Option

The SYNTAX option specifies that the compiler is to continue into syntax checking after initialization (or after preprocessing if the MACRO option applies) unless an unrecoverable error is detected. The NOSYNTAX option without an argument causes processing to stop unconditionally after initialization (or preprocessing). With an argument, continuation depends on the severity of errors detected so far, as follows:

NOSYNTAX(W)	No syntax checking if a warning, error, severe error, or unrecoverable error is detected.
NOSYNTAX(E)	No syntax checking if an error, severe error, or unrecoverable error is detected.
NOSYNTAX(S)	No syntax checking if a severe error or unrecoverable error is detected.

If the SOURCE option applies, the compiler will generate a source listing even if syntax checking is not performed.

The use of this option can prevent wasted runs when debugging a PL/I program that uses the preprocessor.

TERMINAL Option

The TERMINAL option is applicable only in a TSO environment. It specifies that some or all of the compiler listing produced during compilation is to be printed at the terminal. If TERMINAL is specified without an argument, diagnostic and informatory messages are printed at the terminal. You can add an argument, which takes the form of an option list, to specify other parts of the compiler listing that are to be printed at the terminal.

The listing at the terminal is independent of that written on SYSPRINT. However, if SYSPRINT is associated with the terminal, only one copy of each option requested will be printed even if it is requested in the TERMINAL option and also as an independent option. The following option keywords, their negative forms, or their abbreviated forms, can be specified in the option list:

AGGREGATE, ATTRIBUTES, ESD, INSOURCE, LIST, MAP, OPTIONS, SOURCE, STORAGE, and XREF.

The other options that relate to the listing (that is, FLAG, GONUMBER, GOSTMT, LINECOUNT, LMESSAGE/SMESSAGE, MARGINI, NEST, and NUMBER) will be the same as for the SYSPRINT listing.

XREF Option

The XREF option specifies that the compiler is to include in the compiler listing a list of all identifiers used in the PL/I program together with the numbers of the statements in which they are declared or referenced. The only exception is that label references on END statements are not included. If both ATTRIBUTES and XREF apply, the two tables are combined.

Compiler Listing

During compilation, the compiler generates a listing, most of which is optional, that contains information about the source program, the compilation, and the object module. It places this listing in the data set defined by the DD statement with the name SYSPRINT (usually output to a printer). In a TSO environment, you can also request a listing at your terminal (using the TERMINAL option). The following description of the listing refers to its appearance on a printed page.

An example of the listing produced for a typical PL/I program is given in appendix F.

Figure 4.5 specifies the components that can be included in the compiler listing, and the order in which they appear. The rest of this section then describes these in detail.

Of course, if compilation terminates before reaching a particular stage of processing, the corresponding listings will not appear.

System information will appear before and after the listings for each job step if these items use the same output class as the processing programs. The output class for system information is specified in the MSGCLASS parameter of the JOB statement. The level of information produced is specified in the MSGLEVEL parameter.

The listing comprises a small amount of standard information that always appears, together with those items of optional information specified or supplied by default. The listing at the terminal contains only the optional information that has been requested in the TERMINAL option.

HEADING INFORMATION

The first page of the listing is identified by the name of the compiler, the compiler version number, the time compilation commenced (if the system has the timer feature), and the date; this page, and subsequent pages are numbered.

The listing either ends with a statement that no errors or warning conditions were detected during the compilation, or with one or more messages. The format of the messages is described under "Messages," later in this chapter. If the machine has the timer feature, the listing also ends with a statement of the CPU time taken for the compilation and the elapsed time during

Listings	Options required
Options used for the compilation	OPTIONS
Preprocessor input	MACRO and INSOURCE
Source program	SOURCE
Statement nesting level	NEST
Attribute table	ATTRIBUTES
Cross-reference table	XREF
Aggregate length table	AGGREGATE
Storage requirements	STORAGE
Statement offset addresses	SOURCE, OFFSET, NOSTMT
External symbol dictionary	ESD
Static internal storage map	MAP
Object listing	LIST
Messages	FLAG

Figure 4.5. Compiler listings and associated options

the compilation; these times will differ only in a multiprogramming environment.

The following paragraphs describe the optional parts of the listing in the order in which they appear.

OPTIONS USED FOR THE COMPILATION

If the option OPTIONS applies, a complete list of the options used for the compilation, including the default options, appears on the first page.

PREPROCESSOR INPUT

If both the options MACRO and INSOURCE apply, the input to the preprocessor is listed, one record per line, each line numbered sequentially at the left.

If the preprocessor detects an error, or the possibility of an error, it prints a message on the page or pages following the input listing. The format of these messages is exactly as described for the compiler messages described under "Messages," later in this chapter.

SOURCE PROGRAM

If the option SOURCE applies, the input to the compiler is listed, one record per line; if the input records contain printer control characters or %SKIP or %PAGE statements, the lines will be spaced accordingly.

If the option NUMBER applies, and the source program contains line numbers, these numbers are printed to the left of each line.

If the option STMT applies, the statements in the source program are numbered sequentially by the compiler, and the number of the first statement in the line appears to the left of each line in which a statement begins. When an END statement closes more than one group or block, all the implied END statements are included in the count, for example:

```
1 P: PROC;
2 X: BEGIN;
3    IF A=B
       THEN A=1;
4       ELSE DO;
5              A=0;
6              C=B;
7       END X;
9       D=E;
10      END;
```

If the source statements are generated by the preprocessor, columns 73-80 contain the following information:

Column	Information
73-77	Input line number from which the source statement is generated. This number corresponds to the line number in the preprocessor input listing.
78,79	Two-digit number giving the maximum depth of replacement by the preprocessor for this line. If no replacement occurs, the columns are blank.
80	"E" signifying that an error has occurred while replacement is being attempted. If no error has occurred, the column is blank.

STATEMENT NESTING LEVEL

If the option NEST applies, the block level and the do-level are printed to the right of the statement or line number under the headings LEV and NT respectively, for example:

```
STMT LEV   NT

  1              A:PROC OPTIONS(MAIN);
  2    1           B:PROC(L);
  3    2             DO I=1 to 10;
  4    2    1          DO J=1 TO 10;
  5    2    2           X(I,J)=N;
  6    2    2             END;
  7    2    1          BEGIN;
  8    3    1              X=Y;
  9    3    1          END;
 10    2    1        END B;
 11    1           END A;
```

ATTRIBUTE AND CROSS-REFERENCE TABLE

If the option ATTRIBUTES applies, the compiler prints an attribute table containing a list of the identifiers in the source program together with their declared and default attributes. In this context, the attributes include any relevant

options, such as REFER, and also descriptive comments, such as:

```
/*STRUCTURE*/
```

If the option XREF applies, the compiler prints a cross-reference table containing a list of the identifiers in the source program together with the numbers of the statements or lines in which they appear. If both ATTRIBUTES and XREF apply, the two tables are combined.

Attribute Table

If an identifier is declared explicitly, the number of the DECLARE statement is listed. An undeclared variable is indicated by asterisks. The statement numbers of statement labels and entry labels are also given.

The attributes INTERNAL and REAL are never included; they can be assumed unless the respective conflicting attributes, EXTERNAL and COMPLEX, appear.

For a file identifier, the attribute FILE always appears, and the attribute EXTERNAL appears if it applies; otherwise, only explicitly declared attributes are listed.

For an array, the dimension attribute is printed first; the bounds are printed as in the array declaration, but expressions are replaced by asterisks.

For a character string or a bit string, the length, preceded by the word BIT or CHARACTER, is printed as in the declaration, but an expression is replaced by an asterisk.

Cross-reference Table

If the cross-reference table is combined with the attribute table, the numbers of the statements or lines in which an identifier appears follow the list of attributes for the identifier. The number of a statement in which an implicitly-pointer qualified based variable appears will be included not only in the list of statement numbers for that variable, but also in the list of statement numbers for the pointer associated with it implicitly.

AGGREGATE LENGTH TABLE

If the option AGGREGATE applies, the compiler prints an aggregate length table, together with the sum of the lengths of aggregates whose lengths do not vary. In general, each entry consists of an aggregate identifier preceded by a statement or line number and followed by the length of the aggregate in bytes.

The statement or line number identifies either the DECLARE statement for the aggregate, or, for a controlled aggregate, an ALLOCATE statement for the aggregate. An entry appears for each ALLOCATE statement involving a controlled aggregate, as such statements can have the effect of changing the length of the aggregate during execution. Allocation of a based aggregate does not have this effect, and only one entry, which is that corresponding to the DECLARE statement, appears.

The length of an aggregate may not be known during compilation, either because the aggregate contains elements having adjustable lengths or dimensions, or because the aggregate is dynamically defined. In these cases, the word "adjustable" or "defined" appears in the "length in bytes" column.

An entry for a COBOL mapped structure, that is, for a structure into which a COBOL record is read or from which a COBOL record is written, or for a structure passed to or from a COBOL program, has the word "COBOL" appended. Such an entry will appear only if the compiler determines that the COBOL and PL/I mapping for the structure is different, and creation of a temporary structure mapped according to COBOL rules is not suppressed by one of the options NOMAP, NOMAPIN, and NOMAPOUT.

An entry for a FORTRAN mapped array, that is, an array passed to or from a FORTRAN program, has the word "FORTRAN" appended.

If a COBOL or FORTRAN entry does appear it is additional to the entry for the PL/I mapped version of the structure.

STORAGE REQUIREMENTS

If the option STORAGE applies, the compiler lists the following information under the heading "Storage Requirements" on the page following the end of the aggregate length table:

1. The storage area in bytes for each procedure.

2. The storage area in bytes for each begin block.

3. The storage area in bytes for each on-unit.

4. The length of the program control section. The program control section is the part of the object module that contains the executable part of the program.

5. The length of the static internal control section. This control section contains all storage for variables declared STATIC INTERNAL.

STATEMENT OFFSET ADDRESSES

If the option OFFSET applies, the compiler lists, for each primary entry point, the offsets at which statements occur. This information is found, under the heading "Table of Offsets and Statement Numbers," following the end of the storage requirements table.

EXTERNAL SYMBOL DICTIONARY

If the option ESD applies, the compiler lists the contents of the external symbol dictionary (ESD).

The ESD is a table containing all the external symbols that appear in the object module. (The machine instructions in the object module are grouped together in what are termed control sections; an external symbol is a name that can be referred to in a control section other than the one in which it is defined.) The contents of an ESD appear under the following headings:

SYMBOL - An 8-character field that identifies the external symbol.

TYPE - Two characters from the following list to identify the type of entry:

- SD Section definition: the name of a control section within the object module.
- CM Common area: a type of control section that contains no data or executable instructions.
- ER External reference: an external symbol that is not defined in the object module.
- WX Weak external reference: an external symbol that is not defined in this module and that is not to be resolved unless an ER entry is encountered for the same reference.
- PR Pseudo-register: a field in a communications area, the task communications area (TCA), used by the compiler and by the library subroutines for handling files and controlled variables.
- LD Label definition: the name of an entry point to the external procedure other than that used as the name of the program control section.

ID - Four-digit hexadecimal number: all entries in the ESD, except LD-type entries, are numbered sequentially, commencing from 0001.

ADDR - Hexadecimal representation of the address of the external symbol.

LENGTH - The hexadecimal length in bytes of the control section (SD, CM, and PR entries only).

ESD Entries

The external symbol dictionary always starts with the following standard entries; the entries for an external procedure with the label NAME are shown in figure 4.6.

1. SD-type entry for PLISTART. This control section transfers control to the initialization routine IBMBPIR. When initialization is complete, control passes to the address stored in the control section PLIMAIN. (Initialization is required only once during the execution of a PL/I program, even if it calls another external procedure; in such a case, control passes directly to the entry point named in the CALL statement, and not to the address contained in PLIMAIN.)

2. SD-type entry for the program control section (the control section that contains the executable instructions of the object module). This name is the first label of the external procedure, padded on the left with asterisks to seven characters if necessary, and extended on the right with the character 1.

3. SD-type entry for the static internal control section (which contains main storage for all variables declared STATIC INTERNAL). This name is the first label of the external procedure, padded on the left with asterisks to seven characters if necessary, and extended on the right with the character 2.

4. ER-type entry for IBMBPIRA, the entry point of the PL/I resident library subroutine that handles program initialization and termination.

EXTERNAL SYMBOL DICTIONARY

SYMBOL	TYPE	ID	ADDR	LENGTH
PLISTART	SD	0001	000000	000034
***NAME1	SD	0002	000000	000100
***NAME2	SD	0003	000000	000100
PLITABS	WX	0004	000000	
IBMBPIRA	ER	0005	000000	
IBMBPIRD	ER	0006	000000	
IBMBPIRC	ER	0007	000000	
PLICALLA	LD		000006	
PLICALLB	LD		00000A	
PLIMAIN	SD	0008	000000	000004

Figure 4.6. Standard entries in the ESD

Other ESD Entries

The remaining entries in the external symbol dictionary vary, but generally include the following:

1. SD-type entry for the 4-byte control section PLIMAIN, which contains the address of the primary entry point to the external procedure. This control section is present only if the procedure statement includes the option MAIN.

2. Weak external reference to PLITABS, a library subroutine that contains the standard or locally-defined tab setting for stream-oriented output.

3. LD-type entries for all names of entry points to the external procedure.

4. A PR-type entry for each block in compilation.

5. ER-type entries for all the library subroutines and external procedures called by the source program. This list includes the names of resident library subroutines called directly by compiled code (first-level subroutines), and the names of other resident library subroutines that are called by the first-level subroutines.

6. CM-type entries for non-string element variables declared STATIC EXTERNAL without the INITIAL attribute.

7. SD-type entries for all other STATIC EXTERNAL variables and for external file names.

8. PR-type entries for all file names. For external file names, the name of the pseudo-register is the same as the file name; for internal file names, the compiler generates names as for the display pseudo-registers.

9. PR-type entries for all controlled variables. For external variables, the name of the variable is used for the pseudo-register name; for internal variables, the compiler generates names.

STATIC INTERNAL STORAGE MAP

If the option MAP applies, the compiler generates a listing of the contents of the static internal control section; this listing is termed the static internal storage map.

OBJECT LISTING

If the option LIST applies, the compiler generates a listing of the machine instructions of the object module, including any compiler-generated subroutines, in a form similar to IBM System/360 assembler language.

Both the static internal storage map and the object listing contain information that cannot be fully understood without a knowledge of the structure of the object module. This is beyond the scope of this manual, but a full description of the object module, the static internal storage map, and the object listing can be found in OS PL/I Optimizing Compiler: Execution Logic.

MESSAGES

If the preprocessor or the compiler detects an error, or the possibility of an error, they generate messages. Messages generated by the preprocessor appear in the listing immediately after the listing of the statements processed by the preprocessor. Messages generated by the compiler appear at the end of the listing. All messages are graded according to their severity, as follows:

An informatory (I) message calls attention to a possible inefficiency in the program or gives other information generated by the compiler that may be of interest to the programmer.

A warning (W) message calls attention to a possible error, although the statement to which it refers is syntactically valid.

An error (E) message describes an error detected by the compiler for which the compiler has applied a "fix-up" with confidence. The resulting program will execute and will probably give correct results.

A severe error (S) message specifies an error detected by the compiler for which the compiler cannot apply a "fix-up" with confidence. The resulting program will execute but will not give correct results.

An unrecoverable error (U) message describes an error that forces termination of the compilation.

The compiler lists only those messages with a severity equal to or greater than that specified by the FLAG option, as follows:

Type of message	Option
Informatory	FLAG(I)
Warning	FLAG(W)
Error	FLAG(E)
Severe Error	FLAG(S)
Unrecoverable Error	Always listed

Each message is identified by an 8-character code of the form IELnnnnI, where:

1. The first three characters "IEL" identify the message as coming from the optimizing compiler.
2. The next four characters are a 4-digit message number.
3. The last character "I" is an operating system code for the operator indicating that the message is for information only.

The text of each message, an explanation, and any recommended programmer response, are given in the messages publication for this compiler.

RETURN CODE

For every compilation job or job step, the compiler generates a return code that indicates to the operating system the degree of success or failure it achieved. This code appears in the "end of step" message that follows the listing of the job control statements and job scheduler messages for each step. Its meaning is as follows:

Return Code	Meaning
0000	No error detected; compilation completed; successful execution anticipated.
0004	Possible error (warning) detected; compilation completed; successful execution probable.
0008	Error detected; compilation completed; successful execution probable.
0012	Severe error detected; compilation may have been completed; successful execution improbable.
0016	Unrecoverable error detected; compilation terminated abnormally; successful execution impossible.

Batched Compilation

Batched compilation allows the compiler to compile more than one external PL/I procedure in a single job step. The compiler creates an object module for each external procedure and stores it sequentially either in the data set defined by the DD statement with the name SYSPUNCH, or in the data set defined by the DD statement with the name SYSLIN. Batched compilation can increase compiler

throughput by reducing operating system and compiler initialization overheads.

To specify batched compilation, include a compiler PROCESS statement as the first statement of each external procedure except possibly the first. The PROCESS statements identify the start of each external procedure and allow compiler options to be specified individually for each compilation. The first procedure may require a PROCESS statement of its own, because the options in the PARM parameter of the EXEC statement apply to all procedures in the batch, and may conflict with the requirements of subsequent procedures.

The method of coding a PROCESS statement and the options that may be included are described under "Optional Facilities," earlier in this chapter. The options apply to the compilation of the source statements between one PROCESS statement and the next PROCESS statement. If you omit any of the options, those specified in the EXEC statement, or default values apply; apart from the SIZE option, discussed below, there is no carry over from the EXEC statement or any preceding PROCESS statement.

The return code generated by a batched compilation is the highest code that would be returned if the procedures were compiled separately.

SIZE Option

In a batched compilation, the SIZE specified in the first procedure of a batch (by a PROCESS or EXEC statement, or by default) is used throughout. If SIZE is specified in subsequent procedures of the batch, it is diagnosed and ignored. The compiler does not reorganize its storage between procedures of a batch.

NAME Option

The NAME option specifies that the compiler is to place a linkage editor NAME statement as the last statement of the object module. The use of this option in the PARM parameter of the EXEC statement, or in a PROCESS statement determines how the object modules produced by a batched compilation will be handled by the linkage editor. When the batch of object modules is link edited, the linkage editor combines all the object modules between one NAME statement and the preceding NAME statement into a single load module; it takes the name of the load module from the NAME statement that follows the last object module that is to be included. For example:

```
//   EXEC PLIXC,PARM.PLI='NAME(''A''),LIST'
                  .
                  .
                  .
  ALPHA: PROC OPTIONS(MAIN);
                  .
                  .
                  .
         END ALPHA;
* PROCESS;
  BETA:           PROC;
                  .
                  .
                  .
         END BETA;
* PROCESS NAME('B');
  GAMMA: PROC;
                  .
                  .
                  .
         END GAMMA;
```

Compilation of the PL/I procedures ALPHA, BETA, and GAMMA, would result in the following object modules and NAME statements:

```
Object module for ALPHA
     NAME A (R)
Object module for BETA
Object module for GAMMA
     NAME B (R)
```

From this sequence of object modules and control statements, the linkage editor would produce two load modules, one named A containing the object module for the external PL/I procedure ALPHA, and the other named B containing the object modules for the external PL/I procedures BETA and GAMMA.

You should not specify the option NAME if you intend to process the object modules with the loader. The loader processes all object modules into a single load module; if there is more than one name, the loader recognizes the first one only and ignores the others.

JOB CONTROL LANGUAGE FOR BATCHED PROCESSING

The only special consideration relating to JCL for batched processing refers to the data set defined by the DD statement with the name SYSLIN. If you include the option OBJECT, ensure that this DD statement contains the parameter DISP=(MOD,KEEP) or DISP=(MOD,PASS). (The IBM-supplied cataloged procedures specify

DISP=(MOD,PASS).) If you do not specify DISP=MOD, successive object modules will overwrite the preceding modules.

Examples

Simple batched compilation using an IBM-supplied cataloged procedure (PLIXCL)

```
//OPT4#7  JOB
//STEP1  EXEC  PLIXCL,PARM.PLI='NAME(''PGM1'')'
//PLI.SYSIN  DD  *

     /*THIS PROGRAM CALCULATES A SERIES OF SQUARE-ROOT VALUES
         AND PRINTS OUT THE VALUES*/

  FIRST: PROC OPTIONS(MAIN);
     DO I=1250 TO 1500 BY 50;
       DO J=10, 15, 20;
            K=SQRT(I/J);
            PUT SKIP(2) DATA;
            END;
     END;
   END FIRST;

* PROCESS NAME('PGM2');

     /*THIS PROGRAM CALCULATES THE VALUE OF AN ARRAY EXPRESSION
         FOR ALL ELEMENTS OF THE SOURCE ARRAYS, AND PRINTS THE
         RESULTS*/

  SECOND: PROC OPTIONS(MAIN);

         DCL A(5) INIT(1,2,4,8,16),
           B(5) INIT(3,5,7,9,11),
           C(5,5);

     DO I=1 TO 5;
        DO J=1 TO 5;
           C(I,J)=12*A(I)/B(J);
           END;
        END;
     PUT EDIT(A)(X(7),F(7,2));
     PUT SKIP EDIT(B)(X(7),F(7,2));
     PUT SKIP EDIT(C)(5(X(7),F(7,2),SKIP));
  END SECOND;

* PROCESS  NAME('PGM3');

     /*THIS PROGRAM CALCULATES THE VALUE OF AN EXPRESSION USING
         INPUT DATA, AND PRINTS THE RESULT*/

  THIRD: PROC OPTIONS(MAIN);

        ON ENDFILE(SYSIN) GO TO FINISH;

NEXT: GET DATA(A,B);
        C=A+8*B**2/3;
        PUT SKIP DATA;
        GO TO NEXT;
  FINISH: END THIRD;
/*
```

Figure 4.7. Example of batched compilation

is shown in figure 4.7; four external PL/I procedures are compiled in a batch and are link edited to form three load modules.

The EXEC statement contains the compiler options specified explicitly for both procedure steps, PLI and LKED, of the cataloged procedure.

The procedure step, PLI, invokes the compiler to batch-compile the four external

procedures FIRST, SECOND, PRINT, and THIRD. All compiler options except SIZE, either specified in the PARM.PLI parameter or assumed by default, apply to all the four compilations except where overridden by PROCESS statements. The SIZE option applies to all the compilations in the batch. The NAME option in the EXEC statement specifies that the object module compiled from procedure FIRST will be processed by the linkage editor into a load module named PGM1, which will contain no other procedures.

The first PROCESS statement includes the ESD option, which specifies a listing of the external symbol dictionary for the object module compiled from procedure SECOND.

The second PROCESS statement includes the NAME option, which causes the compiler to insert a linkage editor NAME statement as the last statement of the object module compiled from the procedure PRINT; since this option does not appear in the preceding PROCESS statement, the object modules for procedures SECOND and PRINT will be combined into a single load module (named PGM2) by the linkage editor.

The third process statement includes the NAME and FLAG options. The NAME option causes the compiler to insert a linkage-editor NAME statement as the last statement of the object module compiled from the procedure THIRD; this object module is link-edited into a single load module named PGM3. The FLAG option specifies that only error, severe error, and unrecoverable error messages are to be listed by the compiler.

The second procedure step, LKED, invokes the linkage editor to combine the object modules, according to the names specified in the PROCESS statements, into the three load modules PGM1, PGM2, and PGM3, and to store them in the private library PUBPGM, from which they can later be called for execution. The DD statement with the qualified name LKED.SYSLMOD overrides the corresponding DD statement in the cataloged procedure to provide information on this private library.

How these load modules are executed is shown in figure 4.8; PUBPGM is named again in the DD statement with the name JOBLIB; a library defined by a DD statement with this name serves as an extension of the system library for the duration of the job in which the statement appears. The linkage editor and system libraries are described in chapters 5 and 9, respectively.

Compile-time Processing (Preprocessing)

The preprocessing facilities of the compiler are described in the language reference manual for this compiler. You can include in a PL/I program statements that, when executed by the preprocessor stage of the compiler, modify the source program or cause additional source statements to be included from a library. The following discussion supplements the information contained in the language reference manual by providing some illustrations of the use of the preprocessor and explaining how to establish and use source statement libraries.

INVOKING THE PREPROCESSOR

The preprocessor stage of the compiler is executed if you specify the compiler option MACRO. The compiler and the preprocessor use the data set defined by the DD

```
//OPT4#8  JOB
//STEPX EXEC PGM=PGM1
//STEPLIB  DD DSN=L.LIBRARY,DISP=SHR
//         DD DSN=PUBPGM,UNIT=2311,VOL=SER=D186,DISP=OLD
//SYSPRINT DD SYSOUT=A
//STEPXX EXEC PGM=PGM2
//STEPLIB  DD DSN=L.LIBRARY,DISP=SHR
//         DD DSN=PUBPGM,UNIT=2311,VOL=SER=D186,DISP=OLD
//SYSPRINT DD SYSOUT=A
//STEPXXX EXEC PGM=PGM3
//STEPLIB  DD DSN=L.LIBRARY,DISP=SHR
//         DD DSN=PUBPGM,UNIT=2311,VOL=SER=D186,DISP=OLD
//SYSPRINT DD SYSOUT=A
//SYSIN DD *
A=27 B=42; A=53 B=17;
/*
```

Figure 4.8. Execution of program compiled in figure 4.7

statement with the name SYSUT1 during processing. They also use this data set to store the preprocessed source program until compilation begins. The IBM-supplied cataloged procedures for compilation all include a DD statement with the name SYSUT1.

The term MACRO owes its origin to the similarity of some applications of the preprocessor to the macro language available with such processors as the IBM System/360 Assembler. Such a macro language allows you to write a single instruction in a program to represent a sequence of instructions that have previously been defined.

The format of the preprocessor is output as follows:

Column 1	Printer control character, if any, transferred from the position specified in the MARGINS option.
Columns 2-72	Source program. If the original source program used more than 71 columns, then additional lines are included for any lines that need continuation. If the original source program used less than 71 columns, then extra blanks are added on the right.
Columns 73-80	Sequence number, right-aligned. If either SEQUENCE or NUMBER apply, this is taken from the sequence number field. Otherwise, it is a preprocessor generated number, in the range 1 through 99999. This sequence number will be used in the listing produced by the INSCURCE and SOURCE options, and in any preprocessor diagnostic messages.
Column 81	blank
Columns 82,83	Two-digit number giving the maximum depth of replacement by the preprocessor for this line. If no replacement cccurs, the columns are blank.
Column 84	"E" signifying that an error has occurred while replacement is being attempted. If no errcr has occurred, the column is blank.

Three other compiler options, MDECK, INSOURCE, and SYNTAX, are meaningful only when you also specify the MACRO optiсn. All are described earlier in this chapter.

A simple example of the use of the preprocessor to produce a source deck fcr a procedure SUBFUN is shown in figure 4.9; according to the value assigned to the preprocessor variable USE, the source statements will represent either a subroutine or a function.

```
//OPT4#9  JOB
//STEP1  EXEC  PLIXC,PARM.PLI='MACRO,NOSYNTAX,MDECK'
//PLI.SYSPUNCH  DD  DSNAME=NEWLIB(SUBPROC),DISP=(NEW,CATLG),UNIT=2311,
//       VOL=SER=D186,SPACE=(CYL,(1,1,1))
//PLI.SYSIN  DD  *
  SUBFUN: PROC(CITY);

     DCL IN FILE RECORD,
         1 DATA,
                 2 NAME CHAR(10),
                 2 POP FIXED(7),
         CITY CHAR(10);

     %DCL USE CHAR;
     %USE='SUB'  /* FOR FUNCTION, SUBSTITUTE %USE='FUN' */;

 NEXT: READ FILE(IN) INTO(DATA);
     IF NAME=CITY THEN DO;
     %IF USE='FUN' %THEN %GOTO L1;
     NO=POP; END;
     %GO TO L2;
 %L1:; RETURN(POP); END;
 %L2:;  ELSE GO TO NEXT;
     END SUBFUN;
/*
```

Figure 4.9. Using the preprocessor to create a member of a source program library

THE %INCLUDE STATEMENT

The language reference manual for this compiler describes how to use the %INCLUDE statement to incorporate source statements from a library into a PL/I program. (A library is a type of data set that can be used for the storage of other data sets, termed members.) A set of source statements that you may wish to insert into a PL/I program by means of a %INCLUDE statement must exist as a data set (member) within a library. Creating a library and placing members in this library, are described in chapter 9.

The %INCLUDE statement includes one or more pairs of identifiers. Each pair of identifiers specifies the name of a DD statement that defines a library and, in parentheses, the name of a member of the library. For example, the statement:

```
%INCLUDE DD1(INVERT),DD2(LOOPX)
```

specifies that the source statements in member INVERT of the library defined by the DD statement with the name DD1, and those in member LOOPX of the library defined by the DD statement with the name DD2, are to be inserted consecutively into the source program generated by the preprocessor. The compilation job step must include appropriate DD statements.

If you omit the ddname from any pair of identifiers in a %INCLUDE statement, the preprocessor assumes the ddname SYSLIB. In such a case, you must include a DD statement with the name SYSLIB. (The IBM-supplied cataloged procedures do not include a DD statement with this name in the compilation procedure step.)

The use of a %INCLUDE statement to include the source statements for SUBFUN in the procedure TEST is shown in figure 4.10. The library NEWLIB is defined in the DD statement with the qualified name PLI.SYSLIB, which is added to the statements of the cataloged procedure PLIXCLG for this job. Since the source statement library is defined by a DD statement with the name SYSLIB, the %INCLUDE statement need not include a ddname.

```
//OPT4#10 JOB
//STEP1  EXEC   PLIXCLG,PARM.PLI='MACRO,OBJECT'
//PLI.SYSLIB  DD  DSNAME=NEWLIB,DISP=OLD
//PLI.SYSIN  DD  *
  TEST: PROC OPTIONS(MAIN);

        DCL NAME CHAR(10),
            NO FIXED(7);

        ON ENDFILE(SYSIN) GO TO FINISH;

 AGAIN: GET FILE(SYSIN) LIST(NAME);
        CALL SUBFUN(NAME);
        PUT DATA(NAME,NO);
        GO TO AGAIN;
   %INCLUDE SUBPROC;
  FINISH: END TEST;
/*
//GO.IN  DD  DSNAME=POPLIST,DISP=OLD
//GO.SYSIN DD *
'ABERDEEN'
'DONCASTER'
/*
```

Figure 4.10. Including source statements from a library

Dynamic Invocation of the Compiler

You can invoke the optimizing compiler from an assembler language program by using one of the macro instructions ATTACH, CALL, LINK, or XCTL. The following information supplements the description of these macro instructions given in the manual OS/360 Supervisor and Data Management Macro Instructions.

To invoke the compiler specify IEL0AA as the entry point name.

You can pass three address parameters to the compiler:

- The address of a compiler option list.
- The address of a list of ddnames for the data sets used by the compiler.
- The address of a page number that is to be used for the first page of the compiler listing on SYSPRINT.

These addresses must be in adjacent fullwords, aligned on a fullword boundary. Register 1 must point to the first address in the list, and the first (left-hand) bit of the last address must be set to 1, to indicate the end of the list.

Note: If you want to pass parameters in an XCTL macro instruction, you must use the execute (E) form of the macro instruction. Remember also that the XCTL macro instruction indicates to the control program that the load module containing the XCTL macro instruction is completed. Thus the parameters must be established in a portion of main storage outside the load module containing the XCTL macro instruction, in case the load module is deleted before the compiler can use the parameters.

The format of the three parameters for all the macro instructions is described below.

OPTION LIST

The option list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). The remainder of the list can comprise any of the compiler option keywords, separated by one or more blanks, a comma, or both of these.

DDNAME LIST

The ddname list must begin on a halfword boundary. The first two bytes contain a binary count of the number of bytes in the list (excluding the count field). Each entry in the list must occupy an 8-byte field; the sequence of entries is as follows:

Entry	Standard ddname
1	SYSLIN
2	not applicable
3	not applicable
4	SYSLIB
5	SYSIN
6	SYSPRINT
7	SYSPUNCH
8	SYSUT1
9	not applicable
10	not applicable
11	not applicable
12	not applicable
13	SYSCIN

If a ddname is shorter than eight bytes, fill the field with blanks on the right. If you omit an entry, fill its field with binary zeros; however you may entirely omit entries at the end of the list.

PAGE NUMBER

The page number is contained in a 6-byte field beginning on a halfword boundary. The first halfword must contain the binary value 4 (the length of the remainder of the field). The last four bytes contain the page number in binary form.

The compiler will add 1 to the last page number used in the compiler listing and put this value in the page-number field before returning control to the invoking routine. Thus, if the compiler is reinvoked, page numbering will be continuous.

Chapter 5: The Linkage Editor and the Loader

This chapter describes two processing programs of the operating system, the linkage editor and the loader. It explains the basic differences between them, describes the processing done by them, the JCL required to invoke them and, for the linkage editor, the additional processing it can do. Both processing programs are fully described in OS: Linkage Editor and Loader.

The object module produced by the compiler from a PL/I program always requires further processing before it can be executed. This further processing, the resolution of external references inserted by the compiler, is performed either by the linkage editor or by the loader, both of which convert an object module into an executable program, which in the case of the linkage editor, is termed a load module.

The linkage editor and the loader require the same type of input, perform the same basic processing, and produce a similar type of output. The basic differences between the two programs lie in the subsequent form and handling of this output.

Basic Differences

The linkage editor converts an object module into a load module, and stores it in a program library in auxiliary storage. The load module becomes a permanent member of that library and can be retrieved at any time for execution in either the job that created it, or in any other job.

The loader, on the other hand, processes the object module, loads the processed output directly into main storage, and executes it immediately. The loader is essentially a one-shot program checkout facility; once the load module has been executed, it cannot be used again without reinvoking the loader. To keep a load module for later execution, or to provide an overlay structure, you must use the linkage editor.

When using the linkage editor, three job steps are required -- compilation, link editing, and execution. When using the loader, only two job steps are required -- compilation and execution.

Choice of Program

If your installation includes both programs, the choice of program will depend on whether or not you want to retain a permanent copy of the load module, and on whether you want to use one of the facilities provided only by the linkage editor. All object modules acceptable to the linkage editor are acceptable to the loader; all load modules produced by the linkage editor, except those produced with the NE (not editable) attribute[1], are also acceptable to the loader. The differences between the two programs are summarized below.

Linkage Editor

- The linkage editor converts an object module into a load module and stores it in a partitioned data set (program library) in auxiliary storage.
- The linkage editor can produce one or more load modules in a single step (for example, output from batch compilation).
- The linkage editor can accept input from other sources as well as from its primary input source and from the automatic call library (SYSLIB).
- The linkage editor can provide an overlay structure for a program.

Loader

- The loader converts an object module into an executable program in main storage, and executes it immediately.
- The loader can produce only one load module in a single job step no matter how many object modules are produced

---

[1]The NE attribute is given to a load module that has no external symbol dictionary (ESD); a load module without an ESD cannot be processed again, either by the linkage editor or by the loader.

(for example, the output from a batch compilation).

- The loader can accept input from its primary input source and from the automatic call library (SYSLIB).

Performance Considerations

If you use the loader, you will gain the advantage of a considerable saving in both time and auxiliary storage when running your PL/I program. Although the execution time will be unchanged, both the scheduling time and the processing time will be reduced, and much less auxiliary storage will be needed. These savings are achieved as follows:

Scheduling Time: Scheduling time for the loader is much less than that for link editing and execution because the loader needs only one job step.

Processing Time: The time taken to process an object module by the loader is approximately half that taken by the linkage editor to process the same module. This is achieved by the elimination of certain input/output operations required by the linkage editor, and by a reduction in module access time by the use of chained scheduling and improved buffering in the loader program.

Auxiliary Storage: The amount of auxiliary storage required by the loader when your job is compiled, loaded, and executed as a single job step, is much less than that required by the linkage editor because two of the standard data sets used by the linkage editor are not needed. If the loader input is to consist of existing load modules the auxiliary storage required for these can be reduced by storing them with unresolved external references. These external references are resolved by the loader.

Module Structure

Object and load modules have very similar structures; they differ only in that a load module that has been processed by the linkage editor contains certain descriptive information required by the operating system; in particular, the module is marked as "executable" or "not executable". A module comprises the following information:

- Text (TXT)
- External symbol dictionary (ESD)
- Relocation dictionary (RLD)
- END instruction

Text

The text of an object or load module consists of the machine instructions that represent the PL/I statements of the source program. These instructions are grouped together in what are termed control sections; a control section is the smallest group of machine instructions that can be processed by the linkage editor. An object module produced by the optimizing compiler includes the following control sections:

- Program control section: contains the executable instructions of the object module.
- Static internal control section: contains storage for all variables declared STATIC INTERNAL and for constants and static system blocks.
- Control sections termed common areas: one common area is created for each EXTERNAL file name and for each non-string element variable declared STATIC EXTERNAL without the INITIAL attribute.
- PLISTART: execution of a PL/I program always starts with this control section, which passes control to the appropriate initialization subroutine; when initialization is complete, control passes to the address stored in the control section PLIMAIN.
- Control sections for all PL/I library subroutines to be included with the program.

External Symbol Dictionary

The external symbol dictionary (ESD) is a table containing all the external symbols that appear in the object module. An external symbol is a name that can be referred to in a control section other than the one in which it is defined.

The names of the control sections are themselves external symbols, as are the names of variables declared with the EXTERNAL attribute and entry names in the external procedure of a PL/I program. References to external symbols defined

elsewhere are also considered to be external symbols; they are known as external references. Such external references in an object module always include the names of the subroutines from either the OS PL/I Resident Library or the OS PL/I Transient Library that will be required for execution. They may also include calls to your own subroutines that are not part of the PL/I subroutine library, nor already included within the object module. The linkage editor or loader locates all the subroutines referred to, and includes them in the load module, or executable program respectively.

Relocation Dictionary

At execution time, the machine instuctions in a load module use the following two methods of addressing locations in main storage:

1. Names used only within a control section have addresses relative to the starting point of the control section.

2. Other names (external names) have absolute addresses so that any control section can refer to them.

The relocation dictionary (RLD) contains information that enables absolute addresses to be assigned to locations within the load module when it is loaded into main storage for execution. These addresses cannot be determined earlier because the starting address is not known until the module is loaded. The relocation dictionaries from all the input modules are combined into a single relocation dictionary when a load module is produced.

END Instruction

This specifies the compiler-generated control section PLISTART as the entry point for the object module.

Linkage Editor

The linkage editor is an operating system processing program that produces load modules. It always stores the load modules in a library, from which the job scheduler can call them for execution.

The input to the linkage editor can include object modules, load modules, and control statements that specify how the input is to be processed. The output from the linkage editor comprises one or more load modules.

In addition to its primary function of converting object modules into load modules, the linkage editor can also be used to:

- Combine previously link-edited load modules
- Modify existing load modules
- Construct an overlay structure

A load module constructed as an overlay structure can be executed in an area of main storage that is not large enough to contain the entire module at one time. The linkage editor divides the load module into segments that can be loaded and executed in turn.

LINKAGE EDITOR PROCESSING

A PL/I program, compiled by the optimizing compiler, cannot be executed until the appropriate library subroutines have been included. These subroutines are included in two ways:

1. By inclusion in the load module during link editing.

2. By dynamic call during execution.

The first method is used for most of the PL/I resident library subroutines; the following paragraphs describe how the linkage editor locates them. The second is used for the PL/I transient library subroutines, for example those concerned with input and output (including those used for opening and closing files), and those that generate execution-time messages.

In basic processing, as shown in figure 5.1, the linkage editor accepts from its primary input source a data set defined by the DD statement with the name SYSLIN. For a PL/I program, this input is the object module produced by the compiler. The linkage editor uses the external symbol dictionary in this object module to determine whether the module includes any external references for which there are no corresponding external symbols in the module: it attempts to resolve such references by a method termed automatic library call.

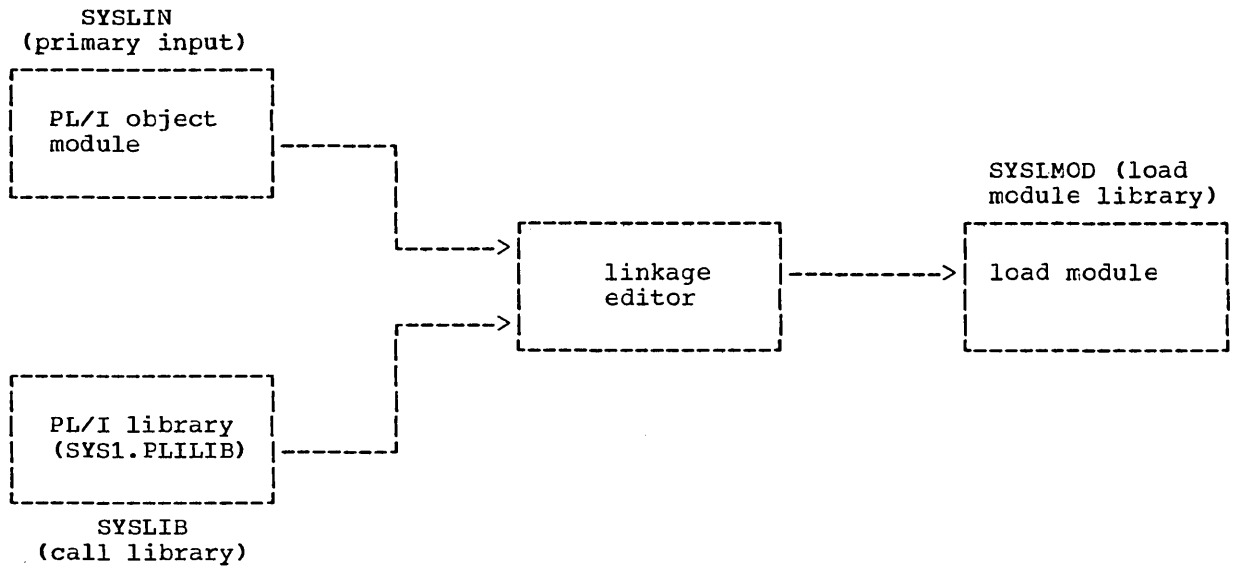


Figure 5.1. Basic linkage editor processing

External symbol resolution by automatic library call involves a search of the data set defined by the DD statement with the name SYSLIB; for a PL/I program, this will be the PL/I resident library. The linkage editor locates the subroutines in which the external symbols are defined (if such subroutines exist), and includes them in the load module.

The linkage editor always places its output (that is, the load module) in the data set defined by the DD statement with the name SYSLMOD.

Any linkage editor processing additional to the basic processing described above must be specified by linkage editor control statements placed in the primary input. These control statements are described in "Additional Processing," later in this chapter.

Main Storage Requirements

The F-level linkage editor has three different versions requiring differing amounts of main storage: 44K, 88K, and 128K bytes. The F-level linkage editor is described in the linkage editor and loader publication.

Job Control Language for the Linkage Editor

Although you will probably use cataloged procedures rather than supply all the job control language (JCL) required for a job step that invokes the linkage editor, you should be familiar with these JCL statements so that you can make the best use of the linkage editor and, if necessary, override the statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a link-edit procedure step are:

PLIXCL	Compile and link edit
PLIXCLG	Compile, link edit, and execute
PLIXLG	Link edit and execute

The following paragraphs describe the essential JCL statements for link editing. The IBM-supplied cataloged procedures are described in chapter 10 and include examples of these statements.

EXEC STATEMENT

The name of the linkage editor is of the form IEWLFxxx, where "xxx" indicates the amount of main storage required for its execution, as follows:

xxx	Amount of main storage
440	44K
880	88K
128	128K

ddname	Contents	Possible device classes[1]
SYSLIN	Primary input data, normally the compiler output	UNIT=SYSSQ or input job stream (specified by DD *)
SYSLMOD	Load module	UNIT=SYSDA
SYSUT1	Temporary workspace	UNIT=SYSDA
SYSPRINT	Listing, including messages	UNIT=SYSSQ (or SYSOUT=)
SYSLIB	Automatic call library (normally the PL/I resident library)	UNIT=SYSDA

[1]SYSSQ Magnetic tape or direct-access device
SYSDA Direct access device

Figure 5.2. Linkage editor standard data sets

The aliases IEWL or LINKEDIT are often used for the linkage editor and normally refer to the version at your installation with the largest design level. You should find out what versions are available at your installation.

The basic EXEC statement is:

```
//stepname EXEC PGM=IEWL
```

By using the PARM parameter of the EXEC statement, you can select one or more of the optional facilities provided by the linkage editor; these facilities are described in "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The linkage editor always requires four standard data sets. You must define these data sets in DD statements with the ddnames SYSLIN, SYSLMOD, SYSUT1, and SYSPRINT.

A fifth data set, defined by a DD statement with the name SYSLIB, is necessary if you want to use automatic library call. The five data set names, together with other characteristics of the data sets, are shown in figure 5.2.

Primary Input (SYSLIN)

Primary input to the linkage editor must be a standard data set defined by a DD statement with the name SYSLIN; this data set must have consecutive organization. The input must comprise one or more object modules and/or linkage editor control statements; a load module cannot be part of the primary input, although it can be introduced by the control statement INCLUDE. For a PL/I program, the primary input is usually a data set containing an object module produced by the compiler. This data set may be on magnetic tape or on a direct-access device, or you can include it in the input job stream. In all cases, the input must be in the form of 80-byte F-format records.

The IBM-supplied cataloged procedure PLIXLG includes the DD statement:

```
//SYSLIN DD DDNAME=SYSIN
```

which specifies that the primary input data set may be defined in a DD statement with the name SYSIN. If you use this cataloged procedure, specify this DD statement by using the qualified ddname LKED.SYSIN. For example, to link edit and execute an object module placed in the input stream, you can use the following statements:

```
//LEGO        JOB
//STPE1       EXEC PLIXLG
//LKED.SYSIN  DD *
      .
      .
      .
      (insert here the object module to be
      link edited and executed)
      .
      .
      .
/*
```

If object modules with identically named control sections appear in the primary input, the linkage editor processes only the first appearance of that control section.

You can include load modules or object modules from one or more libraries in the primary input by using a linkage editor INCLUDE statement as described in "Additional Processing," later in this chapter.

Output (SYSLMOD)

Output (that is, one or more load modules) from the linkage editor is always stored in a data set defined by the DD statement with the name SYSLMOD, unless you specify otherwise. This data set is usually called a library; libraries are fully described in chapter 9.

The IBM-supplied cataloged procedures include the following DD statement:

```
//SYSLMOD DD DSNAME=&&GOSET(GO),
//    UNIT=SYSDA,
//    DISP=(MOD,PASS),
//    SPACE=(1024,(50,20,1),RLSE))
```

which defines a temporary library named &&GOSET and assigns the member name GO to the load module produced by the linkage editor. To retain the load module after execution of the job, replace this DD statement with one that defines a permanent library. For example, assume that you have a permanent library called USLIB on 2311 disk pack serial number 371; to name the load module MOD1 and place it in this library, code:

```
//LKED.SYSLMOD DD DSNAME=USLIB(MOD1),
//    UNIT=2311,VOL=SER=371,DISP=OLD
```

The size of a load module must not exceed 512K bytes for programs executed under MFT; a much larger load module is allowed for MVT. The SPACE parameter in the DD statement with the name SYSLMOD used in the IBM-supplied cataloged procedures allows for an initial allocation of 50K bytes and, if necessary, 15 further allocations of 20K bytes (a total of 350K bytes); this should suffice for most applications.

Temporary Workspace (SYSUT1)

The linkage editor requires a data set for use as temporary workspace. It is defined by a DD statement with the name SYSUT1. This data set must be on a direct-access device. The following statement contains the essential parameters:

```
//SYSUT1 DD UNIT=SYSDA,
// SPACE=(1024,(200,20))
```

You should normally never need to alter the DD statement with the name SYSUT1 in an IBM-supplied cataloged procedure, except to increase the SPACE allocation when processing very large programs.

If your installation supports dedicated workfiles, these can be used to provide temporary workspace for the link-edit job step, as described in chapter 10.

Automatic Call Library (SYSLIB)

Unless you specify otherwise, the linkage editor will always attempt to resolve external references by automatic library call (see "Linkage Editor Processing," earlier in this chapter). To enable it to do this, you must define the data set or data sets to be searched in a DD statement with the name SYSLIB. (To define second and subsequent data sets, include additional, unnamed, DD statements immediately after the DD statement SYSLIB; the data sets so defined will be treated as a single continuous data set for the duration of the job step.)

For a PL/I program, the DD statement SYSLIB will normally define the PL/I resident library. The subroutines of the resident library are stored in two data sets, SYS1.PLIBASE (the base library) and SYS1.PLITASK (the multitasking library). The base library contains all the resident library subroutines required by a non-multitasking program. The multitasking library contains subroutines that are peculiar to multitasking, together with multitasking variants of some of the base library subroutines.

For link editing a non-multitasking program, specify only the base library in the SYSLIB DD statement. The following DD statement will usually suffice:

```
//SYSLIB DD DSN=SYS1.PLIBASE,DISP=CLD
```

For link editing a multitasking program, specify both the multitasking library and the base library. When attempting to resolve an external reference, the linkage editor will first search the multitasking library; if it cannot find the required subroutine, it will then search the base library. To ensure that the search is

carried out in the correct sequence, the DD statements defining the two sections of the library must be in the correct sequence: multitasking library first, base library second. The following DD statements will usually suffice:

```
//SYSLIB DD DSNAME=SYS1.PLITASK,DISP=OLD
//       DD DSNAME=SYS1.PLIBASE,DISP=OLD
```

Listing (SYSPRINT)

The linkage editor generates a listing that includes reference tables relating to the load modules that it produces and also, when necessary, messages. The information that may appear is described under "Listing Produced by the Linkage Editor," later in this chapter.

You must define the data set on which you wish the linkage editor to store its listing in a DD statement with the name SYSPRINT. This data set must have consecutive organization. Although the listing is usually printed, it can be stored on any magnetic-tape or direct-access device. For printed output, the following statement will suffice:

```
//SYSPRINT DD SYSOUT=A
```

EXAMPLE OF LINKAGE EDITOR JCL

A typical sequence of job control statements for link editing an object module is shown in figure 5.3. The DD statement SYSLIN indicates that the object module will follow immediately in the input stream; for example, it might be an object deck created by invoking the optimizing compiler with the DECK option, as described in chapter 4. The DD statement with the name SYSLMOD specifies that the linkage editor is to name the load module LKEX, and that it is to place it in a new library named MODLIB; the keyword NEW in the DISP parameter indicates to the operating system that this DD statement specifies the creation of a library.

Optional Facilities

The linkage editor provides a number of optional facilities that are selected by including the appropriate keywords from the following list in the PARM parameter of the EXEC statement that invokes it:

```
LIST
MAP or XREF
LET or XCAL
NCAL
SIZE
```

Code PARM= followed by the list of options, separating the options with commas and enclosing the list within single quotation marks, for example:

```
//STEPA EXEC PGM=IEWL,PARM='LIST,MAP'
```

If you are using a cataloged procedure, you must include the PARM parameter in the EXEC statement that invokes the procedure and qualify the keyword PARM with the name of the procedure step that invokes the linkage editor, for example:

```
//STEPA EXEC PLIXCLG,PARM.LKED='LIST,XREF'
```

The linkage editor options are of two types:

1. Simple keywords, for example, LIST, that specifies a facility. LET, LIST, MAP, NCAL, XCAL, and XREF are of this type.

```
//LINK     JOB
//STEP1    EXEC PGM=IEWL
//SYSLMOD  DD DSNAME=MODLIB(LKEX),UNIT=2311,VOL=SER=D186
//            SPACE=(CYL,(10,10,1)),DISP=(NEW,KEEP)
//SYSUT1   DD UNIT=SYSDA,SPACE=(1024,(200,20))
//SYSPRINT DD SYSOUT=A
//SYSLIB   DD DSNAME=SYS1.PL1BASE,DISP=OLD
//SYSLIN   DD *
                  .
                  .
                  .
    (insert here the object module to be link-edited)
                  .
                  .
                  .
/*
```

Figure 5.3. Typical job control statements for link editing a PL/I program

2. Keywords that permit you to assign a value to a function (for example, SIZE=10K).

The linkage editor options, in alphabetic order, are as follows.

LET Option

The LET option specifies that the linkage editor is to mark the load module as "executable" even if slight errors or abnormal conditions have been found during link editing provided these do not exceed severity 2.

LIST Option

The LIST option specifies that all linkage editor control statements processed should be listed in the data set defined by the DD statement with the name SYSPRINT.

MAP Option

The MAP option specifies that the linkage editor is to produce a map of the load module showing the relative locations and lengths of all control sections in the load module.

NCAL Option

The NCAL option specifies that no external references are to be resolved by automatic library call. However, the load module is marked "executable" provided that there are no errors.

You can use the NCAL option to conserve auxiliary storage in private libraries, since, by preventing the resolution of external references during link editing, you can store load modules without the relevant library subroutines; the DD statement with the name SYSLIB is not required. Before executing these load modules, you must link edit them again to resolve the external references, but the load module created need exist only while it is being executed. You can use this technique to combine separately compiled PL/I procedures into a single load module.

SIZE Option

The SIZE option specifies the amount of main storage, in bytes, to be allocated to the linkage editor. The format of the SIZE option is:

SIZE=(m[,n])

where "m" is the amount of main storage in bytes or K bytes (where K=1024) to be allocated to the linkage editor; it must include "n" and it must be greater than "n."

and "n" which is optional, is the amount of main storage (in bytes or K bytes) to be allocated to the load module buffer.

The following table gives values for "m" and "n" for the three versions of the F-level linkage editor:

Version	m(minimum)	n (Min)	n (Max)	m-n (Min)
44K	44K	6K	100K	38K
88K	88K	6K	100K	44K
128K	128K	6K	100K	66K

If you specify SIZE incorrectly, or if you omit it, default values set at system generation are used. If you specify SIZE greater than the region or partition size, the maximum amount of main storage will be used.

XCAL Option

The XCAL option specifies that the linkage editor will mark the load module as "executable" even if slight errors or abnormal conditions, including improper branches between control sections, have been found during link editing. XCAL, which implies LET, applies only to an overlay structure.

XREF Option

The XREF option specifies that the linkage editor is to print a map of the load module and a cross-reference list of all the external references in each control section. XREF implies MAP.

Listing Produced by the Linkage Editor

The linkage editor generates a listing, most of which is optional, that contains information about the link-editing process and the load module that it produces. It places this listing in the data set defined by the DD statement with the name SYSPRINT (usually output to a printer). The following description of the listing refers to its appearance on a printed page.

The listing comprises a small amount of standard information that always appears, together with those items of optional information specified in the PARM parameter of the EXEC statement that invokes the linkage editor, or that are applied by default. The optional components of the listing and the corresponding linkage editor options are as shown in figure 5.4.

Listings	Options Required
Control statements processed by the linkage editor	LIST
Map of the load module	MAP or XREF
Cross-reference table	XREF

Figure 5.4. Linkage editor listings and associated options

The first page of the listing is identified by the linkage editor version and level number followed by a list of the linkage editor options used.

The following paragraphs describe the optional components of the listing in the order in which they appear.

An example of the listing produced for a typical PL/I program is given in appendix F.

Diagnostic Messages and Control Statements

The linkage editor generates messages, describing errors or conditions, detected during link editing, that may lead to error. These messages are listed immediately after the heading information on page 1 of the linkage editor listing. They are listed again at the end of the linkage editor listing under the heading "Diagnostic Message Directory" which is described later in this chapter.

If you have specified the option LIST, the names of all control statements processed by the linkage editor are listed immediately preceding the messages, and are identified by the 7-character code IEW0000.

Each message is identified by a similar 7-character code of the form IEWnnnnx, where:

- The first three characters "IEW" identify the message as coming from the linkage editor.
- The next three characters are a 3-digit message number.
- The last character "x" is a severity code whose meaning is as follows:

  0 A condition that will not cause an error during execution. The load module is marked as "executable".

  1 A condition that may cause an error during execution. The load module is marked as "executable".

  2 An error that could make execution impossible. The load module is marked as "not executable" unless you have specified the option LET.

  3 An error that will make execution impossible. The load module is marked as "not executable".

  4 An error that makes recovery impossible. Linkage editor processing is terminated, and no output other than messages is produced.

At the end of the listing, immediately preceding the "Diagnostic Message Directory" (described later in this chapter), the linkage editor places a statement of the disposition of the load module. The disposition statements, with one exception, are self-explanatory; the exception is:

```
****modulename DOES NOT EXIST BUT HAS
BEEN ADDED TO DATA SET
```

This appears when the NAME statement has been used to add a new module to the data set defined by the DD statement with the name SYSLMOD. The use of the NAME statement is described under "Module Name," later in this chapter. If you name a new module by including its name in the DSNAME parameter of the DD statement with the name SYSLMOD, the linkage editor assumes that you want to replace an existing module (even if the data set is new).

DIAGNOSTIC MESSAGE DIRECTORY

When processing of a load module has been completed, the linkage editor lists in full all the messages whose numbers appear in the preceding list. The text of each message, an explanation, and any recommended programmer response, are given in the linkage editor and loader publication.

The warning message IEW0461, together with a return code of 0004, frequently appears in the linkage editor listing for a PL/I program. It refers to external references that have not been resolved because NCAL is specified. The references occur in PL/I library subroutines that are link edited with your program as a result of automatic library call. Some library subroutines may, in turn, call other library subroutines. For those secondary subroutines that are required, the compiler generates another external symbol dictionary containing alternative names for the subroutines. These new references can be resolved, and the required subroutines placed in the new load module. If the secondary subroutines in turn call other subroutines, the process is repeated.

MODULE MAP

The linkage editor listing includes a module map only if you specify the options MAP or XREF. The map lists all the control sections in the load module and all the entry point names in each control section. The control sections are listed in order of appearance in the load module; alongside each control section name is its address relative to the start of the load module (address 0) and its length in bytes. The entry points within the load module appear on the printed listing below and to the right of the control sections in which they are defined; each entry point name is accompanied by its address relative to the start of the load module.

Each control section that is included by automatic library call is indicated by an asterisk. For an overlay structure, the control sections are arranged by segment in the order in which they are specified.

After the control sections, the module map lists the pseudo-registers established by the compiler. Pseudo-registers are fields in a communications area, the task communications area (TCA), used by PL/I library subroutines and compiled code during execution of a PL/I program. The main storage occupied by the TCA is not allocated until the start of execution of a PL/I program; it does not form part of the load module. The addresses given in the list of pseudo-registers are relative to the start of the TCA.

At the end of the module map, the linkage editor supplies the following information:

The total length of the pseudo-registers.

The relative address of the instruction with which execution of the load module will commence (ENTRY ADDRESS).

The total length of the load module. For an overlay structure, the length is that of the longest path.

All the addresses and lengths given in the module map and associated information are in hexadecimal.

CROSS-REFERENCE TABLE

The linkage editor listing includes a "Cross-reference Table" only if you specify the option XREF. This option produces a listing that comprises all the information described under "Module Map," above, together with a cross-reference table of external references. The table gives the location of each reference within the load module, the symbol to which the reference refers, and the name of the control section in which the symbol is defined.

For an overlay structure, a cross-reference table is provided for each segment. It includes the number of the segment in which each symbol is defined.

Unresolved symbols are identified in the cross-reference table by the entries $UNRESOLVED or $NEVER-CALL. An unresolved weak external reference (WXTRN) is identified by the entry $UNRESOLVED(W).

RETURN CODE

For every linkage editor job or job step, the linkage editor generates a return code that indicates to the operating system the degree of success or failure it achieved. This code appears in the "end of step" message and is derived by multiplying the highest severity code (see "Diagnostic Messages and Control Statements," earlier in this chapter) by four, as follows:

Return Code	Meaning
0000	No messages issued; link editing completed without error; successful execution anticipated.
0004	Warning messages only issued; link editing completed; successful execution probable.
0008	Error messages only issued; link editing completed; execution may fail.
0012	Severe error messages issued; link editing may have been completed, but with errors; successful execution improbable.
0016	Unrecoverable error message issued; link editing terminated abnormally; successful execution impossible.

The return code 0004 almost invariably appears after a PL/I program has been link edited because some external references will not have been resolved. (Refer to "Diagnostic Message Directory," earlier in this chapter.)

Additional Processing

Basic processing by the linkage editor produces a single load module from the data that it reads from its primary input, but it has several other facilities that you can call upon by using linkage editor control statements. The use of those statements of particular relevance to a PL/I program is described below. All the linkage editor control statements are fully described in the linkage editor and loader publication.

FORMAT OF CONTROL STATEMENTS

A linkage editor control statement is an 80-byte record that contains two fields. The operation field specifies the operation required of the linkage editor; it must be preceded and followed by at least one blank character. The operand field names the control sections, data sets, or modules that are to be processed, and it may contain symbols to indicate the manner of processing; the field consists of one or more parameters separated by commas. Some control statements may have multiple operand fields separated by commas.

The position of a control statement in the linkage editor input depends on its function.

In the following descriptions of the control statements, items within brackets [] are optional.

MODULE NAME

A load module must have a name so that the linkage editor and the operating system can identify it. A name comprises up to eight characters, the first of which must be alphabetic.

You can name a load module in one of two ways:

1. If you are producing a single load module from a single link-edit job step, it is sufficient to include its name as a member name in the DSNAME parameter of the DD statement with the name SYSLMOD.
2. If you are producing two or more load modules from a single link-edit job step, you will need to use the NAME statement. (The optimizing compiler can supply the NAME statements when you use batch compilation as described in chapter 4.)

The format of the NAME statement is:

```
NAME name[(R)]
```

where "name" is any name of up to seven characters; the first character must be alphabetic. The NAME statement serves two functions:

- It identifies a load module. The name specified will be given to the load module. "(R)", if present, specifies that the load module is to replace an existing load module of the same name in the data set defined by the DD statement with the name SYSLMOD.
- It acts as a delimiter between input for different load modules in one link-edit step.

The NAME statement must appear in the primary input to the linkage editor (the standard data set defined by the DD statement SYSLIN); if it appears elsewhere, the linkage editor ignores it. The statement must follow immediately after the last object module that will form part of

the load module it names (or after the INCLUDE control statement that specifies the last object module).

Alternative Names

You can use the ALIAS statement to give a load module an alternative name; a load module can have as many as sixteen aliases in addition to the name given to it in a DD statement with the name SYSLMOD, or by a NAME statement.

The format of the ALIAS statement is:

```
ALIAS name
```

where "name" is any name of up to eight characters; the first character must be alphabetic. You can include more than one name in an ALIAS statement, separating the names by commas, for example:

```
ALIAS FEE,FIE,FOE,FUM
```

An ALIAS statement can be placed before, between, or after object modules and control statements that are being processed to form a load module, but it must precede the NAME statement that specifies the primary name of the load module.

To execute a load module, you can include an alias instead of the primary name in the PGM parameter of an EXEC statement.

Aliases can be used for external entry points in a PL/I procedure. Hence a CALL statement or a function reference to any of the external entry names will cause the linkage editor to include the module containing the alias entry names without the need to use the INCLUDE statement for this module.

ADDITIONAL INPUT SOURCES

The linkage editor can accept input from sources other than the primary input defined in the DD statement with the name SYSLIN. For example, automatic library call enables the linkage editor to include modules from a data set (a library) defined by the DD statement with the name SYSLIB. You can name these additional input sources by means of the INCLUDE statement, and you can direct the automatic library call mechanism to alternative libraries by means of the LIBRARY statement.

INCLUDE Statement

The INCLUDE statement causes the linkage editor to process the module or modules indicated. After the included modules have been processed, the linkage editor continues with the next item in the primary input. If an included sequential data set also contains an INCLUDE statement, that statement is processed as if it were the last item in the data set, as shown in figure 5.5.

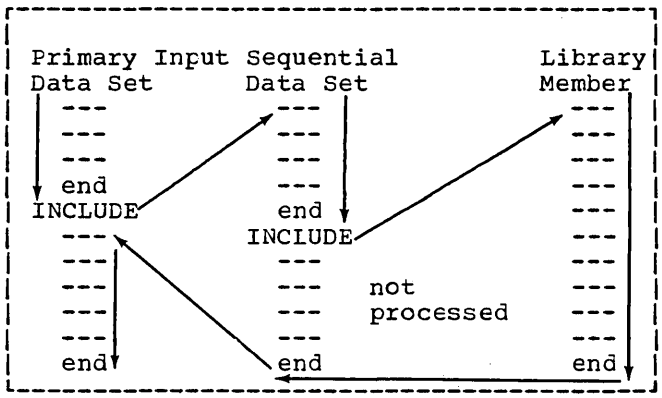


Figure 5.5. Processing of additional data sources

The format of the INCLUDE statement is:

```
INCLUDE ddname[(membername)]
```

where "ddname" is the name of a DD statement that defines either a sequential data set or a library that contains the modules and control statements to be processed. If the DD statement defines a library, replace "membername" with the names of the modules to be processed, separated by commas. You can specify more than one ddname, each of which may be followed by any number of member names in a single INCLUDE statement. For example:

```
INCLUDE D1(MEM1,MEM2),D2(MODA,MODB)
```

specifies the inclusion of the members MEM1 and MEM2 from the library defined by the DD statement with the name D1, and the members MODA and MODB from the library defined by the DD statement with the name D2.

LIBRARY Statement

The basic function of the LIBRARY statement is to name call libraries in addition to those named in the DD statement SYSLIB. The format of the LIBRARY statement is:

LIBRARY ddname(membername)

where "ddname" is the name of a DD statement that defines the additional call library, and "membername" is the name of the module to be examined by the automatic call mechanism. More than one module can be specified; separate the module names with commas.

OVERLAY STRUCTURES

A load module constructed as an overlay structure can be executed in an area of main storage that is not large enough to contain the entire module at one time. The linkage editor divides the load module into segments that can be loaded and executed in turn. To construct an overlay structure, you must use linkage editor control statements to specify the relationship between the segments. One segment, termed the root segment must remain in main storage throughout the execution of the program.

Design the Overlay Structure

Before preparing the linkage editor control statements, you must design the overlay structure for your program. A tree is a graphic representation of an overlay structure that shows which segments occupy main storage at different times. The design of trees is discussed in the linkage editor and loader publication, but for the purposes of this chapter, figure 5.6 contains a simple example. The program comprises six procedures, A, B, C, D, E, and F. Procedure B calls procedure C which, in turn, calls procedures D and E. (Only procedure A requires the option MAIN.)

The main procedure (A) must be in main storage throughout the execution of the program. Since the execution of procedure B will be completed before procedure F is called, the two procedures can occupy the same storage; this is depicted by the lines representing the two procedures in figure 5.6 starting from the common point (node) X. Procedure B must remain in storage while procedures C, D, and E are executed, but procedures D and E can occupy the same storage; thus the lines representing procedures D and E start from the node X.

The degree of segmentation that can be achieved can be clearly seen from the figure. Since procedure A must always be present, it must be included in the root segment. Procedures F, D and E can usefully be placed in individual segments, as can procedures B and C be placed together; there is nothing to be gained by separating procedures B and C, since they must be present together at some time during execution.

Control Statements

Two linkage editor control statements, OVERLAY and INSERT, control the relationship of the segments in the overlay structure. The OVERLAY statement specifies the start of a segment and the INSERT statement specifies the positions of control sections in a segment. You must include the attribute OVLY in the PARM parameter of the EXEC statement that invokes the linkage editor, otherwise the linkage editor will ignore the control statements.

The format of the OVERLAY statement is:

OVERLAY symbol

where "symbol" is the node at which the segment starts (for example, X in figure 5.6). You must specify the start of every segment, except the root segment, in an OVERLAY statement.

The format of the INSERT statement is:

INSERT control-section-name

where "control-section-name" is the name of the control section (that is, procedure) that is to be placed in the segment. More than one control section can be specified, separate the names with commas. The INSERT statements that name the control sections in the root segment must precede the first OVERLAY statement.

Creating an Overlay Structure

The most efficient method of defining an overlay structure, and the simplest for a PL/I program, is to group all the OVERLAY and INSERT statements together and place them in the linkage editor input (SYSLIN) after the object modules that form the program. The linkage editor initially places all these object modules in the root segment, and then moves those control sections that are referred to in INSERT statements into other segments.

This method has the advantage that you can use batched compilation to process all

```
A: PROC OPTIONS(MAIN);
     .
     CALL B;
     .
     CALL F;
     .
     END A;
```

```
B: PROC;
     .
     CALL C;
     .
     END B;
```

```
C: PROC;
     .
     CALL D;
     .
     CALL E;
     .
     END C;
```

```
D: PROC;
     .
     .
     END D;
```

```
E: PROC;
     .
     .
     END E;
```

```
F: PROC;
     .
     .
     END F;
```

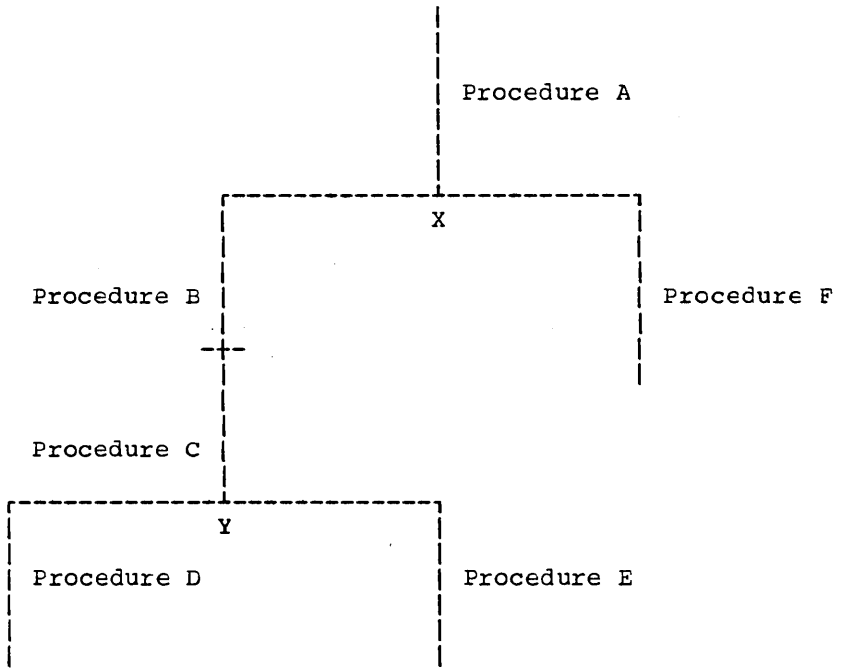


Figure 5.6. Overlay structure and its tree

the procedures in one job step and place the object modules in a temporary data set; this data set must have consecutive organization. You can then place the linkage editor control statements in the input stream, concatenating them with the data set that contains the object modules. (Do not use the NAME compiler option to name the object modules; if you do, the NAME statements inserted by the compiler will cause the linkage editor to attempt to create separate load modules rather than a single overlay structure.)

The use of the IBM-supplied catalcged procedure PLIXCLG tc create and execute the overlay structure of figure 5.6, is shcwn in figure 5.7.

An alternative approach instead of batched compilaticn is to compile the procedures independently and store them as object modules in a private library. You can then use an INCLUDE statement tc place them in the input to the linkage editor (SYSLIN).

```
//OPT5#7      JOB
//STEP1       EXEC PLIXCLG,
              PARM.LKED='OVLY'
//PLI.SYSIN   DD *

  (insert here source statements for
  procedure A)

 * PROCESS;

  (insert here source statements for
  procedure B)

 * PROCESS;

  (insert here source statements for
  procedure C)

 * PROCESS;

  (insert here source statements for
  procedure D)

 * PROCESS;

  (insert here source statements for
  procedure E)

 * PROCESS;

  (insert here source statements for
  procedure F)

 /*
 //LKED.SYSIN DD *
    OVERLAY X
    INSERT B,C
    OVERLAY Y
    INSERT D
    OVERLAY Y
    INSERT E
    OVERLAY X
    INSERT F
 /*
```

Figure 5.7. Creating and executing the overlay structure of figure 5.6

If an INSERT statement contains the name of an external procedure, the linkage editor will move only the related program control section that has the same name. All other control sections established by the compiler, and all the PL/I library subroutines, will remain in the root segment.

It is important that the PL/I library subroutines be in the root segment, since the optimizing compiler does not support exclusive calls (calls between segments that do not lie in the same path). For example, in figure 5.6, procedures in the segment containing D could call procedures in the segments containing A, B, C, and D, but not in the segments containing E or F. Procedures in the segments containing B or C could call procedures in the segments containing A, B, C, D, and E, but not in the segment containing F. A procedure in the segment containing B may not call a procedure in the segment containing A if this latter procedure calls a procedure in the segment containing F.

However, certain library subroutines may not be required by all segments, in which case you can move them into a lower segment. To do this, compile the procedures using the compiler option ESD, and examine the resulting external symbol dictionary. For example, if in figure 5.6 a library subroutine is called only by the segment containing E, you can move it into that segment by placing an INSERT statement, specifying the subroutine name, immediately after the statement INSERT E.

Similarly, you can move control sections from the root segment to lower segments. For example, to move the static internal control section for procedure F into the segment containing F, place the statement INSERT ******FA after the statement INSERT F. Values assigned to static data items are not retained when a segment is overlaid. Do not move static data from the root segment unless it comprises only:

- Values set by the INITIAL attribute and then unchanged (that is, read-only data).
- Values that need not be retained between different loadings of the segment.

LINK EDITING FETCHABLE LOAD MODULES

The PL/I FETCH and RELEASE statements permit the dynamic loading of separate load modules which can be subsequently invoked from the PL/I object program.

Fetchable (or dynamically-loaded) modules should be link edited into a load module library which is subsequently made available for the job step by means of a JOBLIB or STEPLIB DD statement. When link editing a fetchable module into a load module library, specify the linkage editor option LET and supply a linkage editor ENTRY statement that defines the initial point to the fetched module. This entry point will be an entry constant associated with a PROCEDURE or ENTRY statement in a PL/I procedure, or the equivalent in COBOL, FORTRAN, or assembler-language routines.

The name or any alias by which the fetchable load module is identified in the load module library must appear in a FETCH

or RELEASE statement within the scope of the invoking procedure.

Loader

The loader is an operating system processing program that produces and executes load modules. It always stores the load modules directly in main storage where they are executed immediately.

The input to the loader can include single object modules or load modules, several object modules or load modules, or a mixture of both. The output from the loader always comprises an executable program that is loaded into main storage from where it will be executed.

Unlike the linkage editor you cannot use any control statements with the loader. If any linkage editor control statements are used, they will be ignored, and their presence in the input stream will not be treated as an error. Your job will continue to be processed, a message will be generated and, if you have included a DD statement with the name SYSLOUT, this message and the name of the control statement will be printed on your listing.

The loader compensates for the absence of the facilities provided by control statements by allowing the concatenation of both object and load modules in the data set defined by the DD statement with the name SYSLIN, and by allowing an entry point to be specified by means of the EP option, as described in "Optional Facilities," later in this chapter.

LOADER PROCESSING

A PL/I program cannot be executed until the appropriate PL/I library subroutines have been included. All library subroutines are included during loading. In basic processing, as shown in figure 5.8, the loader accepts data from its primary input source, a data set defined by the DD statement with the name SYSLIN. For a PL/I program, this data is the object module produced by the compiler. The loader uses the external symbol dictionary in this object module to determine whether the module includes any external references for which there are no corresponding external symbols in the module: it attempts to resolve such references by a method termed automatic library call as described in "Linkage Editor Processing," earlier in this chapter.

The loader locates the subroutines in which the external symbols are defined (if such subroutines exist) and includes them in the load module. If all external references are resolved satisfactorily the load module is executed.

The loader will always search the link-pack area before searching the PL/I resident library, as shown in figure 5.9. The link-pack area is an area of main

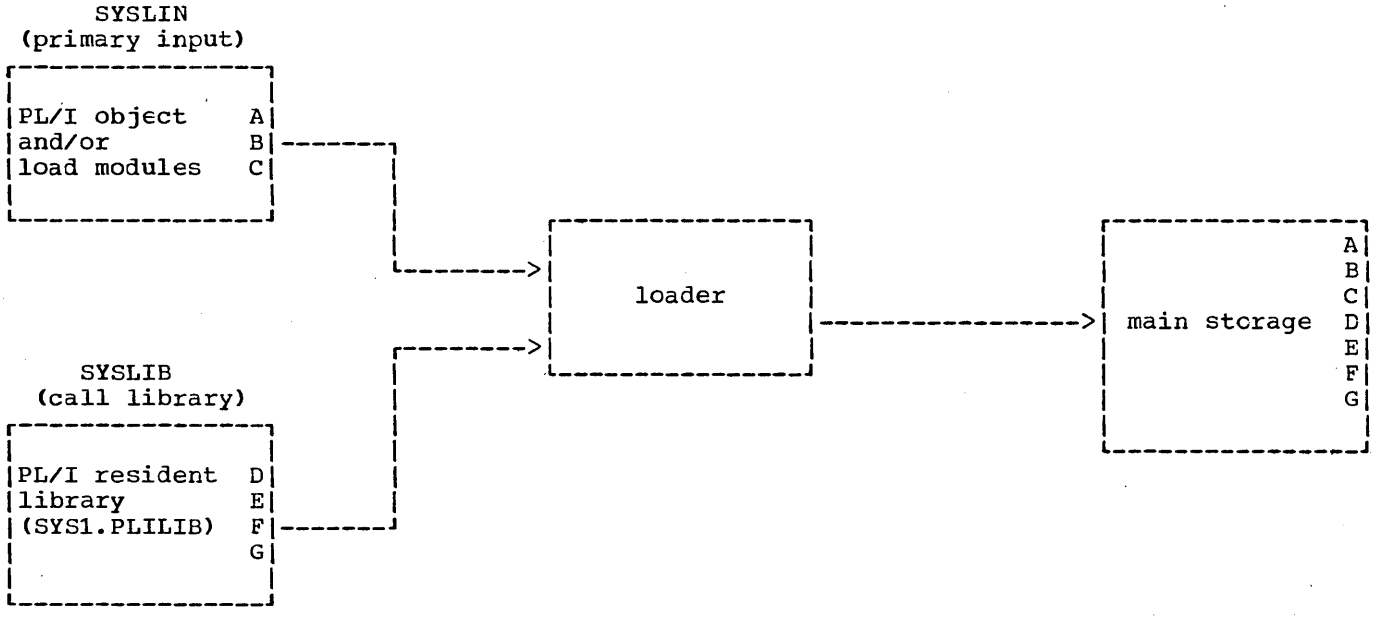


Figure 5.8. Basic loader processing

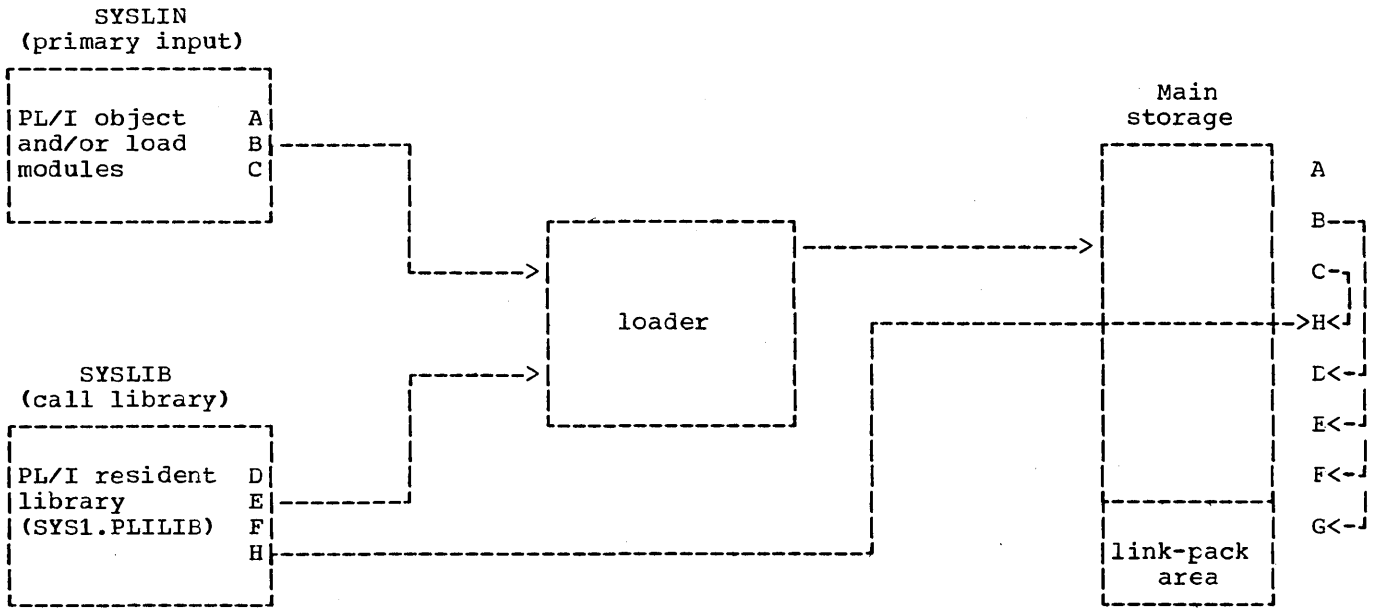


Figure 5.9. Loader processing, link-pack area and SYSLIB resolution

storage in which frequently used load modules are stored permanently. If there is more than one copy of an object module in the data set defined by the DD statement with the name SYSLIN, the loader will load the first and ignore the rest.

Main Storage Requirements

The minimum main storage requirements for the loader are shown in the following table:

Storage required for:	Amount (min) in bytes
Loader program	10K
Data management access routines	4K
Buffers and tables used by loader	3K
PL/I program to be executed	variable

This amounts to at least 17K bytes for the loader and its associated routines and data areas plus the main storage required for the program that is to be executed. If the loader program and the data management access routines were stored in the link-pack area, the amount of main storage required would be 3K bytes for the loader data area plus that required by the program that is to be executed.

Job Control Language for the Loader

Although you will probably use cataloged procedures rather than supply all the job control language (JCL) required for a job step that invokes the loader, you should be familiar with these JCL statements so that you can make the best use of the loader and, if necessary, override statements of the cataloged procedures.

The IBM-supplied cataloged procedures that include a loader procedure step are as follows:

```
PLIXCG    Compile, load-and-execute

PLIXG     Load-and-execute
```

The following paragraphs describe the essential JCL statements for the loader. The IBM-supplied cataloged procedures are described in chapter 10 and include examples of these statements.

EXEC STATEMENT

The name of the loader is IEWLDRGO. It also has the alias LOADER, which is used in the IBM-supplied cataloged procedures, and will be used to refer to the loader program in the rest of this chapter. The basic EXEC statement is:

```
//stepname  EXEC PGM=LOADER
```

ddname	Contents of Data Set	Possible Device Classes[1]
SYSLIN	Primary input (normally the output from the compiler)	SYSSQ or the input job stream (specified by DD *)
SYSLOUT	Loader messages and module map listing	SYSSQ, SYSDA, or SYSOUT=A
SYSPRINT	PL/I execution-time messages and problem output listing	SYSSQ, SYSDA, or SYSOUT=A
SYSLIB	Automatic call library	SYSDA

[1] SYSSQ — Magnetic tape or direct-access device
SYSDA — Direct-access device
SYSOUT=A — Normal printed output class for system output

Figure 5.10. Loader standard data sets

By using the PARM parameter of the EXEC statement, you can select one or more of the optional facilities provided by the loader; these are described under "Optional Facilities," later in this chapter.

DD STATEMENTS FOR THE STANDARD DATA SETS

The loader always requires one standard data set; that defined by the DD statement with the name SYSLIN. Three other standard data sets are optional and if you use them you must define them in DD statements with the names SYSLOUT, SYSPRINT, and SYSLIB. The four data sets, their names, and other characteristics of the data sets, are shown in figure 5.10.

The data sets defined by the DD statements with the names SYSLIN, SYSLIB, and SYSLOUT are those specified at system generation for your installation. Other ddnames may have been specified at your installation; if they have, your JCL statements must use them in place of those given above. In a similar manner the IBM-supplied cataloged procedures PLIXCG and PLIXG use names as shown above; your systems programmer will have to modify these procedures if the names at your installation are different.

Primary Input (SYSLIN)

Primary input to the loader must be a standard data set defined by a DD statement with the name SYSLIN; this data set must have consecutive organization. The input can comprise one or more object modules, one or more load modules, or a mixture of object modules and load modules.

For a PL/I program the primary input is usually a data set containing an object module produced by the compiler. This data set may be on magnetic tape or on a direct-access device, or you can include it in the input job stream. In all cases the input must be in the form of 80-byte F-format records.

The IBM-supplied cataloged procedure PLIXCG includes the DD statement:

```
//SYSLIN DD DSN=&&LOADSET,DISP=(OLD,DELETE)
```

which specifies that the data set &&LOADSET is temporary. If you want to modify this statement you must refer to it by the qualified ddname GO.SYSLIN.

The IBM-supplied cataloged procedure PLIXG does not include a DD statement for the input data set; you must always supply one, specifying the characteristics of your input data set using the qualified ddname GO.SYSLIN.

Automatic Call Library (SYSLIB)

Unless you specify otherwise, the loader will normally attempt to resolve external references by automatic library call. The automatic call library (SYSLIB), and how to specify it, is described in the linkage editor section earlier in this chapter.

Listing (SYSLOUT)

The loader generates a listing that includes a module map (if you have specified the MAP option) and, if errors have been detected during processing,

messages referring to these. The information that may appear is described in "Listing Produced by the Loader," later in this chapter.

You must define the data set in which you want this listing to be stored by a DD statement with the name SYSLOUT and it must have consecutive organization. Although the listing is usually printed it can be stored on any magnetic-tape or direct-access device. For printed output the following DD statement will suffice:

```
//SYSLOUT DD SYSOUT=A
```

Listing (SYSPRINT)

As well as the information listed in the data set defined by the DD statement with the name SYSLOUT certain information produced by the loader is always stored in the data set defined by the DD statement with the name SYSPRINT. This data set, which must have consecutive organization, holds messages that refer to errors that have occurred during execution of your program, as well as the results produced by your program. The information that may appear is described in "Listing Produced by the Loader," later in this chapter. For printed output the following DD statement will suffice:

```
//SYSPRINT DD SYSOUT=A
```

EXAMPLES OF LOADER JCL

A sequence of job control language for the loader is shown in figure 5.11. A PL/I program has been compiled in a job step with the step name PLI; the resultant object module has been placed in the data set defined by the DD statement with the name SYSLIN. Because this module is to be loaded and executed in the same job as the compile step, this DD statement can use the backward reference, indicated by the asterisk, as shown. If the compile and load-and-go steps were in different jobs, the DD statement would have to specify a permanent data set, cataloged or uncataloged.

The IBM-supplied cataloged procedure PLIXCG includes a DD statement with the name SYSLIN in both the compile and load-and-go procedure steps; you do not need to specify this statement unless you want to modify it. The IBM-supplied cataloged procedure PLIXG does not include a DD statement with the name SYSLIN; you must supply one, using the qualified name GO.SYSLIN.

Typical job control language statements for the loader are shown in figure 5.12. The example illustrates how to include, in the input stream, both an object module for input to the loader, and data to be used by your program during execution.

The DD statement with the name SYSLIN and the two following unnamed DD statements define three data sets that are to be concatenated into one data set to be used as input to the loader. The first data set is named OBJMOD and contains an object module. This data set could be the output of the optimizing compiler that has just processed your PL/I program. The second data set is named MODLIB(MOD55) containing a load module that has been given the name MOD55 and stored in the library called MODLIB. The third data set is an object module defined by the DD statement with the name IN. This DD statement appears further on and has the asterisk notation that indicates that the data set defined by this statement follows in the input stream.

```
//LOAD      JOB
            .
            .
            .
//STEP1     EXEC PGM=LOADER
//SYSLIN    DD DSN=*.PLI.SYSLIN,DISP=(OLD,DELETE)
//SYSLIB    DD DSN=SYS1.PLILIB,DISP=SHR
//SYSLOUT   DD SYSOUT=A
//SYSPRINT  DD SYSOUT=A
```

Figure 5.11. Job control language for load-and-go

```
//LOAD      JOB
            .
            .
            .
//STEP1     EXEC PGM=LOADER
//SYSLIN    DD DSN=OBJECT,UNIT=SYSSQ,VOL=SER=30104,DISP=(OLD,KEEP)
//          DD DSN=MODLIB(MOD55),DISP=SHR
//          DD DDNAME=IN
//SYSLIB    DD DSN=SYS1.PLILIB,DISP=SHR
//          DD DSN=PRIVLIB,DISP=SHR
//SYSLOUT   DD SYSOUT=A
//SYSPRINT  DD SYSOUT=A
//IN        DD *
            .
            .
            .
    (insert here the object module to be loaded)
            .
            .
            .
/*
//SYSIN     DD *
            .
            .
            .
    (insert here the execution data, if any)
            .
            .
            .
/*
```

Figure 5.12. Object and load modules in load-and-go

The DD statement with the name SYSLIB and the unnamed DD statement immediately following it define two data sets that are to be concatenated so that they can be searched for unresolved external references by automatic library call. The first data set is the PL/I resident library (SYS1.PLILIB) and the second is a private library called PRIVLIB.

Optional Facilities of the Loader

The loader provides a number of optional facilities that are selected by including the appropriate keywords from the following list in the PARM parameter of the EXEC statement that invokes it:

```
CALL
EP
LET
MAP
PRINT
RES
SIZE
```

Code the PARM parameter as follows:

```
PARM = '[optionlist][/pgmparm]'
```

where "option list" is a list of loader options, and "pgmparm" is a parameter to be passed to the main procedure of the PL/I program to be executed. In the examples given below, the program parameter is referred to as PP.

If both loader options and a program parameter occur in the PARM parameter, the loader options are given first and are separated from the program parameter by a slash. If there are loader options but no program parameter, the slash is omitted, but if there are only program parameters the slash must be coded. If there is more than one option, the option keywords are separated by commas.

The PARM field can have one of three formats:

1. If the special characters / or = are used, the field must be enclosed in single quotes, for example:

```
PARM='MAP,EP=FIRST/PP'
    ='MAP,EP=FIRST'
PARM='/PP'
```

2. If these characters are not included, and there is more than one loader option, the options must be enclosed in parentheses, for example:

PARM=(MAP,LET)

3. If these characters are not included, and there is only one loader option, neither quotes nor parentheses are required, for example:

   PARM=MAP

To overwrite the PARM parameter options specified in a cataloged procedure, you must refer to the PARM parameter by the qualified name PARM.procstepname, for example: PARM.GO.

The loader options are of two types:

1. Simple pairs of keywords: a positive form (for example, CALL) that requests a facility, and an alternative negative form (for example NOCALL) that rejects that facility. CALL, LET, MAP, PRINT, and RES are of this type.

2. Keywords that permit you to assign a value to a function (for example, SIZE=10K). EP and SIZE are of this type.

The loader options, in alphabetic order, are as follows.

CALL Option

The CALL option specifies that the loader will attempt to resolve external references by automatic library call. To preserve compatibility with the linkage editor, the negative form of this option can be specified as NCAL as well as by NOCALL.

EP Option

The EP option specifies the entry point name of the program that is to be executed. The format of the EP option is:

EP=name

where "name" is an external name. If all input modules are load modules you must specify EP=PLISTART.

LET Option

The LET option specifies that the loader will try to execute the problem program even if a severity 2 error has been found.

MAP Option

The MAP option specifies that the loader is to print a map of the load module giving the relative locations and lengths of control sections in the module. You must specify the data set defined by the DD statement with the name SYSLOUT to have this map printed. The module map is described in "Listing Produced by the Loader," later in this chapter.

PRINT Option

The PRINT option specifies that the data set defined by the DD statement with the name SYSLOUT is to be used for messages, the module map, and other loader information.

RES Option

The RES option specifies that the loader will attempt to resolve external references by a search of the link-pack area of main storage. This search will be made after the primary input to the loader has been processed but before the data set defined by the DD statement with the name SYSLIB is opened.

SIZE Option

The SIZE option specifies the amount of main storage, in bytes, to be allocated to the loader. The format of the SIZE option is:

SIZE=yyyyyy specifies that yyyyyy bytes of main storage are to be allocated to the loader.

SIZE=yyyK specifies that yyyK bytes of main storage are to be allocated to the loader (1K=1024).

The values can be enclosed, optionally, in parentheses.

Listing Produced by the Loader

The loader can provide a listing on the SYSLOUT data set; the SYSPRINT data set is used by the problem program. The contents of each is:

Data set	Contents
SYSLOUT	Loader explanatory messages and diagnostic messages, and optionally, a module map.
SYSPRINT	PL/I execution-time messages, and problem program output.

The SYSLOUT listing is described here; the SYSPRINT listing is described in chapter 4.

The items in the SYSLOUT listing appear in the following sequence.

1. Statement identifying the loader.
2. Module map (if specified).
3. Explanatory, error, or warning messages.
4. Diagnostic messages.

MODULE MAP

If the MAP option is specified, a module map is printed in the SYSLOUT listing. The map lists all the control sections in the load module and all the entry point names (other than the first) in each control section. The information for each reference is:

1. The control section or entry point name.
2. An asterisk, if the control section is included by automatic library call.
3. An identifier, as follows:

   SD Section definition: the name of the control section.

   LR Label reference: identifying an entry point in the control section other than the primary entry point.

   CM Common area: an external file, or a non-string element variable declared STATIC EXTERNAL without the INITIAL attribute.

4. Absolute address of the control section or entry point.

Each reference is printed left to right across the page and starts at a preset position. This gives the impression that the references are arranged in columns, but the correct way to read the map is line by line, across the page, not down each column.

The module map is followed by a similar listing of the pseudo-registers. The identifier used here is PR, and the address is the offset from the beginning of the pseudo-register vector (PRV). The total length of the PRV is given at the end.

The total length of the module to be executed, and the absolute address of its primary entry point, are given after the explanatory messages and before the diagnostic messages.

EXPLANATORY AND DIAGNOSTIC MESSAGES

The loader generates messages describing errors or conditions, detected during processing by the loader, that may lead to error. The format of these messages is given in "Diagnostic Messages and Control Statements" in the linkage editor section earlier in this chapter.

When the module to be executed has been processed, the loader prints out in full all the messages referred to above. The text of each message, an explanation, and any recommended programmer response, are given in the linkage editor and loader publication.

The warning message IEW1001 almost always appears in the listing. The explanation for this is the same as that for IEW0461, described under "Diagnostic Message Directory," in the linkage editor section earlier in this chapter.

Chapter 6: Data Sets and Files

This chapter describes briefly the nature and organization of data sets, the data management services provided by the operating system, and the record formats acceptable for auxiliary storage devices. The way in which a data set is associated with a PL/I file is fully described in the language reference manual for this compiler. Methods of creating and accessing data sets in PL/I are given in chapters 7 and 8.

Data Sets

In IBM System/360 Operating System, a data set is any collection of data that can be created by a program and accessed by the same or another program. A data set may be a deck of punched cards; it may be a series of items recorded on magnetic tape or paper tape; or it may be recorded on a direct-access device such as a magnetic disk or drum. A printed listing produced by a program is a data set, but it cannot be accessed by a program.

A data set resides on one or more volumes. A volume is a standard physical unit of auxiliary storage (for example, a reel of magnetic tape or a disk pack) that can be written on or read by an input/output device; a serial number identifies each volume (other than a punched-card or paper-tape volume or a magnetic-tape volume either without labels or with nonstandard labels).

A magnetic-tape or direct-access volume can contain more than one data set; conversely, a single data set can span two or more magnetic-tape or direct-access volumes.

DATA SET NAMES

A data set on a direct-access device must have a name so that the operating system can refer to it. If you do not supply a name, the operating system will supply a temporary one. A data set on a magnetic-tape device must have a name if the tape has standard labels (see "Labels," later in this chapter.) A name consists of up to eight characters, the first of which must be alphabetic. Data sets on punched cards, paper tape, unlabeled magnetic tape, or nonstandard unlabeled magnetic tape do not have names.

You can place the name of a data set, with information identifying the volume on which it resides, in a catalog that exists on the volume containing the operating system. Such a data set is termed a cataloged data set. To catalog a data set use the CATLG subparameter of the DISP parameter of the DD statement. To retrieve a cataloged data set, you do not need to give the volume serial number or identify the type of device; you need only specify the name of the data set and its disposition. The operating system searches the catalog for information associated with the name and uses this information to request the operator to mount the volume containing your data set.

If you have a set of related data sets, you can increase the efficiency of the search for a particular data set by establishing a hierarchy of indexes in the catalog. For example, consider an installation that groups its data sets under four headings: ENGRNG, SCIENCE, ACCNTS, and INVNTRY, as shown in figure 6.1. In turn, each of these groups is subdivided; for example, the SCIENCE group has subgroups called PHYSICS, CHEM, MATH, and BIOLOGY. The MATH subgroup itself contains three subgroups: ALGEBRA, CALCULUS, and BOOL.

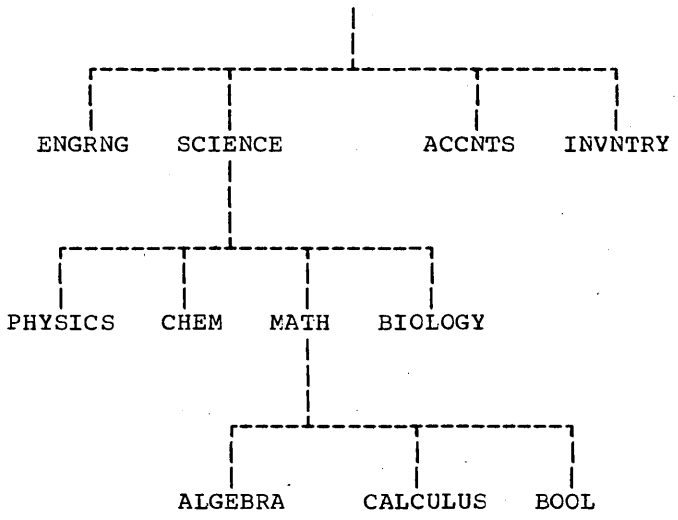


Figure 6.1. A hierarchy of indexes

To find the data set BOOL, the names of all the indexes of which it is part must be specified, beginning with the largest group

SCIENCE, followed by the subgroup name MATH and finally the data set name BOOL. The names are separated by periods. The complete identification needed to find the data set BOOL is

```
SCIENCE.MATH.BOOL
```

such an identifier is termed a qualified name. The maximum length of a qualified name is 44 characters, including the separating periods; each component name has a maximum length of eight characters. (Do not use names that begin with the letters SYS; if the name is qualified do not use P as the nineteenth character. The names assigned by the operating system to unnamed temporary data sets are of this form, with P as the nineteenth character, and these data sets are deleted when the utility program IEHPROGM is used with a SCRATCH statement that includes the keywords VTOC and SYS.)

Some data sets are updated periodically, or are logically part of a group of data sets, each of which is related to the other in time. You can relate such data sets to each other in what is termed a generation data group. Each data set in a generation data group has the same name qualified by a unique parenthesized generation number (for example, STOCK(0), STOCK(-1), STOCK(-2)). The most recently cataloged data set is generation 0, and the preceding generations are -1, -2, and so on. You specify the number of generations to be saved when you establish the generation data group.

For example, consider a generation data group that contains a series of data sets used for weather reporting and forecasting; the name of the data sets is WEATHER. The generations for the group (assuming that three generations are to be saved) are:

```
WEATHER(0)
WEATHER(-1)
WEATHER(-2)
```

When WEATHER is updated, the new data set is specified to the operating system as WEATHER(+1). When it catalogs the new data set, the operating system changes the name to WEATHER(0), changes the former WEATHER(0) to WEATHER(-1), the former WEATHER(-1) to WEATHER(-2), and deletes the former WEATHER(-2).

To find out how to create a generation data group, refer to the job control language and utilities publications.

BLOCKS AND RECORDS

The items of data in a data set are arranged in blocks separated by interblock gaps (IBG)[1].

A block is the unit of data transmitted to and from a data set. Each block contains one record, part of a record, or several records. A block could also contain a prefix field of up to 99 bytes in length depending on the code (ASCII or EBCDIC) in which the data is recorded. These codes are discussed in "Data Codes," below. Specify the block size in the BLKSIZE parameter of the DD statement or in the BLKSIZE option of the ENVIRONMENT attribute.

A record is the unit of data transmitted to and from a program. When writing a PL/I program, you need consider only the records that you are reading or writing; but when you describe the data sets that your program will create or access, you must be aware of the relationship between blocks and records.

If a block contains two or more records, the records are said to be blocked. Blocking conserves storage space in a volume because it reduces the number of input/output operations required to process a data set. Records are blocked and deblocked automatically by the data management routines.

Data Codes: The normal code in which data is recorded in System/360 is the Extended Binary Coded Decimal Interchange Code (EBCDIC) although source input can optionally be coded in BCD (Binary Coded Decimal). However, for magnetic tape only, System/360 will accept data recorded in the American Standard Code for Information Interchange (ASCII). Use the ASCII and BUFOFF options of the ENVIRONMENT attribute if you are reading or writing data sets recorded in ASCII.

A prefix field up to 99 bytes in length may be present at the beginning of each block in an ASCII data set. The use of this field is controlled by the BUFOFF option. For a full description of the options used for ASCII data sets see the language reference manual for this compiler.

---

[1] Although the term "interrecord gap" is widely used in operating system manuals, it is not used here; it has been replaced by the more accurate term "interblock gap."

RECORD FORMATS

The records in a data set must have one of the following formats:

F fixed length

V variable length (D- or V-format)

U undefined length

All formats can be blocked if required, but only fixed- and variable-length records are deblocked automatically by the system; undefined length records must be deblocked by your program.

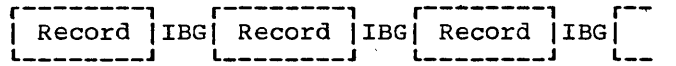
Fixed-length Records (F-format Records)

You can specify the following formats for fixed-length records:

F	Fixed-length, unblocked
FB	Fixed-length, blocked
FS	Fixed-length, unblocked, standard
FBS	Fixed-length, blocked, standard

In a data set with fixed-length records, as shown in figure 6.2, all records have the same length. If the records are blocked, each block contains an equal number of fixed-length records (although the last block may be truncated if there are insufficient records to fill it). If the records are unblocked, each record constitutes a block.

Unblocked records (F-format):



Blocked records (FB-format):

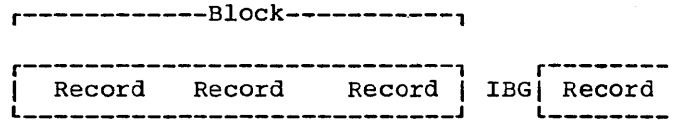


Figure 6.2. Fixed-length records

Because it can base blocking and deblocking on a constant record length, the operating system can process fixed-length records faster than variable-length records. The use of "standard" (FS-format and FBS-format) records further optimizes the sequential processing of a data set on a direct-access device. A standard format data set must contain fixed-length records and must have no embedded empty tracks or short blocks (apart from the last block). With a standard format data set, the operating system can predict whether the next block of data will be on a new track and, if necessary, can select a new read/write head in anticipation of the transmission of that block. A PL/I program never places embedded short blocks in a data set with fixed-length records. A data set containing fixed-length records can be processed as a standard data set even if it is not created as such, providing it contains no embedded short blocks or empty tracks.

Variable-length Records (D- or V-format Records)

You can specify the following formats for variable-length records:

V	Variable-length, unblocked
VB	Variable-length, blocked
VS	Variable-length, unblocked, spanned
VBS	Variable-length, blocked, spanned
D	Variable-length, unblocked, ASCII
DB	Variable-length, blocked, ASCII

V-format permits both variable-length records and variable-length blocks. The first four bytes of each record and of each block contain control information for use by the operating system (including the length in bytes of the record or block). Because of these control fields, variable-length records cannot be read backwards. Illustrations of variable-length records are shown in figure 6.3.

V-format signifies unblocked variable-length records. Each record is treated as a block containing only one record, the first four bytes of the block contain block control information, and the next four contain record control information.

VB-format signifies blocked variable-length records. Each block contains as many complete records as it can accommodate. The first four bytes of the block contain block control information, and the first four bytes of each record contain record control information.

Spanned Records: A spanned record is a variable-length record in which the length of the record can exceed the size of a block. If this occurs, the record is divided into segments and accommodated in two or more consecutive blocks by specifying the record format as either VS or VBS. Segmentation and reassembly are handled automatically. The use of spanned records allows you to select a block size,

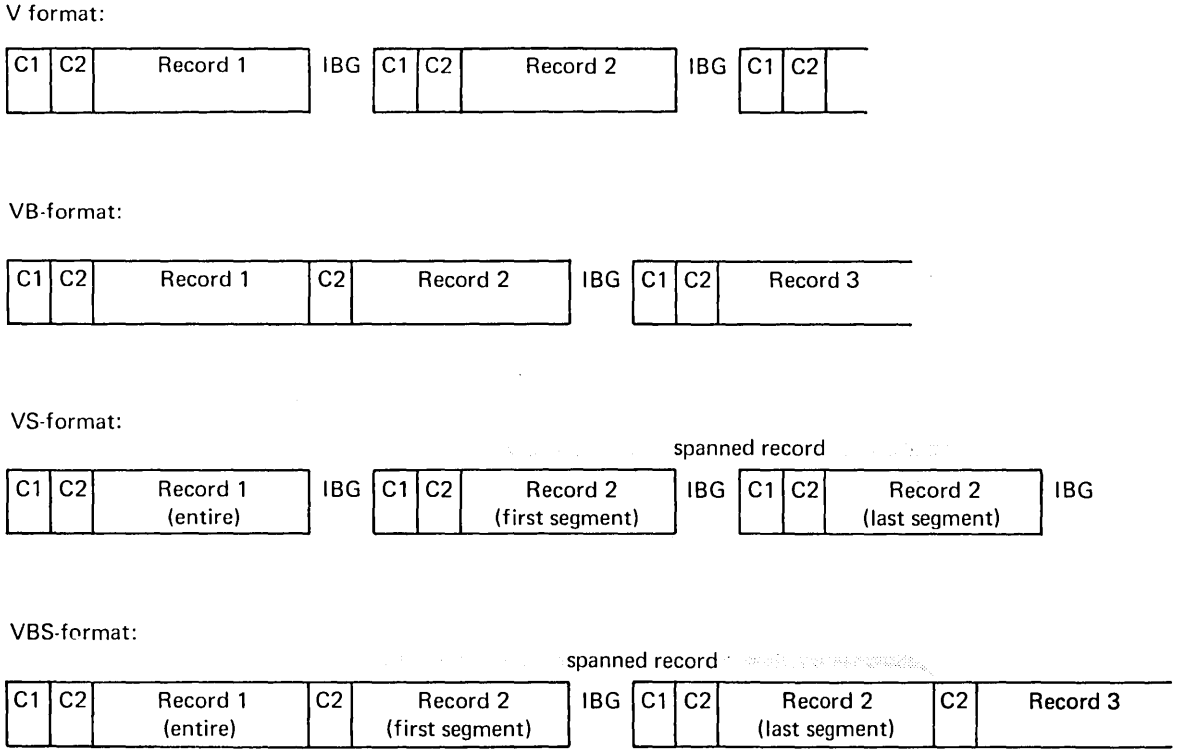


Figure 6.3. Variable-length records

independently of record length, that will combine optimum use of auxiliary storage with maximum efficiency of transmission.

VS-format is similar to V-format. Each block contains only one record or segment of a record. The first four bytes of the block contain block control information, and the next four contain record or segment control information (including an indication of whether the record is complete or is a first, intermediate, or last segment).

With REGIONAL(3) organization, the use of VS-format removes the limitations on block size imposed by the physical characteristics of the direct-access device. If the record length exceeds the size of a track, or if there is no room left on the current track for the record, the record will be spanned over one or more tracks.

VBS-format differs from VS-format in that each block contains as many complete records or segments as it can accommodate; each block is, therefore, approximately the same size (although there can be a variation of up to four bytes, since each segment must contain at least one byte of data).

ASCII Records: For data sets that are recorded in ASCII use D-format as follows:

D-format records are similar to V-format except that the data they contain is recorded in ASCII.

DB-format records are similar to VB-format except that the data they contain is recorded in ASCII.

Undefined-length Records (U-format Records)

U-format permits the processing of records that do not conform to F- and V-formats. The operating system and the compiler treat each block as a record; your program must perform any required blocking or deblocking.

DATA SET ORGANIZATION

The data management routines of the operating system can handle five types of data set, which differ in the way data is stored within them and in the permitted means of access to the data. The three main types of data set and the corresponding keywords describing their PL/I organization[1] are as follows:

Type of Data Set	PL/I Organization
Sequential	CONSECUTIVE
Indexed sequential	INDEXED
Direct	REGIONAL

The fourth type, teleprocessing, is recognized by the compiler by the file attribute TRANSIENT.

The fifth type, partitioned, has no corresponding PL/I organization.

In a sequential (or CONSECUTIVE) data set, records are placed in physical sequence. Given one record, the location of the next record is determined by its physical position in the data set. Sequential organization is used for all magnetic tapes, and may be selected for direct-access devices. Paper tape, punched cards, and printed output are sequentially organized.

An indexed sequential (or INDEXED) data set must reside on a direct-access volume. Records are arranged in collating sequence, according to a key that is associated with every record. An index or set of indexes maintained by the operating system gives the location of certain principal records. This permits direct retrieval, replacement, addition, and deletion of records, as well as sequential processing.

---

[1] Do not confuse the terms "sequential" and "direct" with the PL/I file attributes SEQUENTIAL and DIRECT. The attributes refer to how the file is to be processed, and not to the way the corresponding data set is organized.

A direct (or REGIONAL) data set must reside on a direct-access volume. The records within the data set can be organized in three ways: REGIONAL(1), REGIONAL(2), and REGIONAL(3); in each case, the data set is divided into regions, each of which contains one or more records. A key that specifies the region number and, for REGIONAL(2) and REGIONAL(3), identifies the record, permits direct access to any record; sequential processing is also possible.

A teleprocessing data set (associated with a TRANSIENT file in a PL/I program) must reside in main storage. Records are placed in physical sequence; a key embedded in the record provides direct access to any record.

In a partitioned data set, independent groups of sequentially organized data, each called a member, reside on a direct-access volume. The data set includes a directory that lists the location of each member. Partitioned data sets are often called libraries. The compiler includes no special facilities for creating and accessing partitioned data sets; however, this is not necessary since each member can be processed as a CONSECUTIVE data set by a PL/I program, and there is ready access to the operating system facilities for partitioned data sets through job control language. The use of partitioned data sets as libraries is described in chapter 9.

LABELS

The operating system uses labels tc identify magnetic-tape and direct-access volumes and the data sets they contain, and to store data set attributes (for example, record length and block size). The attribute information must originally come from a DD statement or from your prcgram. Once the label is written you need nct specify the information again.

Magnetic-tape volumes can have standard or nonstandard labels, or they can be unlabeled. Standard labels have two parts: the initial volume label, and header and trailer labels. The initial volume label identifies a volume and its owner; the header and trailer labels precede and follow each data set on the volume. Header labels contain system information, device-dependent information (for example, recording technique), and data set characteristics. Trailer labels are almcst identical with header labels, and are used when magnetic tape is read backwards.

Direct-access volumes have standard labels. Each volume is identified by a volume label, which is stored at a standard location on the volume. This label contains a volume serial number and the address of a volume table of contents (VTOC). The table of contents, in turn, contains a label, termed a data set control block (DSCB), for each data set stored on the volume.

DATA DEFINITION (DD) STATEMENT

A data definition (DD) statement is a job control statement that defines a data set to the operating system, and is a request to the operating system for the allocation of input/output resources. Each job step must include a DD statement for each data set that is processed by the step.

Chapter 1 describes the format of job control statements. The operand field of the DD statement can contain keyword parameters that describe the location of the data set (for example, volume serial number and identification of the unit on which the volume will be mounted) and the attributes of the data itself (for example, record format).

The DD statement enables you to write PL/I source programs that are independent of the data sets and input/output devices they will use. You can modify the parameters of a data set or process different data sets without recompiling your program; for example, you can cause a program that originally read punched cards to accept input from magnetic tape merely by changing the DD statement.

Name of DD Statement

The name that appears in the name field of the DD statement (ddname) identifies the statement so that other job control statements and the PL/I program can refer to it. A ddname must be unique within a job step; if two DD statements in one job step have the same name, the second statement is ignored. Except when specifying the concatenation of two or more data sets, a DD statement must always have a name.

For input only you can concatenate two or more sequential or partitioned data sets (that is, link them so that they are processed as one continuous data set) by omitting the ddname from all but the first of the DD statements that describe them. For example, the following DD statements cause the data sets LIST1, LIST2, and LIST3 to be treated as a single data set for the duration of the job step in which the statements appear:

```
//GO.LIST DD DSNAME=LIST1,DISP=OLD
//         DD DSNAME=LIST2,DISP=OLD
//         DD DSNAME=LIST3,DISP=OLD
```

When read from a PL/I program the concatenated data sets need not be on the same volume, but the volumes must be on the same type of device, and the data sets must have similar characteristics (for example, block size and record format). You cannot process concatenated data sets backwards.

Parameters of DD Statement

The operand field of the DD statement contains keyword parameters that you can use to give the following information:

1. The name of the data set (DSNAME parameter).
2. Description of the device and volume that contain the data set (UNIT, VOLUME, SPACE, LABEL, and SYSOUT parameters).
3. Disposition of the data set before and after execution of the job step (DISP parameter).
4. Data set characteristics (DCB parameter).

The following paragraphs summarize the functions of these groups of parameters. For full details of all the parameters, refer to the job control language publications.

NAMING THE DATA SET

The DSNAME parameter specifies the name of a newly defined data set or refers to the name of an existing data set (for example, DSNAME=ROOTS). You need not specify the DSNAME parameter for a temporary data set (one that exists only for the duration of the job in which it is created); the operating system will give it a temporary name.

DESCRIBING THE DEVICE AND VOLUME

The UNIT parameter specifies the type of input/output device to be allocated for the data set. You can specify the type by giving the actual unit address, the type number of the unit (for example, UNIT=2400 for the 2400 series Nine-track Magnetic Tape Drive), or by naming a group of units established at system generation (for example, UNIT=SYSDA for any direct-access device).

The VOLUME parameter identifies the volume on which the data set resides (for example, VOLUME=SER=12345). It can also include instructions for mounting and demounting volumes.

The SPACE parameter specifies the amount of auxiliary storage required to accommodate a data set on a direct-access device (for example, SPACE=(CYL,10) specifies that 10 cylinders are to be allocated).

The LABEL parameter specifies the type and contents of the data set labels for magnetic tape (for example, LABEL=4 indicates that the data set is the fourth data set on the volume).

The SYSOUT parameter allows you to route an output data set through a system output device (for example, SYSOUT=A). A system output device is any unit (but usually a printer or a card punch) that is used in common by all jobs. The computer operator allocates all the system output devices to specific classes according to device type and function. The usual convention is for class A to refer to a printer and class B to a card punch; the IBM-supplied cataloged procedures assume that this convention is followed. If you use the SYSOUT parameter, the only other information you may have to supply about the data set is the block size, which you can specify either in the DCB parameter of the DD statement or in your PL/I program.

DISPOSITION OF THE DATA SET

The DISP parameter indicates whether a data set exists or is new, and specifies what is to be done with it at the end of the job step (for example, DISP=(NEW,KEEP) specifies that a data set is to be created and that it is to be kept on the volume of the end of the job step). At the end of a job step, you can delete a data set, pass it to the next step in the same job, enter its name in the system catalog or have it removed from the catalog, or you can keep the data set for future use without cataloging it.

The LEAVE and REREAD options of the ENVIRONMENT attribute allow you to use the DISP parameter to control the action taken when the end of a magnetic-tape volume is reached or when a magnetic-tape data set is closed. For a description of these options refer to the language reference manual for this compiler.

DATA SET CHARACTERISTICS

The DCB (data control block) parameter of the DD statement allows you to describe the characteristics of the data in a data set, and the way it will be processed, at execution time. Whereas the other parameters of the DD statement deal chiefly with the identity, location, and disposal of the data set, the DCB parameter specifies information required for the processing of the records themselves. The subparameters of the DCB parameter are described in appendix A. For DCB use, see "Data Control Block," later in this chapter.

The DCB parameter contains subparameters that describe:

1. The organization of the data set and how it will be accessed (CYLOFL, DSORG, LIMCT, NCP, NTM, and OPTCD subparameters).
2. Device dependent information such as the recording technique for magnetic tape or the line spacing for a printer (CODE, DEN, MODE, PRTSP, STACK, and TRTCH subparameters).
3. The record format (BLKSIZE, KEYLEN, LRECL, RECFM, and RKP subparameters).
4. The number of buffers that are to be used (BUFNO subparameter).
5. The printer or card punch control characters (if any) that will be inserted in the first byte of each record (RECFM subparameter).

You can specify BLKSIZE, BUFNO, LRECL, KEYLEN, NCP, RECFM, RKP, and TRKOFL (or their equivalents) in the ENVIRONMENT attribute of a file declaration in your PL/I program instead of in the DCB parameter.

You cannot use the DCB parameter to override information already established for the data set in your PL/I program (by the file attributes declared and the other

attributes that are implied by them). DCB subparameters that attempt to change information already supplied are ignored. An example of the DCB parameter is:

```
DCB=(RECFM=FB,BLKSIZE=400,LRECL=40)
```

which specifies that fixed-length records, 40 bytes in length, are to be grouped together in a block 400 bytes long.

Operating System Data Management

An object module produced by the optimizing compiler uses the data management routines of the operating system to control the storage and retrieval of data. The compiler translates each input and output statement in a PL/I program into a set of machine instructions that result in the issuing of assembler language macro instructions that request the data management routines to perform the required input or output operations. (These macro instructions are described in the supervisor and data management macro instructions publication.)

The macro instructions are either issued directly by compiled code or by appropriate subroutines from the transient library. In the latter case, the compiled code includes a branch to an interface subroutine in the resident library that initiates the flow of control through other required library subroutines.

The data management routines control the organization of data sets, as well as the storage and retrieval of the records they contain. They create and maintain data set labels, indexes, and catalogs; they transmit data between main storage and auxiliary storage; they use the system catalog to locate data sets; and they request the operator to mount and demount volumes as required.

BUFFERS

The data management routines can provide areas of main storage, termed buffers, in which data can be collected before it is transmitted to auxiliary storage, or into which it can be read before it is made available to a program. The use of buffers permits the blocking and deblocking of records, and may allow the data management routines to increase the efficiency of transmission of data by anticipating the needs of a program. Anticipatory buffering requires at least two buffers: while the program is processing the data in one buffer, the next block of data can be read into another. Anticipatory buffering can only be used for data sets being accessed sequentially.

The operating system can further increase the efficiency of transmission in a program that involves many input/output operations by using chained scheduling. In chained scheduling, a series of read or write operations are chained together and treated as a single operation. For chained scheduling to be effective, at least three buffers are necessary. For more information on chained scheduling see the data management services publication.

The data management routines have two ways of making data that has been read into a buffer available to a program. In the move mode, the data is actually transferred from the buffer into the area of main storage occupied by the program. In the locate mode, the program can process the data while it is still in the buffer; the data management routines pass the address of the buffer to the program to enable it to locate the data. Similarly a program can move output data into the buffer or it can build the data in the buffer itself.

ACCESS METHODS

Data management has two access techniques for transmitting data between main storage and auxiliary storage:

The queued access technique deals with individual records, which it blocks and deblocks automatically. Records are retrieved and written by means of macro instructions. The first time a macro instruction is issued to retrieve a record, the data management routines place a block of records in an input buffer and pass the first record to the program that issued the instruction (that is, they deblock the records); each succeeding retrieval passes another record to the program. When the input buffer is empty, it is automatically refilled with another block. Similarly, another macro instruction places records in an output buffer and, when the buffer is full, writes out the records. Since the queued access technique brings records into main storage before they are requested, it can be used only for records that have been stored sequentially.

The basic access technique uses other macro instructions for input and output. These instructions move blocks, not records. When a macro instruction is issued to retrieve a block, the data

management routines pass a block of data to the program that issued the instruction; they do not deblock the records. Similarly, another macro instruction transmits a block to auxiliary storage.

The combination of data set organization, as described earlier in this chapter, and an access technique is termed an access method. The access methods used by the compiler are:

QSAM: Queued sequential access method: this combines the queued access technique with sequential organization.

QISAM: Queued indexed sequential access method: this combines the queued access technique with indexed sequential organization.

BSAM: Basic sequential access method: this combines the basic access technique with sequential organization.

BISAM: Basic indexed sequential access method: this combines the basic access technique with sequential organization.

BDAM: Basic direct access method: this combines the basic access technique with direct organization.

TCAM: Telecommunications access method: this combines the queued access technique with telecommunications organization.

The PL/I library subroutines use QSAM for stream-oriented transmission and all of the above methods for record-oriented transmission, as shown in figure 6.4. They implement PL/I GET and PUT statements by transferring the appropriate number of characters from or to the buffers, and use GET and PUT macro instructions in the locate mode to fill or empty the buffers. (For paper tape, however, the library subroutines use the move mode to permit translation of the transmitted characters before passing them to the PL/I program.)

DATA CONTROL BLOCK

A data control block (DCB) is an area of main storage that contains information about a data set and the volume that contains it. The data management routines refer to this information when they are processing a data set; no data set can be processed unless there exists a corresponding DCB. For a PL/I program, a PL/I library subroutine creates a DCB for the associated data set when a file is opened.

Data Set Organization	File Attributes			Access Methods
CONSECUTIVE	SEQUENTIAL	INPUT OUTPUT UPDATE	BUFFERED	QSAM
			UNBUFFERED	BSAM
INDEXED	SEQUENTIAL	INPUT OUTPUT UPDATE	BUFFERED or UNBUFFERED	QISAM
	DIRECT	INPUT UPDATE	-	BISAM
REGIONAL	SEQUENTIAL	INPUT UPDATE	BUFFERED or UNBUFFERED	BSAM
		OUTPUT		BSAM
	DIRECT	INPUT OUTPUT UPDATE	-	BDAM
TELEPROCESSING	TRANSIENT	INPUT OUTPUT	BUFFERED	TCAM

Figure 6.4. Access methods for record-oriented transmission

A data control block contains two types of information: data set characteristics and processing requirements. The characteristics include record format, record length, block size, and data set organization. The processing information may specify the number of buffers to be used, and it may include device-dependent information (for example, printer line spacing or magnetic-tape recording density), and special processing options that are available for some data-set organizations.

The information in the DCB comes from three sources:

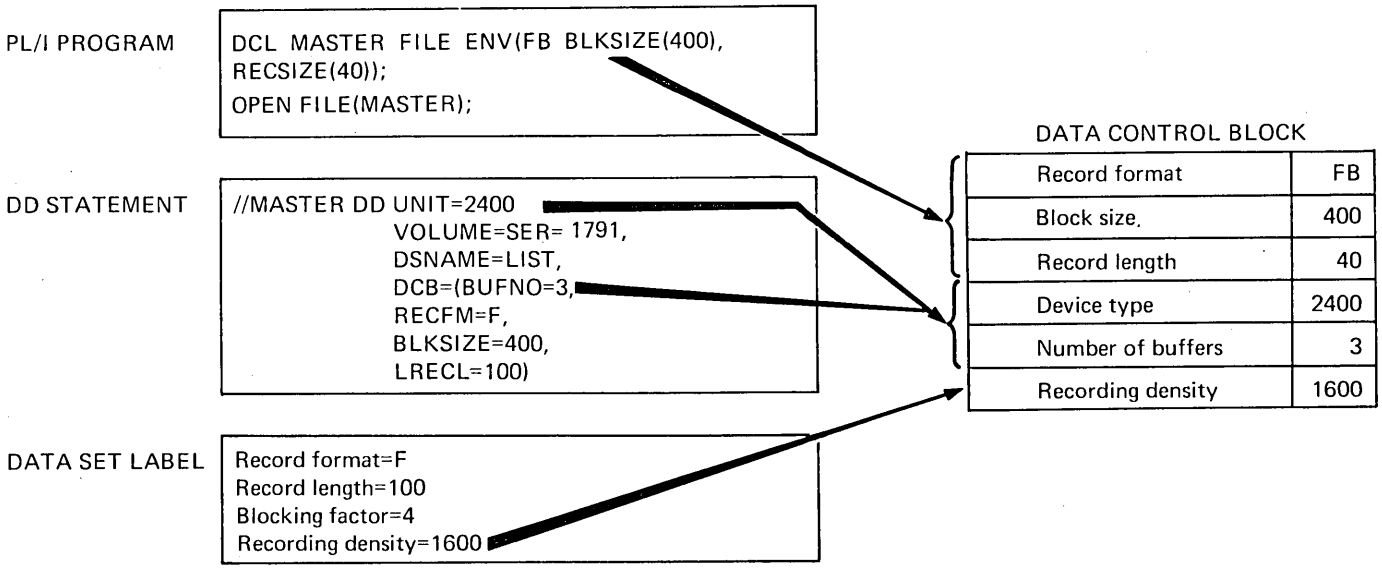
1. The file attributes declared implicitly or explicitly in the PL/I program.
2. The data definition (DD) statement for the data set.
3. If the data set exists, the data set labels.

OPENING A FILE

The execution of a PL/I OPEN statement associates a file with a data set. This requires the merging of the information describing the file and the data set. If any conflict is detected between file attributes and data set characteristics the UNDEFINEDFILE condition will be raised.

Subroutines of the PL/I library create a skeleton data control block for the data set, and use the file attributes from the DECLARE and OPEN statements, and any attributes implied by the declared attributes, to complete the data control block as far as possible, as shown in figure 6.5. They then issue an OPEN macro instruction, which calls the data management routines to check that the correct volume is mounted and to complete the data control block. The data management routines examine the data control block to see what information is still needed and then look for this information, first in the DD statement, and finally, if the data set exists and has standard labels, in the data set labels. For new data sets, the data management routines begin to create the labels (if they are required) and to fill them with information from the data control block.

Neither the DD statement nor the data set label can override information provided by the PL/I program; nor can the data set label override information provided by the DD statement.



Note: Information from the PL/I program overrides that from the DD statement and the data set label. Information from the DD statement overrides that from the data set label.

Figure 6.5. How the operating system completes the DCB

When the DCB fields have been filled in from these sources, control returns to the PL/I library subroutines. If any fields have still not been filled in, the PL/I OPEN subroutine provides default information for some of them; for example, if LRECL has not been specified, it is now provided from the value given for BLKSIZE.

CLOSING A FILE

The execution of a PL/I CLOSE statement dissociates a file from the data set with which it was associated. The PL/I library subroutines first issue a CLOSE macro instruction and, when control returns from the data management routines, release the data control block that was created when the file was opened. The data management routines complete the writing of labels for new data sets and update the labels of existing data sets.

Record Formats for Auxiliary Storage

The following paragraphs state the record formats acceptable for various types of auxiliary storage devices, and summarize the salient operational features of these devices.

CARD READER AND PUNCH

Both the card reader and card punch accept F-format, V-format, and U-format records; the control bytes of V-format records are not punched. Any attempt to block records is ignored.

Each punched card corresponds to one record; you should therefore restrict the maximum record length to 80 bytes (EBCDIC mode) or 160 bytes (column-binary mode). To select the mode, use the MODE subparameter of the DCB parameter of the DD statement; if you omit this subparameter, EBCDIC is assumed. (The column-binary mode increases the packing density of information on a card, punching two bytes in each column. Only six bits of each byte are punched; on input, the two high-order bits of each byte are set to zero; on output, the two high-order bits are lost.) The Card Read Punch 2540 has five stackers into which cards are fed after reading or punching. Two stackers accept only cards that have been read, and two others accept only those that have been punched; the fifth (center) stacker can accept either cards that have been read or those that have been punched. The two stackers in each pair are numbered 1 and 2 and the center stacker is numbered 3, as shown in figure 6.6.

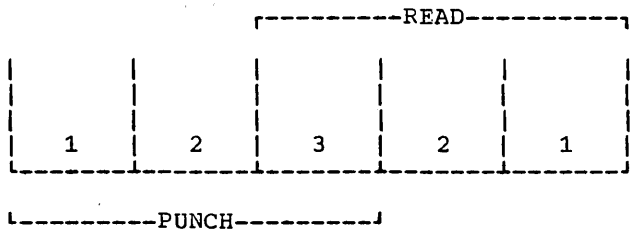


Figure 6.6. Card read punch 2540: stacker numbers

The Card Read Punch 2520 has two stackers, into which cards can be read or punched. The Card Reader 2501 has only one stacker.

Cards are normally fed into the appropriate stacker 1 after reading or punching. You can use the STACK subparameter of the DCB parameter of the DD statement to select an alternative stacker for reading or punching. For punching only, you can select the stacker dynamically by inserting an ANS or System/360 code in the first byte of each record; you must indicate which code you are using in the RECFM subparameter of the DD statement or in the ENVIRONMENT option. The control character is not punched.

PAPER TAPE READER

The paper tape reader accepts F-format and U-format records; each U-format record is followed by an end-of-record character. Use the CODE subparameter of the DCB parameter of the DD statement to request translation of data from one of the six standard paper-tape codes to System/360 internal representation (EBCDIC). Any character found to have a parity error is not transmitted.

PRINTER

The printer accepts F-format, V-format, and U-format records; the control bytes of V-format records are not printed. Each line of print corresponds to one record; you should therefore restrict your record length to the length of one printed line. Any attempt to block records is ignored.

You can use the PRTSP subparameter of the DCB parameter of the DD statement to request the line spacing of your output, or you can control the spacing dynamically by inserting an ANS or System/360 code in the first byte of each record; you must indicate which code you are using in the RECFM subparameter of the DD statement or in the ENVIRONMENT option. The control character is not printed. If you do not specify the line spacing, single spacing (no blanks between lines) is assumed.

MAGNETIC TAPE

Magnetic-tape devices accept D-format, F-format, V-format, and U-format records for both 9-track and 7-track magnetic tape with the one exception that 7-track magnetic tape will not accept V-format records unless the data conversion feature is available. (The data in the control bytes of V-format records is in binary form; in the absence of the data conversion feature, only six of the eight bits in each byte are transmitted to 7-track tape.)

Nine-track magnetic tape is standard in IBM System/360, but some 2400 series magnetic-tape drives incorporate features that facilitate reading and writing 7-track tape. The translation feature changes character data from EBCDIC (the 8-bit code used in System/360) to BCD (the 6-bit code used on 7-track tape) or vice-versa. The data conversion feature treats all data as if it were in the form of a bit string, breaking the string into groups of eight bits for reading into main storage, or into groups of six bits for writing on 7-track tape; the use of this feature precludes reading the tape backwards. To use translation or data conversion, include the TRTCH (tape recording technique) subparameter in the DCB parameter of the DD statement.

The maximum recording density available depends on the model number of the tape drive; single-density tape drive units have a maximum recording density of 800 bytes per inch, and dual-density tape drive units have a maximum of 1600 bytes per inch. For 9-track tapes, a single-density drive offers only the 800 bytes per inch density; the standard density for a dual-density drive is 1600 bytes per inch, but you can use the subparameter DEN (density) of the DD statement to specify 800 bytes per inch. For 7-track tape, the standard recording density for both types of drive unit is 200 bytes per inch; you can use the DEN subparameter of the DCB parameter of the DD statement to select alternatives of 556 or 800 bytes per inch.

Note: When a data check occurs on a magnetic-tape device with short length records (12 bytes on a read and 18 bytes on a write), these records will be treated as noise.

DIRECT-ACCESS DEVICES

Direct-access devices accept F-format, V-format, and U-format records.

The storage space on these devices is divided into conceptual cylinders and tracks. A cylinder is usually the amount of space that can be accessed without movement of the access mechanism, and a track is that part of a cylinder that is accessed by a single read/write head. For example, a 2311 disk pack has ten recording surfaces, each of which has 200 concentric tracks; thus, it contains 200 cylinders, each of which contains ten tracks.

When you create a data set on a direct-access device, you must always indicate to the operating system how much auxiliary storage the data set will require. Use the SPACE parameter of the DD statement to allocate space in terms of blocks, tracks, or cylinders. If you request space in terms of tracks or cylinders, bear in mind that space in a data set on a direct-access device is occupied not only by blocks of data, but by control information inserted by the operating system; if you use small blocks, the control information can result in a considerable space overhead. The following reference cards contain tables that will enable you to determine the amount of space you will require:

2301 Drum Storage Unit, Order No. GX20-1717

2302 Disk storage Drive, Order No. GX20-1706

2303 Drum Storage Unit, Order No. GX20-1718

2311 Disk Storage Drive, Order No. GX20-1705

2314 Storage Facility, Order No. GX20-1710

2321 Data Cell Drive, Order No. GX20-1704

Chapter 7: Defining Data Sets for Stream Files

This chapter describes how to define data sets for use with PL/I files that have the STREAM attribute. It explains how to create and access data sets with CONSECUTIVE organization. The essential parameters of the DD statements used in creating and accessing these data sets are summarized in tables, and several examples of PL/I programs (complete with JCL) are included to illustrate the text.

Data sets with the STREAM attribute are processed by stream-oriented transmission, which allows the PL/I program to ignore block and record boundaries and treat a data set as a continuous stream of data items in character form.

For output, the data management subroutines of the PL/I library convert the data items from the program variables into character form if necessary, and build the stream of characters into records for transmission to the data set.

For input, the library subroutines take records from the data set and separate them into the data items requested by the program, converting them into the appropriate form for assignment to the program variables.

Because stream-oriented transmission always treats the data in a data set as a continuous stream, it can be used only to process data sets with CONSECUTIVE organization.

Creating a Data Set

Any data set created using stream-oriented transmission must have CONSECUTIVE organization, but it is not necessary to specify this in the ENVIRONMENT attribute, since it is the default organization.

Your program deals only with data items, and not with records and blocks as they will exist in the data set. Accordingly, you need not concern yourself with the actual structure of the data set beyond specifying a block size (which is always necessary), unless you propose to use record-oriented transmission to access the data set at a later date.

To create a data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

ESSENTIAL INFORMATION

You must supply the following information, summarized in figure 7.1, when creating a data set:

1. Device that will write or punch your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement).

2. Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size. If you do not specify a record format, U-format is assumed (except for PRINT files when V-format is assumed: see "PRINT Files," later in this chapter).

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE= ...)
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but is not required after end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.

Figure 7.1. Creating a data set: essential parameters of DD statement

If your data set is to follow another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

EXAMPLE

The use of stream-oriented transmission to create a data set on a 2311 disk drive is shown in figure 7.2. The data read from the input stream by the standard file SYSIN includes a field VREC that contains five unnamed 7-character subfields; the field NUM defines the number of these subfields that contain information. The output file WORK transmits to the data set the whole of the field FREC and only those subfields of VREC that contain information. The data set has U-format unblocked records with a maximum block size of 400 bytes (defined in the statement that declares the file WORK). All blocks except the last will contain exactly 400 bytes.

Accessing a Data Set

A data set accessed using stream-oriented transmission need not have been created by stream-oriented transmission, but it must have CONSECUTIVE organization, and all the data in it must be in character form. You can open the associated file for input, and read the records the data set contains; or you can open the file for output, and extend the data set by adding records at the end.

To access a data set, you must identify it to the operating system in a DD statement. The following paragraphs, which are summarized in figure 7.3, indicate the essential information you must include in the DD statement, and discuss some of the optional information you may supply. The discussions do not apply to data sets in the input stream, which are dealt with in chapter 6.

```
//OPT7#2  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 PEOPLE: PROC OPTIONS(MAIN);

         DCL WORK FILE STREAM OUTPUT ENV(U),
             1 REC,
               2 FREC,
                 3 NAME CHAR(19),
                 3 NUM CHAR(1),
                 3 PAD CHAR(25),
               2 VREC CHAR(35),
             IN CHAR(80) DEF REC;

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(WORK) LINESIZE(400);
 MORE:   GET FILE(SYSIN) EDIT(IN)(A(80));
         PUT FILE(WORK) EDIT(IN)(A(45+7*NUM));
         GO TO MORE;
 FINISH: CLOSE FILE(WORK);
         END PEOPLE;
/*
//GO.WORK DD DSN=PEOPLE,UNIT=2311,SPACE=(CYL,(2,1)),DISP=(NEW,KEEP),
//           VOL=SER=D186
//GO.SYSIN DD *
R.C.ANDERSON       0 202848 DOCTOR
B.F.BENNETT        2 771239 PLUMBER          VICTOR HAZEL
R.E.COLE           5 698635 COOK             ELLEN  VICTOR JOAN   ANN     CTTO
J.F.COOPER         5 418915 LAWYER           FRANK  CAROL  DONALD NORMAN BRENDA
A.J.CORNELL        3 237837 BARBER           ALBERT ERIC   JANET
E.F.FERRIS         4 158636 CARPENTER        GERALD ANNA   MARY   HAROLD
/*
```

Figure 7.2. Creating a data set with stream-oriented transmission

Parameters of DD Statement			
When required		What you must state	Parameters
Always		Name of data set	DSNAME=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT= or VOLUME=REF=
	Standard labeled magnetic tape and direct access	Volume serial number	VOLUME=SER=
Magnetic tape: if data set not first in volume or which does not have standard labels		Sequence number	LABEL=
If data set does not have standard labels		Block size[1]	DCB=(BLKSIZE=...)
[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.			

Figure 7.3. Accessing a data set: essential parameters of DD statement

ESSENTIAL INFORMATION

If the data set is cataloged, you need supply only the following information in the DD statement:

1. The name of the data set (DSNAME parameter). The operating system will locate the information describing the data set in the system catalog, and, if necessary, will request the operator to mount the volume containing it.

2. Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, to open the data set for output will result in its being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set is on paper tape or punched cards, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

MAGNETIC TAPE WITHOUT STANDARD LABELS

If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I data management includes no facilities for processing nonstandard labels, which, to the operating system, appear as data sets preceding or following your data set. You can either process the labels as independent data sets or use the LABEL parameter of the DD statement to bypass them; to bypass the labels code LABEL=(2,NL) or LABEL=(,BLP).

RECORD FORMAT

When using stream-oriented transmission to access a data set you do not need to know the record format of the data set (except when you must specify a block size); each GET statement transfers a discrete number of characters to your program from the data stream.

If you do give record format information, it must be compatible with the actual structure of the data set. For example, if a data set is created with F-format records, a record size of 600 bytes, and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes; but if you specify a block size of 3500 bytes, your data will be truncated.

EXAMPLE

The program in figure 7.4 reads the data set created by the program in figure 7.2 and uses the standard file SYSPRINT to list the data it contains. (SYSPRINT is discussed later in this chapter.) Each set of data is read, by the GET statement, into two variables: FREC, which always contains 45 characters; and VREC, which always contains 35 characters. At each execution of the GET statement, VREC consists of the number of characters generated by the expression 7*NUM, together with sufficient blanks to bring the total number of characters to 35. The DISP parameter of the DD statement could read simply DISP=OLD; if the second term is omitted, an existing data set will not be deleted.

```
//OPT7#4  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 PEOPLE: PROC OPTIONS(MAIN);

         DCL WORK FILE STREAM INPUT,
             1 REC,
               2 FREC,
                 3 NAME CHAR(19),
                 3 NUM CHAR(1),
                 3 SERNO CHAR(7),
                 3 PROF CHAR(18),
               2 VREC CHAR(35),
             IN CHAR(80) DEF REC;

         ON ENDFILE(WORK) GO TO FINISH;

         OPEN FILE(WORK);
 MORE:    GET FILE(WORK) EDIT(IN,VREC)(A(45),A(7*NUM));
         PUT FILE(SYSPRINT) SKIP EDIT(IN)(A);
         GO TO MORE;
 FINISH: CLOSE FILE(WORK);
         END PEOPLE;
/*
//GO.WORK DD DSN=PEOPLE,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
```

Figure 7.4. Accessing a data set with stream-oriented transmission

PRINT Files

Both the operating system and the PL/I language include features that facilitate the formatting of printed output. The operating system allows you to use the first byte of each record for a printer control code; the control codes, which are not printed, cause the printer to skip to a new line or page. Tables of printer control codes are given in figures 8.5 and 8.6. In a PL/I program, the use of a PRINT file provides a convenient means of controlling the layout of printed output in stream-oriented transmission; the compiler automatically inserts printer control codes in response to the PAGE, SKIP, and LINE options and format items.

You can apply the PRINT attribute to any STREAM OUTPUT file, even if you do not intend to print the associated data set directly. When a PRINT file is associated with a magnetic-tape or direct-access data set, the printer control codes have no effect on the layout of the data set, but appear as part of the data in the records.

The compiler reserves the first byte of each record transmitted by a PRINT file for an ANS printer control code, and inserts the appropriate codes automatically. A PRINT file uses only the following five printer control codes:

Code	Action
b (blank)	Space 1 line before printing
0	Space 2 lines before printing
-	Space 3 lines before printing
+	No space before printing
1	Start new page

The compiler handles the PAGE, SKIP, and LINE options or format items by padding the remainder of the current record with blanks and inserting the appropriate control code in the next record. If SKIP or LINE specifies more than a three line space, the compiler inserts sufficient blank records with appropriate control codes to accomplish the required spacing. In the absence of a printer control option or format item, when a record is full the compiler inserts a blank code (single line space) in the first byte of the next record.

RECORD FORMAT

You can limit the length of the printed line produced by a PRINT file either by specifying a record length in your PL/I program (ENVIRONMENT attribute), in a DD statement, or by giving a line size in an OPEN statement (LINESIZE option). The record length must include the extra byte for the printer control code, that is, it must be one byte larger than the length of the printed line (five bytes larger for V-format records). The value you specify

in the LINESIZE option refers to the number of characters in the printed line; the compiler adds the printer control bytes.

The blocking of records has no affect on the appearance of the output produced by a PRINT file, but it does result in more efficient use of auxiliary storage when the file is associated with a data set on a magnetic-tape or direct-access device. If you use the LINESIZE option, ensure that your line size is compatible with your block size: for F-format records, block size must be an exact multiple of (line size + 1); for V-format records, block size must be at least nine bytes greater than line size.

Although you can vary the line size for a PRINT file during execution by closing the file and opening it again with a new line size, you must do so with caution if you are using the PRINT file to create a data set on a magnetic-tape or direct-access device: you cannot change the record format established for the data set when the file is first opened. If the line size specified in an OPEN statement conflicts with the record format already established, the UNDEFINEDFILE condition will be raised; to prevent this, either specify V-format records with a block size at least nine bytes greater than the maximum line size you intend to use, or ensure that the first OPEN statement specifies the maximum line size. (Output destined for the printer may be stored temporarily on a direct-access device, unless you specify a printer by using UNIT=, even if you intend it to be fed directly to the printer.)

Since PRINT files have a default line size of 120 characters, you need not give any record format information for them. In the absence of other information, the compiler assumes V-format records; the complete default information is:

```
BLKSIZE=129

LRECL=125

RECFM=VB
```

EXAMPLE

Figure 7.5 illustrates the use of a PRINT file and the printing options of the stream-oriented transmission statements to format a table and write it onto magnetic tape for printing on a later occasion. The table comprises the natural sines of the angles from 0° to 359° 54' in steps of 6'.

The statements in the ENDPAGE on-unit insert a page number at the bottom of each page, and set up the headings for the following page. After the last line of the table has been written, the statement:

```
PUT FILE(TABLE) LINE(54)
```

causes the ENDPAGE condition to be raised to ensure that a number appears at the foot of the last page; the preceding statement sets the flag FINISH to prevent a further set of headings from being written.

The DD statement defining the data set created by this program includes no record-format information; the compiler infers the following from the file declaration and the line size specified in the statement that opens the file TABLE:

```
Record format = VB (the default for a
                    PRINT file)

Record size = 98  (line size + one byte
                   for printer control
                   character + four bytes for
                   record control field)

Block size = 494  (5 x record length +
                   four bytes for block control
                   field)
```

The program in figure 8.8 uses record-oriented transmission to print the table created by the program in figure 7.5.

```
//OPT7#5  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SINE:   PROC OPTIONS(MAIN);

         DCL TABLE FILE STREAM OUTPUT PRINT,
             TITLE CHAR(13) INIT('NATURAL SINES'),
            HEADINGS CHAR(90) INIT('        0        6       12       18
        24       30       36       42       48       54'),
             PGNO FIXED DEC(2) INIT(1),
             FINISH BIT(1) INIT('0'B),
             VALUES(0:359,0:9)FLOAT DEC(6);

         ON ENDPAGE(TABLE) BEGIN;
          PUT FILE(TABLE) EDIT('PAGE',PGNO)(LINE(55),COL(87),A,F(3));
          IF FINISH='0'B THEN DO;
          PGNO=PGNO+1;
          PUT FILE(TABLE) EDIT(TITLE||' (CONT''D)',HEADINGS)
                               (PAGE,A,SKIP(3),A);
          PUT FILE(TABLE) SKIP(2);
          END;
          END;

         DO I=0 to 359;
          DO J=0 TO 9;
           VALUES(I,J)=I+J/10;
           END;
          END;
         VALUES=SIND(VALUES);
         OPEN FILE(TABLE) PAGESIZE(52) LINESIZE(93);
         PUT FILE(TABLE) EDIT(TITLE,HEADINGS) (PAGE,A,SKIP(3),A);
         DO I=0 TO 71;
           PUT FILE(TABLE) SKIP(2);
           DO J=0 TO 4;
            K=5*I+J;
            PUT FILE(TABLE) EDIT(K,VALUES(K,*))(F(3),10 F(9,4));
            END;
           END;
         FINISH='1'B;
         PUT FILE(TABLE) LINE(54);
         CLOSE FILE(TABLE);
         END SINE;
/*
//GO.TABLE DD DSN=SINES,UNIT=2311,DISP=(NEW,CATLG),VOL=SER=D186,
//        SPACE=(CYL,(1,1))
```

Figure 7.5. Creating a data set using a PRINT file

PAGE SIZE, LINE SIZE, AND TABULATING POSITIONS

For a PRINT file, default values for the page size, line size, and the tabulating positions (used by list-directed and data-directed output only) are contained in a module named IBMBSTAB, stored as a member of the system library SYS1.LINKLIB. This module is loaded into main storage at start of execution. It applies to all PRINT files used in the PL/I program unless a static external structure PLITABS is present in the program.

These default values can be overridden by declaring a structure named PLITABS, with the STATIC EXTERNAL attributes, in the PL/I program. If such a structure is included, it will be used in place of IBMBSTAB.

The default value 60 for page size and 120 for line size can be overridden for individual files by using the PAGESIZE and LINESIZE options in the OPEN statement, so PLITABS is needed only if you wish to change the default tabulating positions, which are: 25, 49, 73, 97, and 121.

The structure must be declared as shown in figure 7.6.

```
DECLARE 1 PLITABS STATIC EXTERNAL,
       (2 NOFFSET INIT(14),    /* OFFSET TO NUMBER OF TABS */
        2 NPAGESIZE INIT(page size),
        2 NLINESIZE INIT(line size),
        2 NPAGELENGTH INIT(page length),
        2 NFILL1 INIT(0),      /* RESERVED */
        2 NFILL2 INIT(0),      /* RESERVED */
        2 NFILL3 INIT(0),      /* RESERVED */
        2 NUMBER_OF_TABS INIT(number-of-tab-positions),
        2 NTAB1 INIT(first-tab-position),
        2 NTAB2 INIT(second-tab-position),
        2 NTAB3 INIT(third-tab-position))FIXED BIN(15,0);
```

Figure 7.6. Tabulating structure PLITABS

Insert the appropriate values for page size, line size, page length, the number of tab positions, and the actual positions of the tabs. A maximum of 255 tab positions can be specified.

Standard Files

PL/I includes two standard files, SYSIN for input and SYSPRINT for output. If your program includes a GET statement that does not include the FILE option, the compiler inserts the file name SYSIN; if it includes a PUT statement without the FILE option, the compiler inserts the name SYSPRINT.

If you do not declare SYSPRINT, the compiler will give the file the attribute PRINT in addition to the normal default attributes; the complete file declaration will be:

```
SYSPRINT FILE STREAM OUTPUT PRINT EXTERNAL
```

Since SYSPRINT is a PRINT file, the compiler also supplies a default line size of 120 characters and a V-format record. You need give only a minimum of information in the corresponding DD statement; if your installation uses the usual convention that the system output device of class A is a printer, the following is sufficient:

```
//SYSPRINT DD SYSOUT=A
```

If you use one of the IBM-supplied cataloged procedures to execute your program, even this DD statement is not required, since it is included in the GC procedure step.

You can override the attributes given to SYSPRINT by the compiler by explicitly declaring or opening the file. If you do so, bear in mind that this file is also used by the error-handling routines of the compiler, and that any change you make in the format of the output from SYSPRINT will also apply to the format of execution-time error messages. When an error message is printed, eight blanks are inserted at the start of each line except the first; consequently, if you specify a line size of less than 72 characters, the messages will not be output to SYSPRINT.

The compiler does not supply any special attributes for the standard input file SYSIN; if you do not declare it, it receives only the normal default attributes. The data set associated with SYSIN is usually in the input stream; if it is not in the input stream, you must supply full DD information.

Chapter 8: Defining Data Sets for Record Files

This chapter describes how to define data sets for use with PL/I files that have the RECORD attribute. It explains how to create and access data sets for the three types of organization: CONSECUTIVE, INDEXED, and REGIONAL recognized by PL/I, and how to create and access data sets for teleprocessing. The essential parameters of the DD statements used in creating and accessing these data sets are summarized in tables, and several examples of PL/I programs (complete with JCL) are included to illustrate the text.

Data sets with the RECORD attribute are processed by record-oriented transmission in which data is transmitted to and from auxiliary storage exactly as it appears in the program variables; no data conversion takes place. A record in a data set corresponds to a variable in the program.

CONSECUTIVE Data Sets

A data set with CONSECUTIVE organization can exist on any type of auxiliary storage device. Records are stored sequentially in the order in which you write them.

CREATING A CONSECUTIVE DATA SET

When you create a CONSECUTIVE data set you must specify:

1. Device that will write or punch your data set (UNIT, SYSOUT, or VOLUME parameter of DD statement).

2. Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size. If you do not specify a record format, U-format is assumed.

If you want to keep a magnetic-tape or direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

When creating a data set on a direct-access device, you must specify the amount of space required for it (SPACE parameter of DD statement).

If you want your data set stored on a particular magnetic-tape or direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter).

If you do not supply a serial number for a magnetic-tape data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing.

If your data set is to follow another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape. The essential information for creating a CONSECUTIVE data set is summarized in figure 8.1.

The DCB subparameters of the DD statement that apply to CONSECUTIVE data sets are listed in figure 8.2; they are described in appendix A. You can specify record format (RECFM), block size (BLKSIZE), record size (LRECL), and number of buffers (BUFNO) in the ENVIRONMENT attribute of the DECLARE statement in your PL/I program instead of in a DD statement.

ACCESSING A CONSECUTIVE DATA SET

You can access a CONSECUTIVE data set in three ways. You can open the associated file for input, and read the records the data set contains; you can open the file for output, and extend the data set by adding records at the end; or you can open the file for update, and read and rewrite each record in turn. (The operating system does not permit updating a CONSECUTIVE data set on magnetic tape; you must read the data set and write the updated records into a new data set.)

Storage Device	Parameters of DD Statement		
	When required	What you must state	Parameters
All	Always	Output device	UNIT= or SYSOUT= or VOLUME=REF=
		Block size[1]	DCB=(BLKSIZE=...
Direct access only	Always	Storage space required	SPACE=
Magnetic tape only	Data set not first in volume and for magnetic tapes that do not have standard labels	Sequence number	LABEL=
Direct access and standard labeled magnetic tape	Data set to be used by another job step but not required at end of job	Disposition	DISP=
	Data set to be kept after end of job	Disposition	DISP=
		Name of data set	DSNAME=
	Data set to be on particular device	Volume serial number	VOLUME=SER= or VOLUME=REF=

[1]Alternatively, you can specify the block size in your PL/I program by using the ENVIRONMENT attribute.

Figure 8.1. Creating a CONSECUTIVE data set: essential parameters of DD statement

Subparameter	Specifies
BLKSIZE	Maximum number of bytes per block
BUFNO	Number of data management buffers
CODE	Paper tape: code in which the tape is punched
DEN	Magnetic tape: tape recording density
LRECL	Maximum number of bytes per record
MODE	Card reader or punch: mode or operation (column binary or EBCDIC)
OPTCD	Optional data-management services and data-set attributes
PRTSP	Printer line spacing (0, 1, 2, or 3)
RECFM	Record format and characteristics
TRTCH	Magnetic tape: tape recording technique for 7-track tape

Figure 8.2. DCB subparameters for CONSECUTIVE data sets

To access a data set, you must identify it to the operating system in a DD statement. The following paragraphs, which are summarized in figure 8.3, indicate the essential information you must include in the DD statement, and discuss some of the optional information you may supply. The discussions do not apply to data sets in the input stream, which are dealt with in chapter 6.

Parameters of DD Statement			
When required		What you must state	Parameters
Always		Name of data set	DSNAME=
		Disposition of data set	DISP=
If data set not cataloged	All devices	Input device	UNIT= or VOLUME=REF=
	Standard labeled magnetic tape and direct access	Volume serial number	VOLUME=SER=
Magnetic tape: if data set not first in volume or which does not have standard labels		Sequence number	LABEL=
If data set does not have standard labels		Block size[1]	DCB=(BLKSIZE=...)
[1]Alternatively, you can specify the block size in your PL/I program by using either the ENVIRONMENT attribute or the LINESIZE option.			

Figure 8.3. Accessing a CONSECUTIVE data set: essential parameters of DD statement

Essential Information

If the data set is cataloged, you need supply only the following information in the DD statement:

1. The name of the data set (DSNAME parameter). The operating system will locate the information describing the data set in the system catalog, and, if necessary, will request the operator to mount the volume containing it.

2. Confirmation that the data set exists (DISP parameter). If you open the data set for output with the intention of extending it by adding records at the end, code DISP=MOD; otherwise, to open the data set for output will result in its being overwritten.

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and, for magnetic-tape and direct-access devices, give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

If the data set is on paper tape or punched cards, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter).

If the data set follows another data set on a magnetic-tape volume, you must use the LABEL parameter of the DD statement to indicate its sequence number on the tape.

Magnetic Tape Without Standard Labels

If a magnetic-tape data set has nonstandard labels or is unlabeled, you must specify the block size either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (BLKSIZE subparameter). The DSNAME parameter is not essential if the data set is not cataloged.

PL/I data management includes no facilities for processing nonstandard labels which to the operating system appear as data sets preceding or following your data set. You can either process the labels as independent data sets or use the LABEL parameter of the DD statement to bypass them; to bypass the labels code LABEL=(2,NL) or LABEL=(,BLP).

Record Format

If you give record-format information, it must be compatible with the actual structure of the data set. For example, if a data set is created with F-format records, a record size of 600 bytes, and a block size of 3600 bytes, you can access the records as if they are U-format with a maximum block size of 3600 bytes; but if

you specify a block size of 3500 bytes, your data will be truncated.

EXAMPLE OF CONSECUTIVE DATA SETS

Creating and accessing CONSECUTIVE data sets on magnetic tape are illustrated in the program of figure 8.4. The program merges the contents of two existing data sets, DS1 and DS2, and writes them onto a new data set, DS3; each of the original data sets contains 15-byte fixed-length records arranged in EBCDIC collating sequence. The two input files, IN1 and IN2, have the default attribute BUFFERED, and locate mode is used to read reccrds from the associated data sets into the respective buffers. The output file, OUT, is not buffered, allowing move mode to be used to write the output records directly from the input buffers.

```
//OPT8#4  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 MERGE: PROC OPTIONS(MAIN);

        DCL  (IN1,IN2,OUT) FILE RECORD SEQUENTIAL,
             (ITEM1 BASED(A),ITEM2 BASED(B)) CHAR(80);

             ON ENDFILE(IN1) BEGIN;
              ON ENDFILE(IN2) GO TO FINISH;
 NEXT2:       WRITE FILE(OUT) FROM(ITEM2);
              READ FILE(IN2) SET(B);
              GO TO NEXT2;
              END;

             ON ENDFILE(IN2) BEGIN;
              ON ENDFILE(IN1) GO TO FINISH;
 NEXT1:       WRITE FILE(OUT) FROM(ITEM1);
              READ FILE(IN1) SET(A);
              GO TO NEXT1;
              END;

             OPEN FILE(IN1) INPUT,
                  FILE(IN2) INPUT,
                  FILE(OUT) OUTPUT;
             READ FILE(IN1) SET(A);
             READ FILE(IN2) SET(B);
 NEXT:       IF ITEM1>ITEM2 THEN DO;
              WRITE FILE(OUT) FROM(ITEM2);
              READ FILE(IN2) SET(B);
              GO TO NEXT;
              END;
             ELSE DO;
              WRITE FILE(OUT) FROM(ITEM1);
              READ FILE(IN1) SET(A);
              GO TO NEXT;
              END;
 FINISH:     CLOSE FILE(IN1),FILE(IN2),FILE(OUT);
             END MERGE;
/*
//GO.OUT DD  DSN=DS3,UNIT=2311,DCB=(RECFM=FB,BLKSIZE=400,LRECL=80),
//          DISP=(NEW,KEEP),VOL=SER=D186,SPACE=(CYL,(1,1))
//GO.IN1 DD  *
          (insert here data to be included in the input stream)
//GO.IN2 DD  *
          (insert here data to be included in the input stream)
/*
```

Figure 8.4. Creating and accessing a CONSECUTIVE data set

You cannot use a PRINT file for record-oriented transmission, and record-oriented transmission statements cannot include the printing options (PAGE, SKIP, etc). You can still exercise some control over the layout of printed output by including a printer control code as the first byte of each of your output records; you can also use similar control codes to select the stacker to which cards punched by your program are fed.

The operating system recognizes two types of code for printer and card punch commands, ANS code and machine code. You must indicate which code you are using, either in your PL/I program (ENVIRONMENT attribute), or in the DD statement (RECFM subparameter). If you specify one of these codes, but transmit your data to a device other than a printer or a card punch, the operating system will transmit the control bytes as part of your records. If you use an invalid control code, "space 1 line" or "stacker 1" will be assumed.

The ANS control codes, which are listed in figure 8.5, cause the specified action to occur before the associated record is printed or punched.

Code	Action
b	Space 1 line before printing (blank code)
0	Space 2 lines before printing
-	Space 3 lines before printing
+	Suppress space before printing
1	Skip to channel 1
2	Skip to channel 2
3	Skip to channel 3
4	Skip to channel 4
5	Skip to channel 5
6	Skip to channel 6
7	Skip to channel 7
8	Skip to channel 8
9	Skip to channel 9
A	Skip to channel 10
B	Skip to channel 11
C	Skip to channel 12
V	Select stacker 1
W	Select stacker 2

The channel numbers refer to the printer carriage control tape. (See IBM 1403 Printer Component Description.)

Figure 8.5. ANS printer and card punch control codes

The machine control codes differ according to the type of device. The codes for the 1403 Printer are listed in figure 8.6, and figure 8.7 gives those for the 2540 Card Read Punch.

Print and then act	Action	Act immediately (no printing)
Code byte		Code byte
00000001	Print only (no space)	-
00001001	Space 1 line	00001011
00010001	Space 2 lines	00010011
00011001	Space 3 lines	00011011
10001001	Skip to channel 1	10001011
10010001	Skip to channel 2	10010011
10011001	Skip to channel 3	10011011
10100001	Skip to channel 4	10100011
10101001	Skip to channel 5	10101011
10110001	Skip to channel 6	10110011
10111001	Skip to channel 7	10111011
11000001	Skip to channel 8	11000011
11001001	Skip to channel 9	11001011
11010001	Skip to channel 10	11010011
11011001	Skip to channel 11	11011011
11100001	Skip to channel 12	11100011

The channel numbers refer to the printer carriage control tape. (See IBM 1403 Printer Component Description.)

Figure 8.6. 1403 printer control codes

There are two types of command for the printer, one causing the action to occur after the record has been transmitted, and the other producing immediate action but transmitting no data (you must include the second type of command in a blank record).

Code byte	Action
00000001	Select stacker 1
01000001	Select stacker 2
10000001	Select stacker 3

Figure 8.7. 2540 Card Read Punch control characters

The essential requirements for producing printed output or punched cards are exactly the same as those for creating any other CONSECUTIVE data set (described above). For a printer, if you do not use one of the control codes, all data will be printed sequentially, with no spaces between records; each block will be interpreted as the start of a new line. When you specify a block size for a printer or card punch, and are using one of the control codes, include the control bytes in your block size; for example, if you want to print lines of 100 characters, specify a block size of 101.

Example

The program in figure 8.8 uses record-oriented transmission to read and print the contents of the data set SINES, created by the PRINT file in figure 7.5. Since the data set SINES is cataloged, only two parameters are required in the DD statement that defines it. The output file PRINTER is declared with the ENVIRONMENT option CTLASA, specifying that the first byte of each record will be interpreted as an ANS printer control code. The information given in the ENVIRONMENT attribute could alternatively have been given in the DD statement, as follows:

```
DCB=(RECFM=VA,BLKSIZE=102)
```

```
//OPT8#8  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 PRT:     PROC OPTIONS(MAIN);

          DCL TABLE FILE RECORD INPUT SEQUENTIAL,
           PRINTER FILE RECORD OUTPUT SEQL ENV(V BLKSIZE(102) CTLASA),
           LINE CHAR(94) VAR;

          ON ENDFILE(TABLE) GO TO FINISH;

          OPEN FILE(TABLE),FILE(PRINTER);
 NEXT:    READ FILE(TABLE) INTO(LINE);
          WRITE FILE(PRINTER) FROM(LINE);
          GO TO NEXT;
 FINISH: CLOSE FILE(TABLE),FILE(PRINTER);
          END PRT;
/*
//GO.TABLE DD DSNAME=SINES,DISP=OLD
//GO.PRINTER DD SYSOUT=A
```

Figure 8.8. Printing with record-oriented transmission

INDEXED Data Sets

A data set with INDEXED organization can exist only on a direct-access device. Each record in the data set is identified by a key that is recorded with the record. A key is a string of not more than 255 characters; all the keys in a data set must have the same length. The records in the data set are arranged according to the collating sequence of their keys. Once an INDEXED data set has been created, the keys facilitate the direct retrieval, addition, and deletion of records.

INDEXES

To provide faster access to the records in the data set, the operating system creates and maintains a system of indexes to the records in the data set. The lowest level of index is the track index. There is a track index for each cylinder in the data set; it occupies the first track (or tracks) of the cylinder, and lists the keys of the last records on each track in the cylinder. A search can then be directed to the first track that has a key that is higher than or equal to the key of the required record.

If the data set occupies more than one cylinder, the operating system develops a higher level index called a cylinder index. Each entry in the cylinder index identifies the key of the last record in the cylinder. To increase the speed of searching the cylinder index, you can request in a DD statement that the operating system develop a master index for a specified number of cylinders; you can have up to three levels of master index; figure 8.9 illustrates the index structure. The part of the data set that contains the cylinder and master indexes is termed the index area.

When an INDEXED data set is created, all the records are written in what is called the prime data area. If more records are added later, the operating system does not rearrange the entire data set; it inserts each new record in the appropriate position and moves up the other records on the same track. Any records forced off the track by the insertion of a new record are placed in an overflow area. The overflow area can consist either of a number of tracks set aside in each cylinder for the overflow records from that cylinder (cylinder overflow area), or a separate area for all overflow records (independent overflow area). Figure 8.10 shows how records are added to an INDEXED data set.

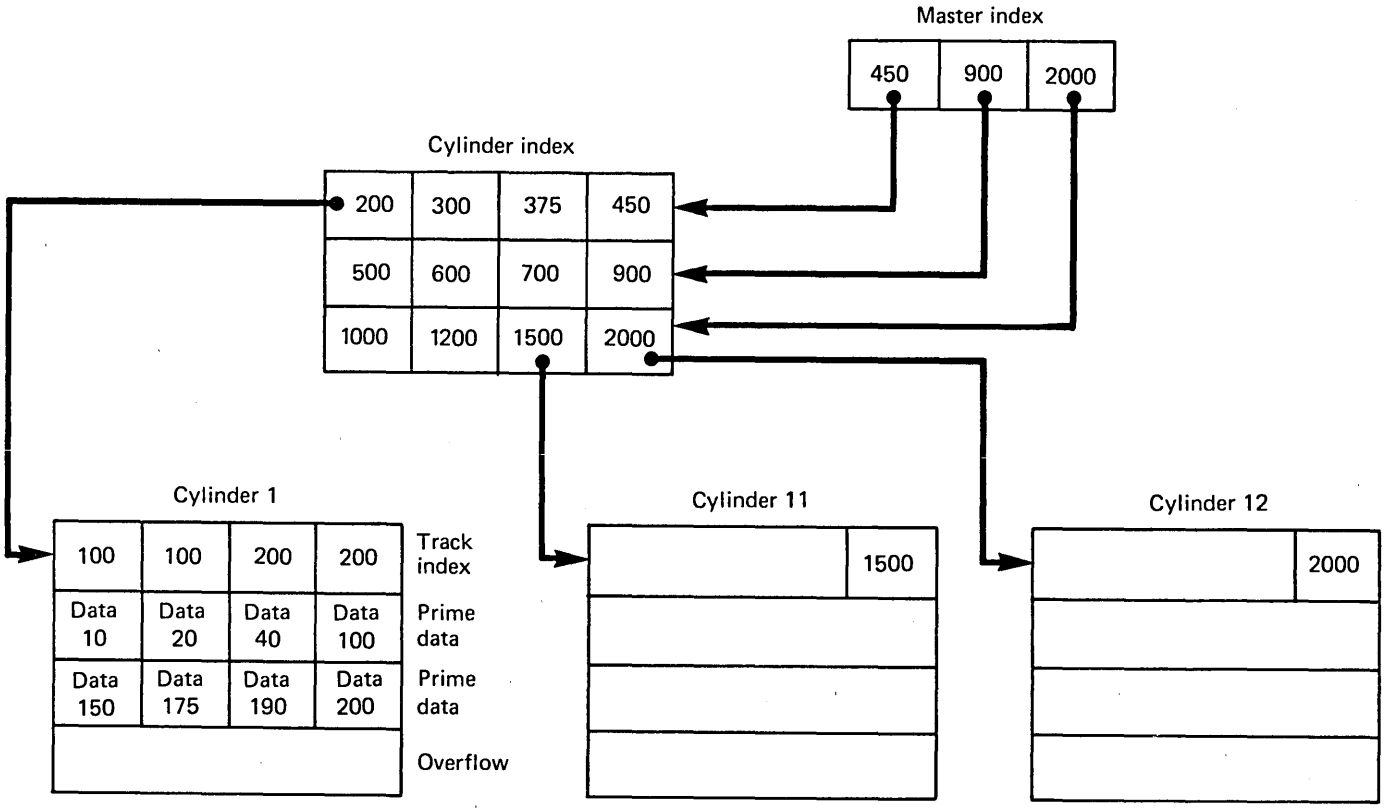


Figure 8.9. Index structure of an INDEXED data set

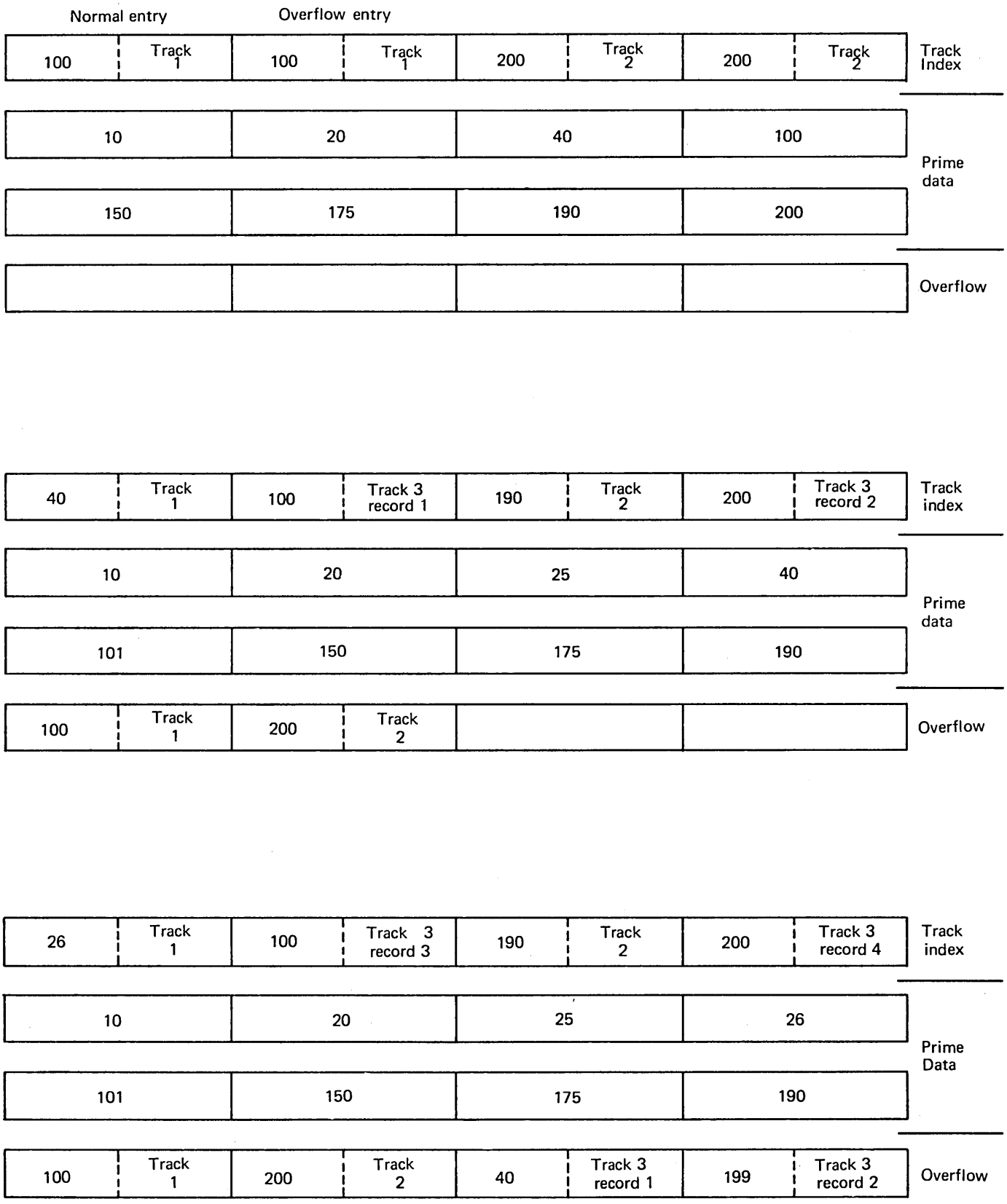


Figure 8.10. Adding records to an INDEXED data set

Each entry in the track index consists of two parts:

1. The normal entry, which points to the last record on the track.

2. The overflow entry, which contains the key of the first record transferred to the overflow area and also points to the last record transferred from the track to the overflow area.

If there are no overflow records from the track, both index entries point to the last record on the track. An additional field is added to each record that is placed in the overflow area. It points to the previous record transferred from the same track; the first record from each track is linked to the corresponding overflow entry in the track index.

CREATING AN INDEXED DATA SET

When you create an INDEXED data set, your program must write the records in the data set sequentially in the order of ascending key values; the associated file must be opened for SEQUENTIAL OUTPUT.

You can use a single DD statement to define the whole of the data set (index area, prime area, and overflow area), or you can use two or three statements to define the areas independently. If you use two DD statements, you can define either the index area and the prime area together, or the prime area and the overflow area together.

If you want the whole of the data set to be on a single volume, there is no advantage to be gained by using more than one DD statement except to define an independent overflow area (see "Overflow Area," later in this chapter). But, if you use separate DD statements to define the index and/or overflow area on volumes separate from that which contains the prime area, you will increase the speed of direct access to the records in the data set by reducing the number of access mechanism movements required.

When you use two or three DD statements to define an INDEXED data set, the statements must appear in the order: index area; prime area; overflow area. The DD statement must have a name (ddname), but the name fields of a second or third DD statement must be blank. The DD statements for the prime and overflow areas must specify the same type of unit (UNIT parameter). You must include all the DCB information for the data set in the first DD statement; DCB=DSORG=IS will suffice in the other statements.

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Output device	UNIT= or VOLUME=REF=
	Storage space required	SPACE=
	Data control block information: refer to figure 8.12.	DCB=
More than one DD statement	Name of data set and area (index, prime, overflow)	DSNAME=
Data set to be used in another job step but not required after end of job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=
Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

Figure 8.11. Creating an INDEXED data set: essential parameters of DD statement

An INDEXED data set consisting of fixed-length records can be extended by adding records sequentially at the end, until the original space allocated for the prime data is filled. The corresponding file must be opened for sequential output and you must include DISP=MOD in the DD statement.

Essential Information

To create an INDEXED data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

You must supply the following information when creating an INDEXED data set:

1. Device that will write or punch your data set (UNIT or VOLUME parameter of DD statement).

2. Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size.

If you want to keep a direct-access data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing. All the essential parameters required in a DD statement for the creation of an INDEXED data set are summarized in figure 8.11, and figure 8.12 lists the DCB subparameters needed.

Appendix A contains a description of the DCB subparameters.

You cannot place an INDEXED data set on a system output (SYSOUT) device.

You must request space for the prime data area in the SPACE parameter. Your request must be in units of cylinders unless you place the data set in a specific position on the volume (by specifying a track number in the SPACE parameter). In the latter case, the number of tracks you specify must be equivalent to an integral number of cylinders, and the first track must be the first track of a cylinder other than the first cylinder in the volume. You can also use the SPACE parameter to specify the amount of space to be used for the cylinder and master indexes (unless you use a separate DD statement for this purpose). If you do not specify the space for the indexes, the operating system will use part of the independent overflow area; if there is no independent overflow area, it will use part of the prime data area.

In the DCB parameter, you must always specify the data set organization (DSORG=IS), and in the first (or only) DD statement you must also specify the length of the key (KEYLEN).

DCB Subparameters		
When required	To specify	Subparameters
These are always required	Record format[1]	RECFM=F, FB, FBS, V, VB, or VBS
	Block size[1]	BLKSIZE=
	Data set organization	DSORG=IS
	Key length	KEYLEN=
Include at least one of these if overflow is required	Cylinder overflow area and number of tracks per cylinder for overflow records	CPTCD=Y and CYLOFL=
	Independent overflow area	CPTCD=I
These are optional	Record length[1]	LRECL=
	Embedded key (relative key position)	RKP=
	Master index	OPTCD=M
	Automatic processing of dummy records	OPTCD=L
	Number of data management buffers[1]	BUFNO=
	Number of tracks in cylinder index for each master index entry	NTM=
[1]Alternatively, can be specified in ENVIRONMENT attribute.		

Note: Full DCB information must appear in the first, or only, DD statement. Subsequent statements require only DSORG=IS.

Figure 8.12. DCB subparameters for an INDEXED data set

Name of Data Set

If you use only one DD statement to define your data set, you need not name the data set unless you intend to access it in another job. But, if you include two or three DD statements, you must specify a data set name, even for a temporary data set.

The DSNAME parameter in a DD statement that defines an INDEXED data set not only gives the data set a name, but it also identifies the area of the data set to which the DD statement refers:

```
DSNAME=name(INDEX)

DSNAME=name(PRIME)

DSNAME=name(OVFLOW)
```

If the data set is temporary, prefix its name with &&. If you use one DD statement to define the prime and index or prime and overflow area, code DSNAME=name(PRIME); if you use one DD statement, code DSNAME=name(PRIME), or simply DSNAME=name.

Record Format and Keys

An INDEXED data set can contain either fixed- or variable-length records, blocked or unblocked. You must always specify the record format either in your PL/I program (ENVIRONMENT attribute) or in the DD statement (RECFM subparameter).

The key associated with each record can be contiguous with or embedded within the data in the record; you can save storage space in the data set if you use blocked records with embedded keys.

If the records are unblocked, the key of each record is recorded in the data set in front of the record even if it is also embedded within the record, as shown in (a) and (b) of figure 8.13. If blocked records do not have embedded keys, the key of each

record is recorded within the block in front of the record, and the key of the last record in the block is also recorded in front of the block, as shown in (c) of figure 8.13. When blocked records have embedded keys, the individual keys are not recorded separately in front of each record in the block; the key of the last record in the block is recorded in front of the block, as shown in (d) of figure 8.13.

If you use blocked records with non-embedded keys, the record size that you specify must include the length of the key, and the block size must be a multiple of this combined length. Otherwise, record

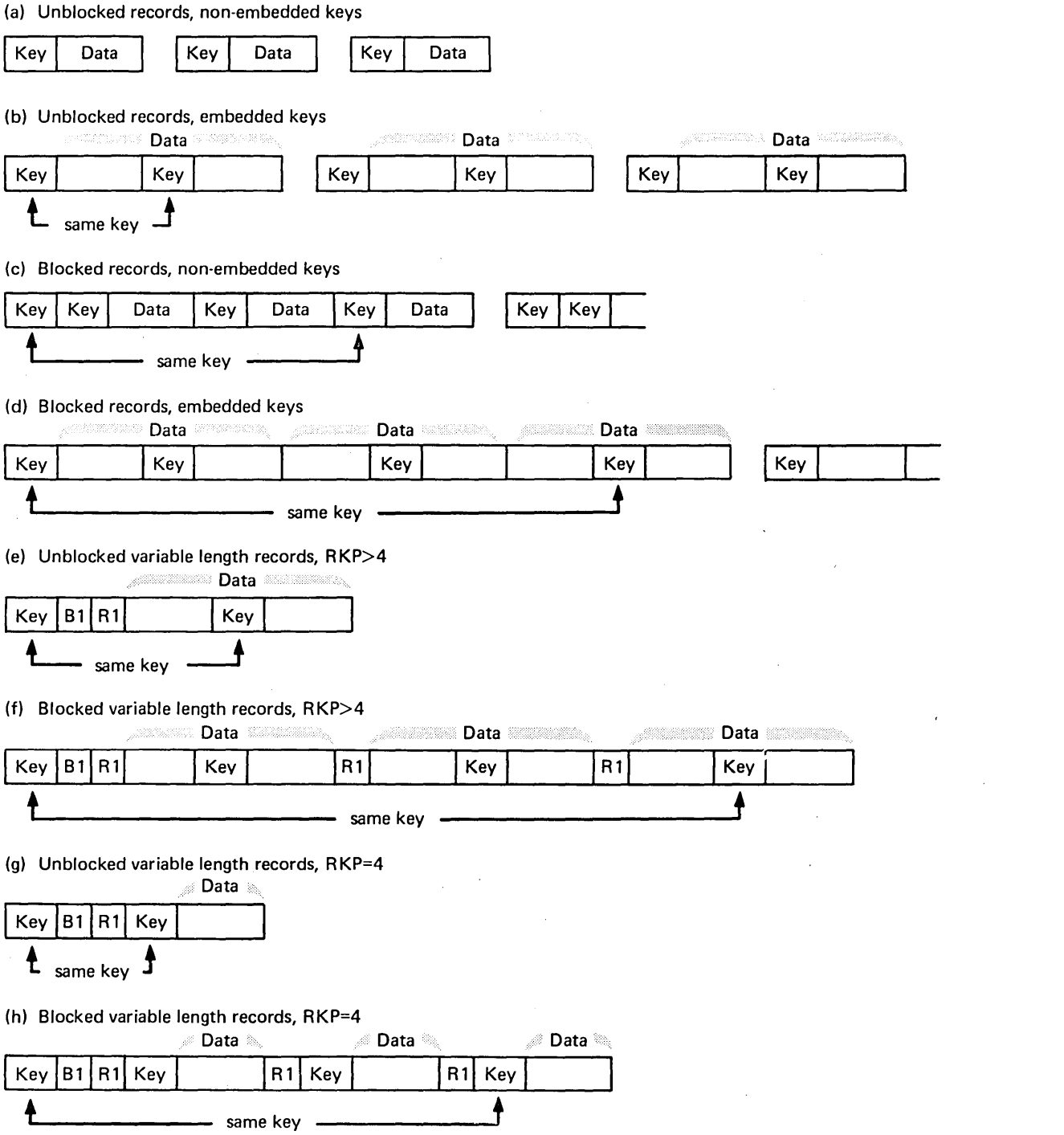


Figure 8.13. Record formats in an INDEXED data set

length and block size refer only to the data in the record. Record format information is shown in figure 8.14.

	RKP	LRECL	BLKSIZE
Blocked records	Not zero	R	R * B
	Zero or omitted	R + K	B*(R+K)
Unblocked records	Not zero	R	R
	Zero or omitted	R	R

R = Size of data in record

K = Length of keys (as specified in KEYLEN subparameter)

B = Blocking factor

Example: For blocked records, non-embedded keys, 100 bytes of data per record, 10 records per block, key length = 20:
LRECL=120,BLKSIZE=1200,RECFM=FB

Figure 8.14. Record format information for an INDEXED data set

If you use records with embedded keys, you must include the DCB subparameter RKP to indicate the position of the key within the record. For fixed-length records the value specified in the RKP subparameter is one less than the byte number of the first character of the key; that is, if RKP=1, the key starts in the second byte of the record. The value assumed if you omit this subparameter is RKP=0, which specifies that the key is not embedded in the record but is separate from it.

For variable-length records, the value specified in the RKP subparameter must be the relative position of the key within the record plus four. The extra four bytes take into account the 4-byte control field used with variable-length records. For this reason you must never specify RKP less than four. When deleting records you must always specify RKP equal to or greater than five, since the first byte of the data is used to indicate deletion.

For unblocked records, the key, even if embedded, is always recorded in a position preceding the actual data. Consequently, the RKP subparameter need not be specified for unblocked records.

Overflow Area

If you intend to add records to the data set on a future occasion, you must request either a cylinder overflow area or an independent overflow area, or both.

For a cylinder overflow area, include the DCB subparameter OPTCD=Y and use the subparameter CYLOFL to specify the number of tracks in each cylinder to be reserved for overflow records. A cylinder overflow area has the advantage of a short search time for overflow records, but the amount of space available for overflow records is limited, and much of the space may be unused if the overflow records are not evenly distributed throughout the data set.

For an independent overflow area, use the DCB subparameter OPTCD=I to indicate that overflow records are to be placed in an area reserved for overflow records from all cylinders, and include a separate DD statement to define the overflow area. The use of an independent area has the advantage of reducing the amount of unused space for overflow records, but entails an increased search time for overflow records.

It is good practice to request cylinder overflow areas large enough to contain a reasonable number of additional records and an independent overflow area to be used as the cylinder overflow areas are filled.

If the prime data area is not filled during creation, you cannot use the unused portion for overflow records, nor for any records subsequently added during direct access (although you can fill the unfilled portion of the last track used). You can reserve space for later use within the prime data area by writing "dummy" records during creation: see "Dummy Records," later in this chapter.

Master Index

If you want the operating system to create a master index for you, include the DCB subparameter OPTCD=M, and indicate in the NTM subparameter the number of tracks in the cylinder index you wish to be referred to by each entry in the master index. The operating system will automatically create up to three levels of master index, the first two levels addressing tracks in the next lower level of the master index.

Dummy Records

You cannot change the specification of an INDEXED data set after you have created it. Therefore, you must foresee your future needs where the size and location of the index, prime, and overflow areas are concerned, and you must decide whether you want the operating system to identify and skip dummy (deleted) records.

If you code OPTCD=L, the operating system will identify any record that is named in a DELETE statement by placing the bit string (8)'1'B in the first byte. Subsequently, during SEQUENTIAL processing of the data set, such records will be ignored; if they are forced off a track when the data set is being updated, they will not be placed in the overflow area. Do not specify OPTCD=L when using blocked records with non-embedded keys; if you do, the string (8)'1'B will overwrite the key of the "deleted" record.

You can include a dummy record in an INDEXED data set by setting the first byte of data to (8)'1'B and writing the record in the usual way.

ACCESSING AN INDEXED DATA SET

You can open an INDEXED data set for sequential or direct access, and for input or update in each case. Sequential input allows you to read the records in ascending key sequence, and in sequential update you can read and rewrite each record in turn; during sequential access, if OPTCD=L is specified when the data set is created, dummy records are ignored. Using direct input, you can read records using the READ statement, and in direct update you can read or delete existing records or add new ones.

To access an INDEXED data set, you must define it in one, two or three DD statements; the DD statements must correspond with those used when the data set is created. The following paragraphs indicate the essential information you must include in each DD statement, and figure 8.15 summarizes this information.

If the data set is cataloged, you need supply only the following information in each DD statement:

1. The name of the data set (DSNAME parameter). The operating system will locate the information that describes the data set in the system catalog and, if necessary, will request the operator to mount the volume that contains it.

2. Confirmation that the data set exists (DISP parameter).

If the data set is not cataloged, you must, in addition, specify the device that will process the data set and give the serial number of the volume that contains it (UNIT and VOLUME parameters).

REORGANIZING AN INDEXED DATA SET

It is necessary to reorganize an INDEXED data set periodically because the addition of records to the data set results in an increasing number of records in the overflow area. Therefore, even if the overflow area does not eventually become full, the average time required for the direct retrieval of a record will increase. The frequency of reorganization depends on how often the data set is updated, on how much storage is available in the data set, and on your timing requirements.

Reorganizing the data set also eliminates records that are marked as "deleted," but are still present within the data set.

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=
If data set not cataloged	Input device	UNIT= or VOLUME=REF=
	Volume serial number	VOLUME=SER=

Figure 8.15. Accessing an INDEXED data set: essential parameters of DD statement

There are two ways to reorganize an INDEXED data set:

1. Read the data set into an area of main storage or onto a temporary CONSECUTIVE data set, and then recreate it in the original area of auxiliary storage.

2. Read the data set sequentially and write it into a new area of auxiliary storage; you can then release the original auxiliary storage.

EXAMPLES OF INDEXED DATA SETS

The creation of a simple INDEXED data set is illustrated in figure 8.16. The data set contains a telephone directory, using the subscribers' names as keys to the telephone numbers.

```
//OPT8#16  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 TELNOS: PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD SEQUENTIAL KEYED ENV(INDEXED),
             CARD CHAR(80),
             NAME CHAR(20) DEF CARD POS(1),
             NUMBER CHAR(3) DEF CARD POS(21),
             IOFIELD CHAR(3);

         ON ENDFILE(SYSIN) GO TO FINISH;

         OPEN FILE(DIREC) OUTPUT;
 NEXTIN: GET FILE(SYSIN) EDIT(CARD)(A(80));
         IOFIELD=NUMBER;
         WRITE FILE(DIREC) FROM(IOFIELD) KEYFROM(NAME);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(DIREC);
         END TELNOS;
/*
//GO.DIREC DD DSNAME=TELNO(INDEX),UNIT=2311,SPACE=(CYL,1),
//      DCB=(RECFM=F,BLKSIZE=3,DSORG=IS,KEYLEN=20,OPTCD=LIY,CYLOFL=2),
//      DISP=(NEW,KEEP),VOLUME=SER=D186
//      DD DSNAME=TELNO(PRIME),UNIT=2311,SPACE=(CYL,4),DCB=DSORG=IS,
//      DISP=(NEW,KEEP),VOLUME=SER=D186
//      DD DSNAME=TELNO(OVFLOW),UNIT=2311,SPACE=(CYL,4),
//      DCB=DSORG=IS,DISP=(NEW,KEEP),VOL=SER=D186
//GO.SYSIN DD *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESEMAN,D.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,S.          413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF,D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 8.16. Creating an INDEXED data set

The program in figure 8.17 updates this data set and prints out its new contents. The input data includes the following codes to indicate the operations required:

A: Add a new record
C: Change an existing record
D: Delete an existing record

```
//OPT8#17  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DIRUPDT:PROC OPTIONS(MAIN);

         DCL DIREC FILE RECORD KEYED ENV(INDEXED),
             ONCODE BUILTIN,
             NUMBER CHAR(3),
             NAME CHAR(20),
             CODE CHAR(2);

         ON ENDFILE(SYSIN) GO TO PRINT;

         ON KEY(DIREC) BEGIN;
          IF ONCODE=51 THEN PUT FILE(SYSPRINT) SKIP EDIT
                            ('NOT FOUND:',NAME)(A(15),A);
          IF ONCODE=52 THEN PUT FILE(SYSPRINT) SKIP EDIT
                           ('DUPLICATE:',NAME)(A(15),A);
          END;

         OPEN FILE(DIREC) DIRECT UPDATE;
 NEXT: GET FILE(SYSIN) EDIT(NAME,NUMBER,CODE)(A(20),A(3),X(56),A(1));
         IF CODE='A' THEN WRITE FILE(DIREC) FROM(NUMBER) KEYFROM(NAME);
         ELSE IF CODE='C' THEN REWRITE FILE(DIREC) FROM(NUMBER)
                                                      KEY(NAME);
         ELSE IF CODE='D' THEN DELETE FILE(DIREC) KEY(NAME);
         ELSE PUT FILE(SYSPRINT) SKIP EDIT('INVALID CODE:',NAME)
                                          (A(15),A);
         GO TO NEXT;
 PRINT:  CLOSE FILE(DIREC);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(DIREC) SEQUENTIAL INPUT;

         ON ENDFILE(DIREC) GO TO FINISH;

 NEXTIN: READ FILE(DIREC) INTO(NUMBER) KEYTO(NAME);
         PUT FILE(SYSPRINT) SKIP EDIT(NAME,NUMBER)(A);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(DIREC);
         END DIRUPDT;
/*
//GO.DIREC DD DSN=TELNO(INDEX),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//         DD DSN=TELNO(PRIME),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//         DD DSN=TELNO(OVFLOW),UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//GO.SYSIN DD *
NEWMAN,M.W.          516                                              C
GOODFELLOW,D.T.      889                                              A
MILES,R.                                                              D
HARVEY,C.D.W.        209                                              A
BARTLETT,S.G.        183                                              A
CORY,G.                                                               D
READ,K.M.            001                                              A
PITT,W.H.
ROLF,D.F.                                                             D
ELLIOTT,D.           291                                              C
HASTINGS,G.M.                                                         D
BRAMLEY,O.H.         439                                              C
/*
```

Figure 8.17. Updating an INDEXED data set

REGIONAL Data Sets

A data set with REGIONAL organization can exist only on a direct-access device. A REGIONAL data set is divided into regions that are numbered consecutively from zero. The following paragraphs briefly describe the three types of REGIONAL organization.

REGIONAL(1): In this organization a region is a record. Each record in the data set is identified by its region number, an unsigned decimal integer not exceeding 16777215. Region numbers start from 0 at the beginning of the data set. There are no recorded keys.

REGIONAL(2): This organization is similar to REGIONAL(1), but differs, in that a key is recorded with each record. The recorded key is a string of not more than 255 characters. For files with the DIRECT attribute, a record is written in the first vacant space on the track that contains the region number specified in the WRITE statement; for retrieval, the search for a record begins on the track that contains the region number specified in the READ statement, and may continue through the data set until the record has been found. For files that are created sequentially, the record is written in the region specified.

REGIONAL(3): This organization is similar to REGIONAL(2), but differs in that each region corresponds to one track of the direct-access device and is not a record position. Depending on the record length, a region can contain one or more records.

The major advantage of REGIONAL organization over other types of data set organization is that it allows you to control the relative placement of records; by judicious programming, you can optimize record access in terms of device capabilities and the requirements of particular applications. REGIONAL(1) organization is most suited to applications where there will be no duplicate region numbers, and where most of the regions will be filled (reducing wasted space in the data set). REGIONAL(2) and REGIONAL(3) are more appropriate where records are identified by numbers that are thinly distributed over a wide range. You can include in your program an algorithm that derives the region number from the number that identifies a record in such a manner as to optimize the use of space within the data set; duplicate region numbers may occur but, unless they are on the same track, their only effect might be to lengthen the search time for records with duplicate region numbers.

REGIONAL(1) and REGIONAL(2) data sets can contain only F-format unblocked records, but a REGIONAL(3) data set can have unblocked records of all three formats, F, V, and U. The examples at the end of this section illustrate typical applications of all three types of REGIONAL organization.

CREATING A REGIONAL DATA SET

You can use either sequential or direct-access to create a REGIONAL data set.

In sequential creation, you must present records in order of ascending region numbers; for REGIONAL(1) and REGIONAL(2) the region number for each record must exceed that of the preceding record since each region can contain only one record. In all cases, dummy records (identified by (8)'1'B in the first byte) are placed automatically in regions whose numbers are skipped.

For direct creation, one of the PL/I library subroutines formats the whole of the data set when you open the corresponding file. For REGIONAL(1) and (2), and for REGIONAL(3) with F-format records, formatting involves filling the data set with dummy records; for REGIONAL(3) with U-format or V-format records, a record, called the capacity record is written at the start of each track to indicate an empty track. During creation, you can present records in any order.

Essential Information

To create a REGIONAL data set, you must give the operating system certain information either in your PL/I program or in the DD statement that defines the data set. The following paragraphs indicate the essential information, and discuss some of the optional information you may supply; the ENVIRONMENT attribute and the LINESIZE option are discussed fully in the language reference manual for this compiler.

You must supply the following information when creating a REGIONAL data set:

1. Device that will write or punch your data set (UNIT or VOLUME parameter of DD statement).

2. Block size: you can specify the block size either in your PL/I program (ENVIRONMENT attribute or LINESIZE option) or in the DD statement (BLKSIZE subparameter). If you do not specify a record length, unblocked records are assumed and the record length is determined from the block size.

If you want to keep a data set (that is, you do not want the operating system to delete it at the end of your job), the DD statement must name the data set and indicate how it is to be disposed of (DSNAME and DISP parameters). The DISP parameter alone will suffice if you want to use the data set in a later step but will not need it after the end of your job.

If you want your data set stored on a particular direct-access device, you must indicate the volume serial number in the DD statement (SER or REF subparameter of VOLUME parameter). If you do not supply a serial number for a data set that you want to keep, the operating system will allocate one, inform the operator, and print the number on your program listing. All the essential parameters required in a DD statement for the creation of a REGIONAL data set are summarized in figure 8.18, and figure 8.19 lists the DCB subparameters needed. Appendix A contains a description of the DCB subparameters.

You cannot place a REGIONAL data set on a system output (SYSOUT) device.

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Output device	UNIT= or VOLUME=REF=
	Storage space required	SPACE=
	Data control block information: refer to figure 8.19	DCB=
Data set to be used in another job step but not required in another job	Disposition	DISP=
Data set to be kept after end of job	Disposition	DISP=
	Name of data set	DSNAME=
Data set to be on particular volume	Volume serial number	VOLUME=SER= or VOLUME=REF=

Figure 8.18. Creating a REGIONAL data set: essential parameters of DD statement

DCB Subparameters		
When required	To specify	Subparameters
These are always required	Record format[1]	RECFM=F or RECFM=V[2] REGIONAL(3) only or RECFM=U REGIONAL(3) only
	Block size[1]	BLKSIZE=
	Data set organization	DSORG=DA
	Key length (REGIONAL(2) and (3) only)	KEYLEN=
These are optional	Limited search for a record or space to add a record (REGIONAL(2) and (3) only)	LIMCT=
	Number of data management buffers[1]	BUFNO=

[1] Alternatively, can be specified in ENVIRONMENT attribute.
[2] RECFM=VS must be specified in the ENVIRONMENT attribute for sequential input or update.

Figure 8.19. DCB subparameters for a REGIONAL data set

In the DCB parameter, you must always specify the data set organization as direct by coding DSORG=DA. For REGIONAL(2) and REGIONAL(3), you must also specify the length of the recorded key (KEYLEN): refer to the language reference manual for this compiler for a description of how the recorded key is derived from the source key supplied in the KEYFROM option.

For REGIONAL(2) and REGIONAL(3), if you want to restrict the search for space to add a new record, or the search for an existing record, to a limited number of tracks beyond the track that contains the specified region, use the LIMCT subparameter of the DCB parameter. If you omit this parameter, the search will continue to the end of the data set, and then from the beginning of the data set back to the starting point in the data set.

ACCESSING A REGIONAL DATA SET

You can open an existing REGIONAL data set for sequential or direct access, and for input or update in each case. Using sequential input with a REGIONAL(1) data set you can read all the records in ascending region number sequence, and in sequential update you can read and may rewrite each record in turn. Sequential access of a REGIONAL(2) or REGIONAL(3) data set will give you the records in the order in which they appear in the data set, which is not necessarily region number order. Using direct input, you can read any record by supplying its region number and, for REGIONAL(2) and REGIONAL(3), its recorded key; in direct update, you can read or delete existing records or add new ones. The operating system ignores dummy records in a REGIONAL(2) or REGIONAL(3) data set; but a program that processes a REGIONAL(1) data set must be prepared to recognize dummy records.

To access a REGIONAL data set, you must identify it to the operating system in a DD statement. The following paragraphs indicate the minimum information you must include in the DD statement; this information is summarized in figure 8.20.

If the data set is cataloged, you need supply only the following information in your DD statement:

1. The name of the data set (DSNAME parameter). The operating system will locate the information that describes the data set in the system catalog and, if necessary, will request the operator to mount the volume that contains it.

Parameters of DD Statement		
When required	What you must state	Parameters
Always	Name of data set	DSNAME=
	Disposition of data set	DISP=
If data set not cataloged	Input device	UNIT= or VOLUME=REF=
	Volume serial number	VOLUME=SER=

Figure 8.20. Accessing a REGIONAL data set: essential parameters of DD statement

2. Confirmation that the data set exists (DISP parameter).

If the data set is not cataloged, you must, in addition, specify the device that will read the data set and give the serial number of the volume that contains the data set (UNIT and VOLUME parameters).

EXAMPLES OF REGIONAL DATA SETS

REGIONAL(1) Data Sets

Creating a REGIONAL(1) data set is illustrated in figure 8.21.

The program uses the same data as that in figure 8.16, but interprets it in a different way: the data set is effectively a list of telephone numbers with the names of the subscribers to whom they are allocated. The telephone numbers correspond with the region numbers in the data set, the data in each occupied region being a subscriber's name. The SPACE parameter of the DD statement requests space for 1000 twenty-byte records (that is, for 1000 regions); since space is never allocated in units of less than one track and one 2311 track can accommodate 45 twenty-byte records, there will in fact be 1035 regions. Note that there are no recorded keys in a REGIONAL(1) data set.

Updating a REGIONAL(1) data set is illustrated in figure 8.22. The data read by the program is identical with that used in figure 8.17, and the codes are interpreted in the same way. Like the program in figure 8.17, this program updates the data set and lists its contents. Before each new or updated record is written the existing record in the region is tested to ensure that it is a dummy; this is necessary because a WRITE statement can overwrite an existing record in a REGIONAL(1) data set even if it is not a dummy. Similarly, during the sequential reading and printing of the contents of the data set, each record is tested and dummy records are not printed.

REGIONAL(2) Data Sets

The use of REGIONAL(2) data sets is illustrated in figure 8.23, figure 8.24, and figure 8.25. The programs in these figures perform the same functions as those given for REGIONAL(3), with which they can usefully be compared.

The programs depict a library processing scheme, in which loans of books are recorded and reminders are issued for overdue books. Two data sets, STOCK2 and LOANS2, are involved. STOCK2 contains descriptions of the books in the library, and uses the 4-digit book reference numbers as recorded keys; a simple algorithm is used to derive the region numbers from the reference numbers. (It is assumed that there are about 1000 books, each with a number in the range 1000-9999.) LOANS2 contains records of books that are on loan; each record comprises two dates, the date of issue and the date of the last reminder. Each reader is identified by a 3-digit reference number, which is used as a region number in LOANS2; the reader and book numbers are concatenated to form the recorded keys.

In figure 8.23, the data sets STOCK2 and LOANS2 are created. The file LOANS, which is used to create the data set LOANS2 is opened for direct output merely to format the data set; the file is closed immediately without any records being written onto the data set. It is assumed that the number of books on loan will not exceed 100; therefore the SPACE parameter in the DD statement that defines LOANS2 requests 100 blocks of 19 bytes (12 bytes

of data and a 7-byte key: see figure 8.24). Direct creation is also used for the data set STOCK2 because, even if the input data is presented in ascending reference number order, identical region numbers might be derived from successive reference numbers.

Updating of the data set LOAN2 is illustrated in figure 8.24. Each item of input data, read from a punched card, comprises a book number, a reader number, and a code to indicate whether it refers to a new issue (I), a returned book (R), or a renewal (A). The position of the reader number on the card allows the 8-character region number to be derived directly by overlay defining. The DATE built-in function is used to obtain the current date. This date is written in both the issue date and reminder date portions of a new record or an updated record.

The program in figure 8.25 uses a sequential update file (LOANS) to process the records in the data set LOANS2, and a direct input file (STOCK) to obtain the book description from the data set STOCK2 for use in a reminder note. Each record from LOAN2 is tested to see whether the last reminder was issued more than a month ago; if necessary, a reminder note is issued and the current date is written in the reminder date field of the record.

REGIONAL(3) Data Sets

The use of REGIONAL(3) data sets, illustrated in figure 8.26, figure 8.27, and figure 8.28, is similar to the REGIONAL(2) figures, above; only the important differences are discussed here.

To conserve space in the data set STOCK3, U-format records are used. In each record, the author's name and the title of the book are concatenated in a single character string, and the lengths of the two parts of the string are written as part of the record. The average record (including the recorded key) is assumed to be 60 bytes; therefore the average number of records per track (that is, per region) is 25, and there will be 40 regions.

In figure 8.26, the data set STOCK3 is created sequentially; duplicate region numbers are acceptable since each region can contain more than one record.

In figure 8.27, the region number for the data set LOANS3 is obtained simply by testing the reader number; there are only three regions, since a 2311 track can hold 36 nineteen-byte records.

The only notable difference between figure 8.28 and the corresponding REGIONAL(2) figure is in the additional processing required for the anlysis of the records read from the data set STOCK3. The records are read into a varying-length character string and a based structure is overlaid on the string so that the data in the record can be extracted.

```
//OPT8#21  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR1:   PROC OPTIONS(MAIN);

         DCL NOS FILE RECORD OUTPUT DIRECT KEYED ENV(REGIONAL(1)),
             CARD CHAR(80),
             NAME CHAR(20) DEF CARD POS(1),
             NUMBER CHAR(3) DEF CARD POS(21),
             IOFIELD CHAR(20);

         ON ENDFILE (SYSIN) GO TO FINISH;

         OPEN FILE(NOS);
 NEXT:   GET FILE(SYSIN) EDIT(CARD)(A(80));
         IOFIELD=NAME;
         WRITE FILE(NOS) FROM(IOFIELD) KEYFROM(NUMBER);
         GO TO NEXT;
 FINISH: CLOSE FILE(NOS);
         END CRR1;
/*
//GO.NOS DD DSN=NOSA,UNIT=2311,SPACE=(CYL,10),DCB=(RECFM=F,
//          BLKSIZE=20,DSORG=DA),DISP=(NEW,KEEP),VOL=SER=D186
//GO.SYSIN DD *
ACTION,G.           162
BAKER,R.            152
BRAMLEY,O.H.        248
CHEESNAME,L.        141
CORY,G.             336
ELLIOTT,D.          875
FIGGINS,E.S.        413
HARVEY,C.D.W.       205
HASTINGS,G.M.       391
KENDALL,J.G.        294
LANCASTER,W.R.      624
MILES,R.            233
NEWMAN,M.W.         450
PITT,W.H.           515
ROLF.D.E.           114
SHEERS,C.D.         241
SUTCLIFFE,M.        472
TAYLOR,G.C.         407
WILTON,L.W.         404
WINSTONE,E.M.       307
/*
```

Figure 8.21. Creating a REGIONAL(1) data set

```
//OPT8#22  JOB
//STEP1    EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 ACR1:       PROC OPTIONS(MAIN);

         DCL NOS FILE RECORD KEYED ENV(REGIONAL(1)),
             NAME CHAR(20),
             (NEWNO,OLDNO) CHAR(3),
             CODE CHAR(1),
             IOFIELD CHAR(20),
             BYTE1     CHAR(1) DEF IOFIELD POS(1);

         ON ENDFILE(SYSIN) GO TO PRINT;

         OPEN FILE(NOS) DIRECT UPDATE;
 NEXT:       GET FILE(SYSIN) EDIT(NAME,NEWNO,OLDNO,CODE)
             (A(20),2 A(3),X(53),A(1));
         IF CODE='A' THEN GO TO RITE;
             ELSE IF CODE='C' THEN DO;
             DELETE FILE(NOS) KEY(OLDNO);
             GO TO RITE;
             END;
         ELSE IF CODE='D' THEN DELETE FILE(NOS) KEY(OLDNO);
               ELSE PUT FILE(SYSPRINT) SKIP
                         EDIT('INVALID CODE:',NAME)(A(15),A);
         GO TO NEXT;
 RITE:       READ FILE(NOS) KEY(NEWNO) INTO(IOFIELD);
         IF UNSPEC(BYTE1)=(8)'1'B THEN WRITE FILE(NOS) KEYFROM(NEWNO)
                                              FROM(NAME);
         ELSE PUT FILE(SYSPRINT) SKIP EDIT('DUPLICATE:',NAME)(A(15),A);
         GO TO NEXT;
 PRINT:  CLOSE FILE(NOS);
         PUT FILE(SYSPRINT) PAGE;
         OPEN FILE(NOS) SEQUENTIAL INPUT;

         ON ENDFILE(NOS) GO TO FINISH;

 NEXTIN: READ FILE(NOS) INTO(IOFIELD) KEYTO(NEWNO);
         IF UNSPEC(BYTE1)=(8)'1'B THEN GO TO NEXTIN;
         ELSE PUT FILE(SYSPRINT) SKIP EDIT(NEWNO,IOFIELD)(A(5),A);
         GO TO NEXTIN;
 FINISH: CLOSE FILE(NOS);
         END ACR1;
/*
//GO.NOS DD DSN=NOSA,UNIT=2311,VOL=SER=D186,DISP=(OLD,KEEP)
//GO.SYSIN DD *
NEWMAN,M.W          516450                                          C
GOODFELLOW,D.T.     889                                             A
MILES,R.               233                                          D
HARVEY,C.D.W.       209                                             A
BARTLETT,S.G.       183                                             A
CORY,G.                336                                          D
READ,K.M.           001                                             A
PITT,W.H.              515
ROLF,D.F.              114                                          D
ELLIOTT,D.          472875                                          C
HASTINGS,G.M.          391                                          D
BRAMLEY,O.H.        439248                                          C
/*
```

Figure 8.22. Updating a REGIONAL(1) data set

```
//OPT8#23  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR2:    PROC OPTIONS(MAIN);

          DCL STOCK FILE RECORD KEYED ENV(REGIONAL(2)),
              NUMBER CHAR(4),
              1 BOOK,
                2 AUTHOR CHAR(25),
                2 TITLE CHAR(50),
                2 QTY FIXED DEC(3),
              INTER FIXED DEC(5),
              REGION CHAR(8);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(STOCK) DIRECT OUTPUT;
 NEXT:    GET FILE(SYSIN) LIST(NUMBER,BOOK);
          INTER=(NUMBER-1000)/9;  /* INTERMEDIATE FIXED DECIMAL ITEM */
          REGION=INTER;    /* USED TO ENSURE CORRECT PRECISION  */
          WRITE FILE(STOCK) FROM(BOOK) KEYFROM(NUMBER||REGION);
          GO TO NEXT;
 FINISH: CLOSE FILE(STOCK);
          END CRR2;
/*
//GO.STOCK DD DSN=STOCK2,UNIT=2311,SPACE=(CYL,5),DCB=(RECFM=F,
//             BLKSIZE=77,DSORG=DA,KEYLEN=4),DISP=(NEW,CATLG),
//             VOLUME=SER=D186
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9765' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 8.23. Creating a REGIONAL(2) data set

```
//OPT8#24  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DUR2:    PROC OPTIONS(MAIN);
          DCL 1 RECORD,
                2 (ISSUE,REMINDER) CHAR(6),
              SYSIN FILE RECORD INPUT SEQUENTIAL,
              LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(2)),
              CARD CHAR(80),
              DATE BUILTIN,
              BOOK CHAR(4) DEF CARD POS(1),
              READER CHAR(3) DEF CARD POS(10),
              CODE CHAR(1) DEF CARD POS(20),
              REGION CHAR(8) DEF CARD POS(5);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(SYSIN),FILE(LOANS);
          ISSUE,REMINDER=DATE;
 NEXT:    READ FILE(SYSIN) INTO(CARD);
          IF CODE='I' THEN WRITE FILE(LOANS) FROM(RECORD)
                           KEYFROM(READER||BOOK||REGION);
          ELSE IF CODE='R' THEN DELETE FILE(LOANS)
                           KEY(READER||BOOK||REGION);
          ELSE IF CODE='A' THEN REWRITE FILE(LOANS) FROM(RECORD)
                           KEY(READER||BOOK||REGION);
          ELSE PUT FILE(SYSPRINT) SKIP LIST
                           ('INVALID CODE:',BOOK,READER);
          GO TO NEXT;
 FINISH:  CLOSE FILE(SYSIN),FILE(LOANS);
          END DUR2;
/*
//GO.LOANS DD DSN=LOADS2,DISP=OLD
//GO.SYSIN DD *
3085      095        X
5999      003        A
3083      091        R
3083      049        I
/*
```

Figure 8.24. Updating a REGIONAL(2) data set directly

```
//OPT8#25  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SUR2:    PROC OPTIONS(MAIN);

          DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(2)),
              STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(2)),
              (TODAY,LASMTH) CHAR(6),
              YEAR PIC '99' DEF LASMTH,
              MONTH PIC '99' DEF LASMTH POS(3),
              1 RECORD,
                2 (ISSUE,REMINDER) CHAR(6),
              DATE BUILTIN,
              LOANKEY CHAR(7),
              READER CHAR(3) DEF LOANKEY POS(1),
              BKNO CHAR(4) DEF LOANKEY POS(4),
              INTER FIXED DEC(5),
              REGION CHAR(8),
              1 BOOK,
                2 AUTHOR CHAR(25),
                2 TITLE CHAR(50),
                2 QTY FIXED DEC(3);

          TODAY,LASMTH=DATE;
          IF MONTH='01' THEN DO;
            MONTH='12';
            YEAR=YEAR-1;
            END;
          ELSE MONTH=MONTH-1;
          OPEN FILE(LOANS),FILE(STOCK);

          ON ENDFILE(LOANS) GO TO FINISH;

 NEXT:    READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
          IF REMINDER<LASMTH THEN DO;
            REMINDER=TODAY;
            REWRITE FILE(LOANS) FROM(RECORD);
            INTER=(BKNO-1000)/9;  /* INTERMEDIATE FIXED DECIMAL ITEM */
            REGION=INTER;   /* USED TO ENSURE CORRECT PRECISION  */
            READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
            PUT FILE(SYSPRINT) SKIP(4) EDIT(READER,AUTHOR,TITLE)
            (A,SKIP(2));
            END;
          GO TO NEXT;
 FINISH: CLOSE FILE(LOANS),FILE(STOCK);
          END SUR2;
/*
//GO.LOANS DD DSN=LOADS2,DISP=OLD
//GO.STOCK DD DSN=STOCK2,DISP=OLD
```

Figure 8.25. Updating a REGIONAL(2) data set sequentially

```
//OPT8#26  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 CRR3:    PROC OPTIONS(MAIN);

          DCL STOCK FILE RECORD KEYED ENV(REGIONAL(3)),
              1 CARD,
                2 NUMBER CHAR(4),
                2 AUTHOR CHAR(25) VAR,
                2 TITLE CHAR(50) VAR,
                2 QTY1 FIXED DEC(3),
              (L1,L2,X) FIXED DEC(3),
              1 BOOK CTL,
                2 (L3,L4) FIXED DEC(3),
                2 QTY2 FIXED DEC(3),
                2 DESCN CHAR(X) VAR,
              INTER FIXED DEC(5),
              REGION CHAR(8);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(STOCK) SEQUENTIAL OUTPUT;
 NEXT:    GET FILE(SYSIN) LIST(CARD);
          L1=LENGTH(AUTHOR);
          L2=LENGTH(TITLE);
          X=L1+L2;
          ALLOCATE BOOK;
          L3=L1;
          L4=L2;
          QTY2=QTY1;
          DESCN=AUTHOR||TITLE;
          INTER=(NUMBER-1000)/225;      /* INTERMEDIATE FIXED DECIMAL */
          REGION=INTER;                 /* ITEM USED TO ENSURE CORRECT PRECISION    */
          WRITE FILE(STOCK) FROM(BOOK) KEYFROM(NUMBER||REGION);
          FREE BOOK;
          GO TO NEXT;
 FINISH:  CLOSE FILE(STOCK);
          END CRR3;
/*
//GO.STOCK DD DSN=STOCK3,UNIT=2311,SPACE=(CYL,(20,5)),DCB=(RECFM=U,
//       BLKSIZE=110,DSORG=DA,KEYLEN=4),DISP=(,CATLG),VOL=SER=D186
//GO.SYSIN DD *
'1015' 'W.SHAKESPEARE' 'MUCH ADO ABOUT NOTHING'  1
'1214' 'L.CARROLL' 'THE HUNTING OF THE SNARK'  1
'3079' 'G.FLAUBERT' 'MADAME BOVARY'  1
'3083' 'V.M.HUGO' 'LES MISERABLES'  2
'3085' 'J.K.JEROME' 'THREE MEN IN A BOAT'  2
'4295' 'W.LANGLAND' 'THE BOOK CONCERNING PIERS THE PLOWMAN'  1
'5999' 'O.KHAYYAM' 'THE RUBAIYAT OF OMAR KHAYYAM'  3
'6591' 'F.RABELAIS' 'THE HEROIC DEEDS OF GARGANTUA AND PANTAGRUEL'  1
'8362' 'H.D.THOREAU' 'WALDEN, OR LIFE IN THE WOODS'  1
'9765' 'H.G.WELLS' 'THE TIME MACHINE'  3
/*
```

Figure 8.26. Creating a REGIONAL(3) data set

```
//OPT8#27  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 DUR3:    PROC OPTIONS(MAIN);

          DCL 1 RECORD,
                2 (ISSUE,REMINDER) CHAR(6),
              SYSIN FILE RECORD INPUT SEQUENTIAL,
              LOANS FILE RECORD UPDATE DIRECT KEYED ENV(REGIONAL(3)),
              CARD CHAR(80),
              BOOK CHAR(4) DEF CARD POS(1),
              READER CHAR(3) DEF CARD POS(10),
              CODE CHAR(1) DEF CARD POS(20),
              DATE BUILTIN,
              REGION CHAR(8);

          ON ENDFILE(SYSIN) GO TO FINISH;

          OPEN FILE(SYSIN),FILE(LOANS);
          ISSUE,REMINDER=DATE;
 NEXT:    READ FILE(SYSIN) INTO(CARD);
          IF READER<'034' THEN REGION='00000000';
          ELSE IF READER<'067' THEN REGION='00000001';
               ELSE REGION='00000002';
          IF CODE='I' THEN WRITE FILE(LOANS) FROM(RECORD)
                                 KEYFROM(READER||BOOK||REGION);
          ELSE IF CODE='R' THEN DELETE FILE(LOANS)
                                 KEY(READER||BOOK||REGION);
               ELSE IF CODE='A' THEN REWRITE FILE(LOANS) FROM(RECORD)
                                 KEY(READER||BOOK||REGION);
                    ELSE PUT FILE(SYSPRINT) SKIP LIST
                                 ('INVALID CODE',BOOK,READER);
          GO TO NEXT;
 FINISH:  CLOSE FILE(SYSIN),FILE(LOANS);
          END DUR3;
/*
//GO.LOANS DD DSN=LOANS3,DISP=OLD
//GO.SYSIN DD *
3085      095        X
5999      003        A
3083      091        R
3083      049        I
/*
```

Figure 8.27. Updating a REGIONAL(3) data set directly

```
//OPT8#28  JOB
//STEP1 EXEC  PLIXCLG
//PLI.SYSIN  DD  *
 SUR3:   PROC OPTIONS(MAIN);

      DCL LOANS FILE RECORD SEQUENTIAL UPDATE KEYED ENV(REGIONAL(3)),
             STOCK FILE RECORD DIRECT INPUT KEYED ENV(REGIONAL(3)),
             (TODAY,LASMTH) CHAR(6),
             YEAR PIC '99' DEF LASMTH,
             MONTH PIC '99' DEF LASMTH POS(3),
             1 RECORD,
               2(ISSUE,REMINDER) CHAR(6),
             LOANKEY CHAR(7),
             READER CHAR(3) DEF LOANKEY POS(1),
             BKNO CHAR(4) DEF LOANKEY POS(4),
             INTER FIXED DEC(5),
             DATE BUILTIN,
             REGION CHAR(8),
             1 BOOK,
               2 (L1,L2) FIXED DEC(3),
               2 QTY FIXED DEC(3),
               2 DESCN CHAR(75)VAR,
             AUTHOR CHAR(25) VAR,
             TITLE CHAR(50) VAR;

          TODAY,LASMTH=DATE;
          IF MONTH='01' THEN DO;
              MONTH='12';
              YEAR=YEAR-1;
              END;
          ELSE MONTH=MONTH-1;
          OPEN FILE(LOANS),FILE(STOCK);

          ON ENDFILE(LOANS) GO TO FINISH;

 NEXT:    READ FILE(LOANS) INTO(RECORD) KEYTO(LOANKEY);
          IF REMINDER<LASMTH THEN DO;
           REMINDER=TODAY;
           REWRITE FILE(LOANS) FROM(RECORD);
           INTER=(BKNO-1000)/225;     /* INTERMEDIATE FIXED DECIMAL  */
          REGION=INTER;     /*ITEM USED TO ENSURE CORRECT PRECISION  */
           READ FILE(STOCK) INTO(BOOK) KEY(BKNO||REGION);
           AUTHOR=SUBSTR(DESCN,1,L1);
           TITLE=SUBSTR(DESCN,L1+1,L2);
           PUT FILE(SYSPRINT) SKIP(4) EDIT(READER,AUTHOR,TITLE)
                           (A,SKIP(2));
           END;
          GO TO NEXT;
 FINISH: CLOSE FILE(LOANS),FILE(STOCK);
          END SUR3;
/*
//GO.LOANS DD DSN=LOANS3,DISP=OLD
//GO.STOCK DD DSN=STOCK3,DISP=OLD
```

Figure 8.28. Updating a REGIONAL(3) data set sequentially

TELEPROCESSING

Teleprocessing in PL/I is provided by an extension of record-oriented transmission with the addition of the TRANSIENT file attribute and of the PENDING condition. The compiler provides a link between PL/I message processing programs (MPPs) and the Telecommunications Access Method (TCAM) of the operating system.

A TCAM message control program (MCP) handles messages originating from and destined for a number of remote terminals, each of which is identified by a terminal name carried with the message. These messages are transmitted to and from your PL/I message processing program by means of queues in main storage. (These queues are supported by corresponding queues on a direct-access device in auxiliary storage. Your PL/I program has access only to the main storage queues by means of a single buffer for each file.)

The exact message format (specified to the compiler by means of the ENVIRONMENT attribute) depends on the MPP. A message may be a complete unit, or may consist of a number of records so that it can be split up for processing. You must have this message format information to enable you to write the message processing program. Full information on how to write an MPP is given in the language reference manual for this compiler. A full account of TCAM procedure is given in the OS: TCAM Message Processing Program Services and OS: TCAM Message Control Program publications.

MESSAGE PROCESSING PROGRAM (MPP)

This program receives the terminal message as input and produces output according to the data in the message. You can code this program in PL/I.

An MPP is not mandatory at teleprocessing installations, as for example, an MCP is. If the messages you transmit do not require processing, because they are only switched between terminals, an MPP is not required. However, you can pass data to a problem program and you can receive the output with a minimum of delay, and most installations are likely to have a set of processing programs available for these purposes. These programs are stored as load modules, either in main storage or in a library in auxiliary storage.

HOW TO RUN AN MPP

An example of an MPP and the job control language required to run it is shown in figure 8.29. The EXEC statement invokes the cataloged procedure PLIXCL to compile and link edit the PL/I message processing program. The appropriate TCAM modules are included in the program by the linkage editor. The load module produced is stored in the partitioned data set SYS1.MSGLIB under the member name MPPROC.

MPP is declared as a teleprocessing file that can process messages up to 100 bytes long. Similarly OUTMSG is declared as a teleprocessing file that can receive messages up to 500 bytes long.

The READ statement gets a record (that is, a message) from the queue. The terminal identifier is inserted into the KEYTO character string. The record is placed in the INDATA variable for processing. The appropriate READ SET statement could also have been used here.

The WRITE statement puts the data in OUTDATA into the destination queue; the terminal identifier is taken from the character string in TKEY. An appropriate LOCATE statement could also have been used.

Once the load module has been stored on a direct-access device it can be restored for execution at any time. The job control statements to perform this might be:

```
//       JOB
//JOBLIB DD DSNAME=SYS1.MSGLIB,DISP=SHR
//       EXEC PGM=MPPRCC
//DD1    DD QNAME=MPP...
//SYSPRINT  DD  SYSOUT=A
```

The JOBLIB DD statement is required to make SYS1.MSGLIB available so that the operating system can find the program MPPROC. The DD statement with the name DD1 associates the PL/I file with the main storage queue name (MPP).

```
//          JOB
//          EXEC PLIXCL
//PLI.SYSIN DD *
  MPROC: PROC OPTIONS(MAIN);
         DCL MPP FILE RECORD KEYED TRANSIENT ENV(TP(M)RECSIZE(100)),
         OUTMSG FILE RECORD KEYED TRANSIENT ENV(TP(M)RECSIZE(500)),
         INDATA CHAR(100),
         OUTDATA CHAR(500),
         TKEY CHAR(6);
           .
           .
           .
         OPEN FILE(MPP) INPUT,FILE(OUTMSG) OUTPUT;
           .
           .
           .
         READ FILE(MPP) KEYTO(TKEY) INTO(INDATA);
           .
           .
           .
         WRITE FILE(OUTMSG) KEYFORM(TKEY) FROM(OUTDATA);
           .
           .
           .
 ENDTP:  CLOSE FILE(MPP),FILE(OUTMSG);
         END MPPROC;
/*
//LKED.SYSLIB DD DSNAME=SYS1.PL1LIB,DISP=SHR
//LKED.SYSLMOD DD DSNAME=SYS1.MSGLIB(MPPROC),...
```

Figure 8.29. PL/I message processing program

Chapter 9: Libraries of Data Sets

Within the IBM operating system, the terms "partitioned data set" and "library" are used synonymously to signify a type of data set that can be used for the storage of other data sets (usually programs in the form of source, object or load modules). A library must be stored on direct-access storage and be wholly contained in one volume. It contains independent, consecutively-organized, data sets, called members. Each member has a unique name, not more than eight characters long, which is stored in a directory that is part of the library. All the members of one library must have the same data characteristics because only one data set label is maintained.

Members can be created individually until there is insufficient space left for a new entry in the directory, or until there is insufficient space for the member itself. Members can be accessed individually by specifying the member name.

DD statements or ALLOCATE commands are used to create and access members.

Members can be deleted by means of the IBM utility program IEHPROGM. This deletes the member name from the directory so that the member can no longer be accessed; but the space occupied by the member itself cannot be used again unless the library is recreated using, for example, the IBM utility program IEBCOPY. An attempt to delete a member by using the DISP parameter of a DD statement will cause the whole data set to be deleted.

Types of Library

The following types of library may be used with a PL/I program:

1. The system program library SYS1.LINKLIB. This can contain all system processing programs such as compilers and the linkage editor.

2. Private program libraries. These usually contain user-written programs. It is often convenient to create a temporary private library to store the load module output from the linkage editor until it is executed by a later job step in the same job. The library will be deleted at the end of the job. Private libraries are also used for automatic library call by the linkage editor and the loader.

3. The system procedure library, SYS1.PROCLIB. This contains the job control procedures that have been cataloged for your installation.

How to Use a Library

The libraries described above can be used in the following ways.

BY THE LINKAGE EDITOR OR LOADER

The output from the linkage editor is usually placed on a private program library.

The automatic call library used as input to the linkage editor or loader (see chapter 5) can be SYS1.LINKLIB, a private program library, or a subroutine library.

In each case, the processing of directory entries is performed by the operating system.

When you are adding a member to a library, you must specify the member name as follows:

1. When a single module is produced as output from the linkage editor, the member name can be specified as part of the data set name (see later in this chapter).

2. When more than one module is produced as output from the linkage editor, the member name for the first module can be specified as part of the data set name or in the NAME option or NAME control statement. The member names for the subsequent modules must be specified in the NAME option or the NAME control statement.

BY THE OPERATING SYSTEM

When you request the execution of a load module in an EXEC statement or CALL command, the operating system must be able

to retrieve the load module from a library. For a CALL command, this library is specified explicitly or implicitly in the command. For an EXEC statement, the following rules apply.

The operating system will assume the load module is a member of SYS1.LINKLIB, and will search in the directory for that library for the name you have specified, unless you have also specified that the load module is in a private library, in one of the following ways.

If the load module has been added to the private library in a previous step of the job (usually a link-edit step) and the member name was specified as part of the data set name, then you can refer, in the EXEC statement, to the DD statement defining the library instead of specifying the load module name. The library must have been given the disposition PASS.

If the load module exists on the private library before the job starts, then you have several ways of defining the library.

You can define the library in a DD statement, with the ddname JOBLIB, immediately after the JOB statement. This library will be used in place of SYS1.LINKLIB for all the steps of the job. If any load module is not found on the private library, the system will then look for it on SYS1.LINKLIB.

You can define the library in a DD statement with the ddname STEPLIB, at any point in the job control procedure. The private library will be used in place of SYS1.LINKLIB, or any library specified in a JOBLIB DD statement, for the job step in which it appears (though it can also be "passed" to subsequent job steps in the normal way). If any load module is not found on the private library, the system will look for it on the library specified in the JOBLIB DD statement (if used) or on SYS1.LINKLIB. The STEPLIB DD statement can be used in a cataloged procedure.

Alternatively, if you specify SYS1.LINKLIB in the JOBLIB or STEPLIB DD statements, and then concatenate the private library to it, the private library will be used only if a load module cannot be first found on SYS1.LINKLIB.

BY YOUR PROGRAM

Libraries can be used directly by a PL/I program.

If you are adding a new member to a library, its directory entry will be made by the operating system when the associated file is closed, using the member name specified as part of the data set name.

If you are accessing a member of a library, its directory entry can be found by the operating system from the member name that you specify as part of the data set name.

More than one member of the same library can be processed by the same PL/I program, but only one such output file can be open at any one time. Different members are accessed by giving the member name in a DD statement.

Creating a Library

To create a library include in your job step a DD statement containing the following information:

Information Required	Parameter of DD statement
Type of device that will process the library	UNIT=
Serial number of the volume that will contain the library	VOLUME=SER
Name of the library	DSNAME=
Amount of space required for the library	SPACE=
Disposition of the library	DISP=

The information required is similar to that for a consecutively-organized data set (see chapter 8) except for the SPACE parameter.

SPACE PARAMETER

The SPACE parameter in a DD statement that defines a library must always be of the form:

```
SPACE=(units,(quantity,
increment,directory))
```

Although you can omit the third term (increment), indicating its absence by a comma, the last term, specifying the number of directory blocks to be allocated, must always be present.

The amount of auxiliary storage required for a library depends on the number and sizes of the members to be stored in it and on how often members will be added or replaced. (Space occupied by deleted members is not released.) The number of directory blocks required depends on the number of members and the number of aliases. Although you can specify an incremental quantity in the SPACE parameter that will allow the operating system to obtain more space for the data set if necessary, both at the time of creation and when new members are added, the number of directory blocks is fixed at the time of creation and cannot be increased.

If the data set is likely to be large or you expect to do a lot of updating, it might be best to allocate a full volume. Otherwise, make your estimate as accurate as possible to avoid wasting space or time recreating the data set.

The number of directory entries that a 256-byte directory block can contain depends on the amount of user data included in the entries. The maximum length of an entry is 74 bytes, but the entries produced by the linkage editor vary in length between 34 bytes and 52 bytes, which is equivalent to between four and seven entries per block.

For example, the DD statement:

```
//PDS DD UNIT=2311,VOLUME=SER=3412,
//    DSNAME=ALIB,
//    SPACE=(CYL,(50,,10)),
//    DISP=(,CATLG)
```

requests the job scheduler to allocate 50 cylinders of the 2311 disk pack with serial number 3412 for a new partitioned data set named ALIB, and to enter this name in the system catalog. The last term of the SPACE parameter requests that part of the space allocated to the data set be reserved for ten directory blocks.

Creating a Library Member

The members of a library must have identical characteristics otherwise you may subsequently have difficulty retrieving them. This is necessary because the volume table of contents (VTOC) will contain only one data set control block (DSCB) for the library and not one for each member. When using a PL/I program to create a member, the operating system creates the directory entry; you cannot place information in the user data field.

When creating a library and a member at the same time, the DD statement must include all the parameters listed under the heading "Creating a Library," earlier in this chapter (although you can omit the DISP parameter if the data set is to be temporary). The DSNAME parameter must include the member name in parentheses. For example, DSNAME=ALIB(MEM1) names the member MEM1 in the data set ALIB. If the member is placed in the library by the linkage editor, you can use the linkage editor NAME statement or the NAME compiler option instead of including the member name in the DSNAME parameter. You must also describe the characteristics of the member (record format, etc.) either in the DCB parameter or in your PL/I program; these characteristics will also apply to other members added to the data set.

When creating a member to be added to an existing library, you will not need the SPACE parameter; the original space allocation applies to the whole of the library and not to an individual member. Furthermore, you will not need to describe the characteristics of the member, since these are already recorded in the DSCB for the library.

To add two or more members to a library in one job step, you must include a DD statement for each member, and you must close one file that refers to the library before you open another.

Examples

The use of the cataloged procedure PLIXC to compile a simple PL/I program and place the object module in a new library named EXLIB is shown in figure 9.1. The DD statement that defines the new library and names the object module overrides the DD statement SYSLIN in the cataloged procedure. (The PL/I program is a function procedure that, given two values in the form of the character string produced by the TIME built-in function, returns the difference in milliseconds.)

```
//OPT9#1  JOB
//STEP1  EXEC  PLIXC
//PLI.SYSLIN  DD  DSNAME=EXLIB(ELAPSE),UNIT=2311,VOL=SER=D186,
//       SPACE=(CYL,(10,,2)),DISP=(NEW,KEEP)
//PLI.SYSIN  DD  *
   ELAPSE:  PROC(TIME1,TIME2);

     DCL (TIME1,TIME2) CHAR(9),
         H1 PIC '99' DEF TIME1,
         M1 PIC '99' DEF TIME1 POS(3),
         MS1 PIC '99999' DEF TIME1 POS(5),
         H2 PIC '99' DEF TIME2,
         M2 PIC '99' DEF TIME2 POS(3),
         MS2 PIC '99999' DEF TIME2 POS(5),
         ETIME FIXED DEC(7);

     IF H2<H1 THEN H2=H2+24;
     ETIME=((H2*60+M2)*600000+MS2)-((H1*60+M1)*600000+MS1);
     RETURN(ETIME);
     END ELAPSE;
/*
```

Figure 9.1. Creating new libraries for compiled object modules

```
//OPT9#2  JOB
//STEP1  EXEC  PLIXCL
//PLI.SYSIN DD  *
   MNAME:  PROC  OPTIONS(MAIN);

     DCL LINK FILE RECORD SEQUENTIAL INPUT,
         1 DIRBLK,
        2 COUNT BIT(16),
        2 ENTRIES(254) CHAR(1),
         1 ENTRY BASED(A),
        2 NAME CHAR(8),
        2 TTR CHAR(3),
        2 INDIC,
   3 ALIAS BIT(1),
   3 TTRS BIT(2),
   3 USERCT BIT(5),
         (LEN,PTR) FIXED BIN(31);

     ON ENDFILE(LINK) GO TO FINISH;

     OPEN FILE(LINK);
       NEXTBLK: READ FILE(LINK) INTO(DIRBLK);
     LEN=COUNT;
     PTR=1;
       NEXTENT: A=ADDR(ENTRIES(PTR));
     PUT FILE(SYSPRINT) SKIP LIST(NAME);
     PTR=PTR+12+2*USERCT;
     IF PTR+2>LEN THEN GO TO NEXTBLK;
     GO TO NEXTENT;
       FINISH: CLOSE FILE(LINK);
     END MNAME;
/*
//LKED.SYSLMOD  DD  DSN=PUBPGM(DIRLIST),DISP=OLD,VOL=SER=D186,UNIT=2311
```

Figure 9.2. Placing a load module to existing libraries

```
//OPT9#3  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
  NMEM:  PROC OPTIONS(MAIN);

     DCL OUT FILE RECORD SEQUENTIAL OUTPUT,
         IOFIELD CHAR(80) BASED(A);

     ON ENDFILE(IN) GO TO FINISH;

  NEXT: READ FILE(IN) SET(A);
     WRITE FILE(OUT) FROM(IOFIELD);
     GO TO NEXT;
  FINISH: END NMEM;
/*
//GO.OUT   DD  DSN=ALIB(NMEM),UNIT=2311,VOL=SER=D186,
//     DISP=(NEW,CATLG),SPACE=(CYL,(10,1,1)),
//     DCB=(RECFM=FB,BLKSIZE=400,LRECL=80)
//GO.IN  DD  *
 (insert here data to be included in the input stream)
/*
```

Figure 9.3. Creating a library member in a PL/I program

The use of the cataloged procedure PLIXCL to compile and link edit a PL/I program and place the load module in the existing library "FLM" is shown in figure 9.2. (The PL/I program lists the names of the members of a library.)

To use a PL/I program to add or delete one or more records within a member of a library, you must rewrite the entire member in another part of the library; this is rarely an economic proposition, since the space originally occupied by the member

```
//OPT9#4  JOB
//STEP1  EXEC  PLIXCLG
//PLI.SYSIN  DD  *
  UPDTM: PROC OPTIONS(MAIN);

     DCL (OLD,NEW) FILE RECORD SEQUENTIAL,
         DATA CHAR(80);

     ON ENDFILE(OLD)  GO TO FINISH;

     OPEN FILE(OLD) INPUT,FILE(NEW) OUTPUT TITLE('OLD');
 NEXT: READ FILE(OLD) INTO(DATA);
     IF DATA=' ' THEN GO TO NEXT;
     WRITE FILE(NEW) FROM(DATA);
     PUT FILE(SYSPRINT) SKIP LIST(DATA);
     GO TO NEXT;
 FINISH: CLOSE FILE(OLD),FILE(NEW);
     END UPDTM;
/*
//GO.OLD  DD  DSNAME=ALIB(NMEM),DISP=OLD
```

Figure 9.4. Updating a library member

cannot be used again. You must use two files in your PL/I program, but both can be associated with the same DD statement. The program shown in figure 9.4 updates the member created by the program in figure 9.3; it copies all the records of the original member except those that contain only blanks.

Library Structure

The structure of a library is illustrated in figure 9.5. The directory of a library is a series of records (entries) at the beginning of the data set; there is at least one directory entry for each member. Each entry contains a member name, the relative address of the member within the library, and a variable amount of user data. The entries are arranged in ascending alphameric order of member names.

A directory entry can contain up to 62 bytes of user data (information inserted by the program that created the member). An entry that refers to a member (load module) written by the linkage editor includes user data in a standard format, described in the manual System Control Blocks.

If you use a PL/I program to create a member, the operating system creates the directory entry for you and you cannot write any user data. However, you can use assembler language macro instructions to create a member and write your own user data; the method is described in the manual Supervisor and Data Management Services.

Directory entries are stored in fixed-length blocks of 256 bytes, each containing a 2-byte count field specifying the number of active bytes in a block, and as many complete entries as will fit into the remaining 254 bytes. The directory is in effect a sequential data set that contains fixed-length unblocked records, and can be read as such.

The program illustrated in figure 9.2 demonstrates a method of extracting information from directory entries. The program lists the names of all the members of a library; the library must be defined, when the program is executed, in a DD statement with the name LINK.

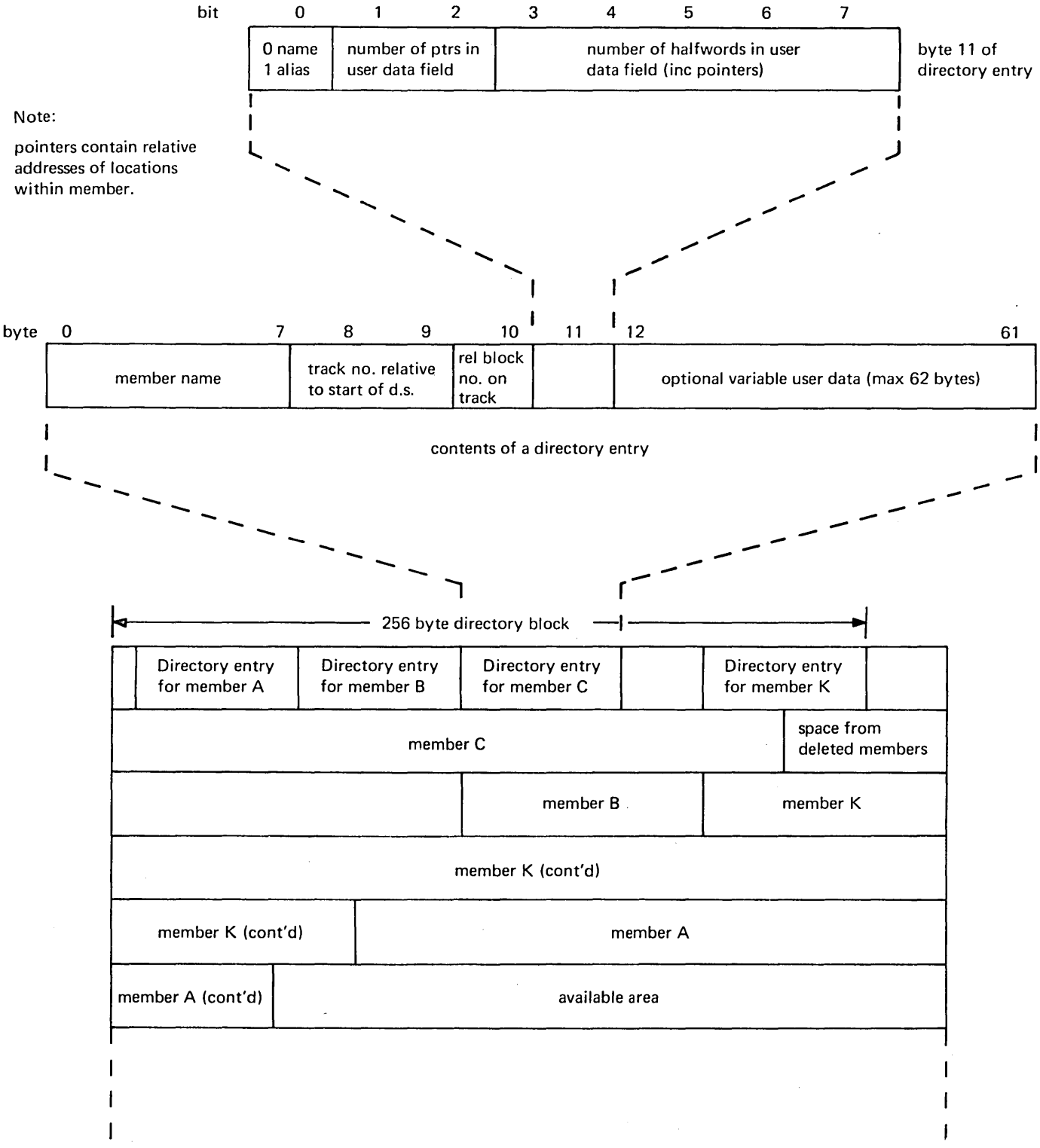


Figure 9.5. Structure of a library

Chapter 10: Cataloged Procedures

This chapter describes the standard cataloged procedures supplied by IBM for use with the OS PL/I Optimizing Compiler, explains how to invoke them, and how to make temporary or permanent modifications to them.

A cataloged procedure is a set of job control statements stored in a system library, the procedure library (SYS1.PROCLIB). It comprises one or more EXEC statements, each of which may be followed by one or more DD statements. You can retrieve the statements by naming the cataloged procedure in the PROC parameter of an EXEC statement in the input stream. When the operating system processes this EXEC statement, it replaces it in the input stream with the statements of the cataloged procedure.

The use of cataloged procedures saves time and reduces errors in coding frequently used sets of job control statements. If the statements in a cataloged procedure do not match your requirements exactly, you can easily modify them or add new statements for the duration of a job. It is recommended that each installation review these procedures and modify them to obtain the most efficient use of the facilities available and to allow for installation conventions; refer to "Permanent Modification," later in this chapter.

Invoking a Cataloged Procedure

To invoke a cataloged procedure, specify its name in the PROC parameter of an EXEC statement. For example, to use the cataloged procedure PLIXC, you could include the following statement in the appropriate position among your other job control statements in the input stream:

```
//stepname EXEC PROC=PLIXC
```

You need not code the keyword PROC; if the first operand in the EXEC statement does not begin PGM= or PROC=, the job scheduler interprets it as the name of a cataloged procedure. The following statement is equivalent to that given above:

```
//stepname EXEC PLIXC
```

When the operating system meets the name of a cataloged procedure in an EXEC statement, it extracts the statements of the cataloged procedure from the procedure library and substitutes them for the EXEC statement in the input job stream. If you include the parameter MSGLEVEL=1 in your JOB statement, the operating system will include the original EXEC statement in its listing, and will add the statements of the cataloged procedure. In the listing, cataloged procedure statements are identified by XX or X/ as the first two characters; X/ signifies a statement that has been modified for the current invocation of the cataloged procedure.

An EXEC statement identifies a job step, which can require either the execution of a program or the invocation of a cataloged procedure. A cataloged procedure includes one or more EXEC statements, which identify procedure steps. However, an EXEC statement in a cataloged procedure cannot invoke another cataloged procedure; it must request the execution of a program.

It may be necessary for you to modify the statements of a cataloged procedure for the duration of the job step in which it is invoked, either by adding DD statements or by overriding one or more parameters in the EXEC or DD statements. For example, cataloged procedures that invoke the compiler require the addition of a DD statement with the name SYSIN to define the data set containing the source statements. Also, whenever you use more than one standard link-edit procedure step in a job, you must modify all but the first cataloged procedure that you invoke if you want to execute more than one of the load modules.

Multiple Invocation of Cataloged Procedures

You can invoke different cataloged procedures, or invoke the same cataloged procedure several times, in the same job. No special problems are likely to arise unless more than one of these cataloged procedures involves a link-edit procedure step, in which case you must take the following precautions to ensure that all your load modules can be executed.

The linkage editor always places a load module that it creates in the standard data set defined by the DD statement with the name SYSLMOD. In the absence of a linkage editor NAME statement (or the NAME compiler option), it uses the member name specified

in the DSNAME parameter as the name of the module. In the standard cataloged procedures, the DD statement with the name SYSLMOD always specifies a temporary library named &&GOSET, and gives the load module the member name GO.

Consider what will happen if, for example, you use the cataloged procedure PLIXCLG twice in a job to compile, link edit, and execute two PL/I programs, and do not name each of the two load modules that will be created by the linkage editor. The linkage editor will name the first load module GO, as specified in the first DD statement with the name SYSLMOD. It will not be able to use the same name for the second load module since the first load module still exists in the library &&GOSET; it will allocate a temporary name to the second load module (a name that is not available to your program). Step GO of the cataloged procedure requests the operating system to initiate execution of the load module named in the first DD statement with the name SYSLMOD in the step LKED, that is, to execute the module named GO from the library &&GOSET. Consequently, the first load module will be executed twice and the second not at all.

To prevent this, use one of the following methods:

- Delete the library &&GOSET at the end of the step GO of the first invocation of the cataloged procedure by adding a DD statement of the form:

  ```
  //GO.SYSLMOD DD DSN=&&GOSET,
       DISP=(OLD,DELETE)
  ```

- Modify the DD statement with the name SYSLMOD in the second and subsequent invocations of the cataloged procedure so as to vary the names of the load modules. For example:

  ```
  //LKED.SYSLMOD DD DSN=&&GOSET(GO1)
  ```

  and so on.

- Use the NAME compiler option to give a different name to each load module and change your job control statements to specify the execution of the load modules with these names.

Dedicated Data Sets

Many of the processing programs in the operating system, including the optimizing compiler and the linkage editor, use temporary workfiles. To avoid allocating data sets for these workfiles each time they are required, an installation using the MVT operating system can dedicate one or more data sets for temporary workfiles, and these remain permanently allocated.

The standard cataloged procedures allow you to assign dedicated data sets to the optimizing compiler and linkage editor. The DD statements for workfiles have the ddname SYSUT1. In these DD statements, the DSNAME parameter is coded:

```
DSNAME=&&ddname
```

where "ddname" is the ddname of that DD statement. Your installation must have assigned these names to the dedicated data sets, otherwise you must override the DD statement in the cataloged procedure in order to specify the names used by your installation.

If the system cannot assign the dedicated data set to your job step, it creates a temporary data set instead. For full details of dedicated data sets see the OS System Programmer's Guide.

Multitasking Using Cataloged Procedures

When you use a cataloged procedure to link edit a multitasking program, you must ensure that the load module includes the multitasking versions of the PL/I resident library subroutines. To enable you to select the appropriate library, the cataloged procedures that invoke the linkage editor and the loader include a symbolic parameter (&LKLBDSN) in the DSNAME parameter of the DD statement SYSLIB, which defines the data set to be used as the automatic call library. This data set is described in chapter 5. The default value of this symbolic parameter is SYS1.PLIBASE, which is the name of the non-multitasking ("base") library.

To ensure that the multitasking library (SYS1.PLITASK) is searched before the base library, include the parameter LKLBDSN='SYS1.PLITASK' in the EXEC statement that invokes the cataloged procedure; for example:

```
//STEPA EXEC PLIXCLG,LKLBDSN='SYS1.PLITASK'
```

The DD statement SYSLIB is always followed in the standard cataloged procedures by another, unnamed, DD statement that includes the parameter DSNAME=SYS1.PLIBASE. The effect of this statement is to concatenate the base library with the multitasking library, if the latter is used; the base library can then be searched for any subroutine common

to multitasking and non-multitasking and therefore not included in the multitasking library. When the non-multitasking library is selected, the second DD statement has no effect.

The use of the symbolic parameter &LKLBDSN means that for non-multitasking programs, SYS1.PLIBASE is concatenated with itself. This has no effect other than a very small increase in job scheduling time, but does avoid the need for different cataloged procedures for link editing multitasking and non-multitasking programs.

Modifying Cataloged Procedures

You can modify a cataloged procedure temporarily by including parameters in the EXEC statement that invokes the cataloged procedure or by placing additional DD statements after the EXEC statement. Temporary modifications apply only for the duration of the procedure step in which the procedure is invoked and only to that procedure step; they do not affect the master copy of the cataloged procedure stored in the procedure library.

Alternatively, you can modify a cataloged procedure permanently by rewriting the job control statements that are stored in the procedure library. Permanent modification should be made only by system programmers responsible for maintaining the procedure library. Some of the considerations that may influence their decisions to modify the standard cataloged procedures are discussed below.

TEMPORARY MODIFICATION

Temporary modifications can apply to EXEC or DD statements in a cataloged procedure. To change a parameter of an EXEC statement, you must include a corresponding parameter in the EXEC statement that invokes the cataloged procedure; to change one or more parameters of a DD statement, you must include a corresponding DD statement after the EXEC statement that invokes the cataloged procedure. Although you may not add a new EXEC statement to a cataloged procedure, you can always include additional DD statements.

EXEC Statement

If a parameter of an EXEC statement that invokes a cataloged procedure has an unqualified name, the parameter applies to all the EXEC statements in the cataloged procedure. The effect on the cataloged procedure depends on the parameters, as follows:

- PARM applies to the first procedure step and nullifies any other PARM parameters.
- COND and ACCT apply to all the procedure steps.
- TIME and REGION apply to all the procedure steps and override existing values.

For example, the statement:

```
//stepname EXEC PLIXCLG,PARM='SIZE(MAX)',
     REGION=144K
```

invokes the cataloged procedure PLIXCLG, substitutes the option SIZE(MAX) for OBJECT and NODECK in the EXEC statement for procedure step PLI, and nullifies the PARM parameter in the EXEC statement for procedure step LKED; it also specifies a region size of 144K for all three procedure steps.

To change the value of a parameter in only one EXEC statement of a cataloged procedure, or to add a new parameter to one EXEC statement, you must identify the EXEC statement by qualifying the name of the parameter with the name of the procedure step. For example, to alter the region size for procedure step PLI only in the preceding example, code:

```
//stepname EXEC PROC=PLIXCLG,
     PARM='SIZE(MAX)',REGION.PLI=144K
```

A new parameter specified in the invoking EXEC statement overrides completely the corresponding parameter in the procedure EXEC statement.

You can nullify all the options specified by a parameter by coding the keyword and equal sign without a value. For example, to suppress the bulk of the linkage editor listing when invoking the cataloged procedure PLIXCLG, code:

```
//stepname EXEC PLIXCLG,PARM.LKED=
```

DD Statement

To add a DD statement to a cataloged procedure, or to modify one or more parameters of an existing DD statement, you must include, in the appropriate position in the input stream, a DD statement with a name of the form "procstepname.ddname". If "ddname" is the name of a DD statement already present in the procedure step identified by "procstepname," the parameters in the new DD statement override the corresponding parameters in the existing DD statement; otherwise, the new DD statement is added to the procedure step. For example, the statement:

```
//PLI.SYSIN DD *
```

adds a DD statement to the procedure step PLI of cataloged procedure PLIXC and the effect of the statement:

```
//PLI.SYSPRINT DD SYSOUT=C
```

is to modify the existing DD statement SYSPRINT (causing the compiler listing to be transmitted to the system output device of class C).

Overriding DD statements must follow the EXEC statement that invokes the cataloged procedure in the same order as the corresponding DD statements of the cataloged procedure. DD statements that are being added must follow the overriding DD statements for the procedure step in which they are to appear.

To override a parameter of a DD statement, code either a revised form of the parameter or a replacement parameter that performs a similar function (for example, SPLIT for SPACE). To nullify a parameter, code the keyword and equal sign without a value. You can override DCB subparameters by coding only those you wish to modify; that is, the DCB parameter in an overriding DD statement does not necessarily override the entire DCB parameter of the corresponding statement in the cataloged procedures.

PERMANENT MODIFICATION

To make permanent modifications to a cataloged procedure, or to add a new cataloged procedure, use the system utility program IEBUPDTE, which is described in the utilities publication. The following paragraphs discuss some of the factors you should have in mind when considering whether to modify the standard cataloged procedures for your installation. For further information on writing installation cataloged procedures see the system programmer's guide.

In general, installation conventions will dictate the options that you include in the PARM, UNIT, and SPACE parameters of the cataloged procedures, and also the blocking factors for output data sets.

If your installation uses the MVT control program of the operating system, you may need to modify some or all of the REGION parameters.

The minimum region size for compilation should be at least 8K bytes larger than the largest value that will be specified in the SIZE compiler option, excluding SIZE(MAX).

In cataloged procedures that invoke the linkage editor, a region size of 100K is specified for the link-edit procedure step.

You can reduce this region size if you are using the 44K F-level linkage editor. In general, the region size should be at least 8K bytes larger than the design size for the particular version of the linkage editor being used. You must alter the region size if you are using the 128K F-level linkage editor.

Under MVT, the operating system requires up to 52K bytes of main storage within a region when initiating or terminating a job step. If you specify a region size of less than 52K bytes, completion of a job may be held up until 52K bytes are available.

The minimum region size used by MVT is dependent on the installation, and is defined at system generation. There is nothing to be gained in reducing the region size below this value.

If your installation uses MFT only, you can delete the REGION parameter from all cataloged procedures, otherwise it will be ignored.

IBM-supplied Cataloged Procedures

The standard PL/I cataloged procedures supplied for use with the optimizing compiler are:

PLIXC	Compile only
PLIXCL	Compile and link edit
PLIXCLG	Compile, link edit, and execute
PLIXLG	Link edit and execute

PLIXCG Compile, load-and-execute

PLIXG Load-and-execute

The individual statements of the cataloged procedures are not fully described, since all the parameters are discussed elsewhere in this publication. These cataloged procedures do not include a DD statement for the input data set; you must always provide one. The following example illustrates the JCL statements you might use to invoke the cataloged procedure PLIXCLG to compile, link edit, and execute, a PL/I program:

```
//COLEGO    JOB
//STEP1     EXEC PLIXCLG
//PLI.SYSIN DD *
                .
                .
                .
    (insert here PL/I program to be
    compiled)
                .
                .
                .
/*
```

No IBM-supplied cataloged procedure is provided to produce an object module on punched cards. You can temporarily modify any of the cataloged procedures that have a compile step to produce a punched card output, for example:

```
//stepname      EXEC PLIXCLG,
                 PARM.PLI='OBJECT,DECK'
//PLI.SYSPUNCH DD SYSOUT=B
//PLI.SYSIN     DD ...
                .
                .
                .
```

Compile Only (PLIXC)

This cataloged procedure comprises only one procedure step, in which the options specified for the compilation are OBJECT and NODECK. (IEL0AA is the symbolic name of the compiler.) In common with the other cataloged procedures that include a compilation procedure step, PLIXC does not include a DD statement for the input data set; you must always supply an appropriate statement with the qualified ddname PLI.SYSIN.

The OBJECT option causes the compiler to place the object module, in a form suitable for input to the linkage editor, in the standard data set defined by the DD statement with the name SYSLIN. This statement defines a temporary data set named &&LOADSET on a magnetic-tape or direct-access device; if you want to retain the object module after the end of your job, you must substitute a permanent name for &&LOADSET (that is, a name that does not commence &&) and specify KEEP in the appropriate DISP parameter for the last procedure step in which the data set is used.

The term MOD in the DISP parameter allows the compiler to place more than one object module in the data set, and PASS ensures that the data set will be available to a later procedure step providing a corresponding DD statement is included there.

The SPACE parameter allows an initial allocation of 250 eighty-byte records and, if necessary, 15 further allocations of 100 records (a total of 1750 records, which should suffice for most applications).

```
//PLIXC      PROC
//PLI        EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT   DD SYSOUT=A
//SYSLIN     DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//              SPACE=(80,(250,100))
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//              DCB=BLKSIZE=1024
```

Compile and Link-edit (PLIXCL)

This cataloged procedure comprises two procedure steps: PLI, which is identical with cataloged procedure PLIXC, and LKED, which invokes the linkage editor (symbolic name IEWL) to link edit the object module produced in the first procedure step.

Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN. The COND parameter in the EXEC statement LKED specifies that this procedure step should be bypassed if the return code produced by the compiler is greater than 9 (that is, if a severe or unrecoverable error occurs during compilation).

The DD statement with the name SYSLIB specifies the PL/I resident library, from which the linkage editor will obtain appropriate modules for inclusion in the load module. The linkage editor always places the load modules it creates in the standard data set defined by the DD statement with the name SYSLMOD. This statement in the cataloged procedure specifies a new temporary library &&GOSET, in which the load module will be placed and given the member name GO (unless you specify the NAME compiler option for the compiler procedure step). In specifying a temporary library, the cataloged procedure assumes that you will execute the load module in the same job; if you want to retain the module, you must substitute your own statement for the DD statement with the name SYSLMOD.

The last statement, DDNAME=SYSIN, illustrates how to concatenate a data set defined by a DD statement with the name SYSIN with the primary input (SYSLIN) to the linkage editor. You could place linkage editor control statements in the input stream by this means, as described in chapter 5.

```
//PLIXCL    PROC LKLBDSN='SYS1.PLIBASE'
//PLI       EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT  DD SYSOUT=A
//SYSLIN    DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//             SPACE=(80,(250,100))
//SYSUT1    DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//             DCB=BLKSIZE=1024
//LKED      EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=100K
//SYSLIB    DD DSN=&LKLBDSN,DISP=SHR
//          DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD   DD DSN=&&GOSET(GO),DISP=(MOD,PASS),UNIT=SYSDA,
//             SPACE=(1024,(50,20,1),RLSE)
//SYSUT1    DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//             DCB=BLKSIZE=1024
//SYSPRINT  DD SYSOUT=A
//SYSLIN    DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//          DD DDNAME=SYSIN
```

Compile, Link-edit, and Execute (PLIXCLG)

This cataloged procedure comprises three procedure steps, PLI and LKED, which are identical with the two procedure steps of PLIXCL, and GO, in which the load module created in the step LKED is executed. The third procedure step will be executed only if no severe or unrecoverable errors occur in the preceding procedure steps.

Input data for the compilation procedure step should be specified in a DD statement with the name PLI.SYSIN, and for the execution procedure step in a DD statement with the name GO.SYSIN.

```
//PLIXCLG    PROC LKLBDSN='SYS1.PLIBASE'
//PLI        EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT   DD SYSOUT=A
//SYSLIN     DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//              SPACE=(80,(250,100))
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(300,60),,CONTIG),
//              DCB=BLKSIZE=1024
//LKED       EXEC PGM=IEWL,PARM='XREF,LIST',COND=(9,LT,PLI),REGION=100K
//SYSLIB     DD DSN=&LKLBDSN,DISP=SHR
//             DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD    DD DSN=&&GOSET(GO),DISP=(MOD,PASS),UNIT=SYSDA,
//              SPACE=(1024,(50,20,1),RLSE)
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//              DCB=BLKSIZE=1024
//SYSPRINT   DD SYSOUT=A
//SYSLIN     DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//             DD DDNAME=SYSIN
//GO         EXEC PGM=*.LKED.SYSLMOD,COND=((9,LT,PLI),(9,LT,LKED)),
//              REGION=100K
//SYSPRINT   DD SYSOUT=A
```

Link-edit and Execute (PLIXLG)

This cataloged procedure comprises two procedure steps, LKED and GO, which are similar to the procedure steps of the same names in PLIXCLG.

In the procedure step LKED, the DD statement with the name SYSLIN does not define a data set, but merely refers the operating system to the DD statement SYSIN, which you must supply with the qualified ddname LKED.SYSIN. This DD statement defines the data set from which the linkage editor will obtain its primary input. Execution of the procedure step GO is conditional on successful execution of the procedure step LKED only.

```
//PLIXLG     PROC LKLBDSN='SYS1.PLIBASE'
//LKED       EXEC PGM=IEWL,PARM='XREF,LIST',REGION=100K
//SYSLIB     DD DSN=&LKLBDSN,DISP=SHR
//            DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLMOD    DD DSN=&&GOSET(GO) DISP=(MOD,PASS),UNIT=SYSSQ,
//               SPACE=(1024,(50,20,1),RLSE)
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(200,20)),
//               DCB=BLKSIZE=1024
//SYSPRINT   DD SYSOUT=A
//SYSLIN     DD DNAME=SYSIN
//GO         EXEC PGM=*.LKED.SYSLMOD,COND=(9,LT,LKED),REGION=100K
//SYSPRINT   DD SYSOUT=A
```

Compile, Load-and-execute (PLIXCG)

This cataloged procedure achieves the same results as PLIXCLG but uses the loader instead of the linkage editor. However, instead of using three procedure steps (compile, link edit, and execute), it has only two (compile, and load-and-execute). In the second procedure step, the loader program is executed; this program processes the object module produced by the compiler and executes the resultant executable program immediately. Input data for the compilation procedure step requires the qualified ddname PLI.SYSIN.

The REGION parameter of the EXEC statement GO specifies 100K bytes. Since the loader requires about 17K bytes of main storage, there are about 83K bytes for your program; if this is likely to be insufficient, you must modify the REGION parameter. The use of the loader imposes certain restrictions on your PL/I program; before using this cataloged procedure, refer to chapter 5, which explains how to use the loader.

```
//PLIXCG     PROC LKLBDSN='SYS1.PLIBASE'
//PLI        EXEC PGM=IEL0AA,PARM='OBJECT,NODECK',REGION=100K
//SYSPRINT   DD SYSOUT=A
//SYSLIN     DD DSN=&&LOADSET,DISP=(MOD,PASS),UNIT=SYSSQ,
//              SPACE=(80,(250,100))
//SYSUT1     DD DSN=&&SYSUT1,UNIT=SYSDA,SPACE=(1024,(60,60),,CONTIG),
//              DCB=BLKSIZE=1024
//GO         EXEC PGM=LOADER,PARM='MAP,PRINT',REGION=100K,
//              COND=(9,LT,PLI)
//SYSLIB     DD DSN=&LKLBDSN,DISP=SHR
//            DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLIN     DD DSN=&&LOADSET,DISP=(OLD,DELETE)
//SYSLOUT    DD SYSOUT=A
//SYSPRINT   DD SYSOUT=A
```

Load-and-execute (PLIXG)

This cataloged procedure achieves the same results as PLIXLG but uses the loader instead of the linkage editor. However, instead of using two procedure steps (link edit and execute), it has only one. In this procedure step, the loader program is executed. This program processes and executes an object module placed in the data set defined by a DD statement with the name SYSLIN; you must supply this statement with the qualified name GO.SYSLIN.

The REGION parameter of the EXEC statement GO specifies 96K bytes. Since the loader requires about 17K bytes of main storage, there are about 83K bytes for your program; if this is likely to be insufficient, you must modify the REGION parameter. The use of the loader imposes certain restrictions on your PL/I program; before using this cataloged procedure, refer to chapter 5, which explains how to use the loader.

```
//PLIXG  PROC LKLBDSN='SYS1.PLIBASE'
//GO     EXEC PGM=LOADER,PARM='MAP,PRINT',REGION=100K
//SYSLIB DD DSN=&LKLBDSN,DISP=SHR
//       DD DSN=SYS1.PLIBASE,DISP=SHR
//SYSLOUTDD SYSOUT=A
//SYSPRINT DD SYSOUT=A
```

Chapter 11: Program Checkout

Program checkout is the application of diagnostic and test processes to a program. You should give adequate attention to program checkout during the development of a program so that:

1. A program becomes fully operational after the fewest possible test runs, thereby minimizing the time and cost of program development.

2. A program is proved to have fulfilled all the design objectives before it is released for production work.

3. A program has complete and clear documentation to enable both operators and program maintenance personnel to use and maintain the program without assistance from the original programmer.

The data used for the checkout of a program should be selected to test all parts of the program. Whilst the data should be sufficiently comprehensive to provide a thorough test of the program, it is easier and more practical to monitor the behaviour of the program if the volume of data is kept to a minimum.

Conversational Program Checkout

The optimizing compiler can be used in conversational mode when writing and testing programs at a terminal. The conversational features are available to users where the TSO (Time Sharing Option) facilities of the operating system are present. The conversational facilities enable you to enter a PL/I program from a terminal, through which you will receive diagnostic messages for the compilation. You can also communicate with the program during execution using PL/I files associated with the terminal. Thus a PL/I program can be checked out during its construction, thereby saving a substantial amount of elapsed time that can occur between test compilation and execution runs in batched processing.

The PL/I program is entered and processed using the PLIC, EDIT, and other commands and features described in the publication OS TSO: PL/I Optimizing Compiler.

Compile-time Checkout

At compile time, both the preprocessor and the compiler can produce diagnostic messages and listings according to the compiler options selected for a particular compilation. The listings and the associated compiler options are discussed in chapter 4. The diagnostic messages produced by the optimizing compiler are identified by a number prefixed "IEL". These diagnostic messages are available in both a long form and a short form. The long messages are designed to be as self-explanatory as possible. The short messages are designed for reproduction at a terminal when the compiler is being used in a TSO environment. The short messages are obtained by specifying the SMESSAGE compiler option. Each message is reproduced in the publication: OS PL/I Optimizing Compiler Messages. This publication includes explanatory notes, examples, and any action to be taken.

Always check the compilation listing for occurrences of these messages to determine whether the syntax of the program is correct. Messages of greater severity than warning (that is, error, severe error, and unrecoverable error) should be acted upon if the message does not indicate that the compiler has been able to "fix" the error correctly. You should appreciate that the compiler, in making an assumption as to the intended meaning of any erroneous statement in the source program, can introduce a further, perhaps more severe, error which in turn can produce yet another error, and so on. When this occurs, the result is that the compiler produces a number of diagnostic messages which are all caused either directly or indirectly by the one error.

Other useful diagnostic aids produced by the compiler are the attribute table and cross-reference table. The attribute table, specified by the ATTRIBUTES option, is useful for checking that program identifiers, especially those whose attributes are contextually and implicitly declared, have the correct attributes. The cross-reference table is requested by the XREF option, and indicates, for each program variable, the number of each statement that refers to the variable.

To prevent unnecessary waste of time and resources during the early stages of developing programs, use the NOOPTIMIZE,

NOSYNTAX, and NOCOMPILE options. These options, when specified, will suppress optimization, subsequent compilation, link editing, and execution should the appropriate error conditions be detected.

The NOSYNTAX option specified with the severity level "W", "E", or "S" will cause compilation of the output from the PL/I preprocessor, if used, to be suppressed prior to the syntax-checking stage should the preprocessor issue diagnostic messages at or above the severity level specified in the option.

The NOCOMPILE option specified with the severity level "W", "E", or "S" will cause compilation to be suppressed after the syntax-checking stage if syntax checking or preprocessing causes the compiler to issue diagnostic messages at or above the severity level specified in the option.

Linkage Editor Checkout

When using the linkage editor, check particularly that any required overlay structuring and incorporation of additional object and load modules have been performed correctly. Diagnostic messages produced by the linkage editor are prefixed "IEW". These messages are fully documented in the publication: OS Linkage Editor and Loader.

When checking the processing performed by the linkage editor, refer to the module map produced by the linkage editor showing the structure of the load module. The module map names the modules that have been incorporated into the program. The compiler produces an external symbol dictionary (ESD) listing if requested by the ESD option. The ESD listing indicates the external names that the linkage editor is to resolve in order to create a load module. The linkage editor is described in chapter 5.

Execution-time Checkout

At execution time, errors can occur in a number of different operations associated with running a program. For instance, an error in the use of a job control statement can cause a job to fail. Most errors that can be detected are indicated by a diagnostic message. The diagnostic messages for errors detected at execution time are also listed in the messages publication for this compiler and identified by the prefix "IBM". The messages are always printed on the SYSPRINT file. They will also be reproduced on a terminal if the compiler is being used in conversational mode.

A failure in the execution of a PL/I program could be caused by one of the following:

1. Logical errors in source programs.
2. Invalid use of PL/I.
3. Unforeseen errors.
4. Operating error.
5. Invalid input data.
6. Unidentified program failure.
7. A compiler or library subroutine failure.
8. System failure.

Logical Errors in Source Programs

Logical errors in source programs can often be difficult to detect. Such errors can sometimes cause a compiler or library failure to be suspected. The more common errors are the failure to convert correctly from arithmetic data, incorrect arithmetic operations and string manipulation operations, and failure to match data lists with their format lists.

Invalid Use of PL/I

It is possible that a misunderstanding of the language, or the failure to provide the correct environment for using PL/I, results in an apparent failure of a PL/I program. For example, the use of uninitialized variables, the use of controlled variables that have not been allocated, reading records into incorrect structures, the misuse of array subscripts, the misuse of pointer variables, conversion errors, incorrect arithmetic operations, and incorrect string manipulation operations can cause this type of failure.

Unforeseen Errors

If an error is detected during execution of a PL/I program in which no on-unit is provided to terminate execution or attempt recovery, the job will be terminated

abnormally. However, the status of a program executed in a batch-processing environment, at the point where the error occurred, can be recorded by the use of an ERROR on-unit that contains the statements:

```
ON ERROR BEGIN;
ON ERROR SYSTEM;
PUT DATA;
END;
```

The statement ON ERROR SYSTEM; contained in the on-unit ensures that further errors caused by attempting to transmit uninitialized variables do not result in a permanent loop.

Operating Error

A job could fail because of an operating error, such as running a job twice so that a data set becomes overwritten or erroneously deleted. Other operating errors include getting card decks into the wrong order and the failure to give operators correct instructions for running a job.

Invalid Input Data

A program should contain checks to ensure that any incorrect input data is detected before it can cause the program to fail.

Use the COPY option of the GET statement if you wish to check values obtained by stream-oriented input. The values will be listed on the file named in the COPY option. If no file name is given, SYSPRINT is assumed.

Unidentified Program Failure

In most circumstances, an unidentified program failure should not occur when using the optimizing compiler. Exceptions to this could include the following:

1. When the program is executed in conjunction with non-PL/I modules, such as FORTRAN or COBOL.

2. When the program obtains, by means of record-oriented transmission, incorrect values for use in label, entry, locator, and file variables.

3. Errors in job control statements, particularly in defining data sets.

If execution of a program terminates abnormally without an accompanying PL/I execution-time diagnostic message, it is probable that the error that caused the failure also inhibited the production of a message. In this situation, it is still possible to check the PL/I source program for errors that could result in overwriting areas of the main storage region that contain executable instructions, particularly the communications region, which contains the address tables for the execution-time error-handling routine. These errors may also be present in modules compiled by the checkout compiler with NODIAGNOSE and COMPATIBLE and executed in conjunction with the modules produced by the optimizing compiler. The types of PL/I program that might cause the main storage to be overwritten erroneously are:

1. Assignment of a value to a non-existent array element. For example:

   ```
   DCL ARRAY(10);
   .
   .
   .
   DO I = 1 TO 100;
   ARRAY(I) = VALUE;
   ```

   To detect this type of error in a module compiled by the optimizing compiler, enable the SUBSCRIPTRANGE condition. For each attempt to access an element outside the declared range of subscript values, the SUBSCRIPTRANGE condition will be raised. If there is no on-unit for this condition, a diagnostic message will be printed and the ERROR condition raised. This facility, although expensive in execution time and storage space, is a valuable program-checkout aid.

2. The use of incorrect locator values for locator (pointer and offset) variables. This type of error is possible if a locator value is obtained by means of record-oriented transmission. Check that locator values created in a program, transmitted to a data set, and subsequently retrieved for use in another program, are valid for use in the second program.

   An error could also be caused by attempting to free a non-based variable. This could be caused by freeing a based variable when its qualifying pointer value has been changed. For example:

```
DCL A STATIC,B BASED (P);
ALLOCATE B;
P = ADDR(A);
FREE B;
```

3. The use of incorrect values for label, entry, and file variables. Errors similar to those described above for locator values are possible for label, entry, and file values that are transmitted and subsequently retrieved.

4. The use of the SUBSTR pseudovariable to assign a string to a position beyond the maximum length of the target string. For example:

```
DCL X CHAR(3);
I=3;
SUBSTR(X,2,I) = 'ABC';
```

   The STRINGRANGE condition can be used to detect this type of error in a module compiled by the optimizing compiler.

Compiler or Library Subroutine Failure

If you are absolutely convinced that the failure is caused by a compiler failure or a library subroutine failure, you should notify your management, who will initiate the appropriate action to correct the error. This could mean calling in IBM personnel for programming support to rectify the problem. Before calling IBM for programming support, refer to the instructions for providing the correct information to be used in diagnosing the problem. These instructions are given in appendix C, "Requirements for Problem Determination and APAR Submission." Meanwhile, you can attempt to find an alternative way to perform the operation that is causing the trouble. A bypass is often feasible, since the PL/I language frequently provides an alternative method of performing a given operation.

System Failure

System failures include machine malfunctions and operating system errors. These failures should be identified to the operator by a system message.

Statement Numbers and Tracing

The compiler FLOW option provides a valuable program-checkout aid. The FLOW(n,m) option creates a table of the numbers of the last "n" branch-out and branch-in statements, and the last "m" procedures and on-units to be entered. (A "branch-out" statement is a statement that transfers control to a statement other than that which immediately follows it, such as a GOTO statement. A branch-in statement is a statement that receives control from a statement other than that which immediately precedes it, such as a PROCEDURE, ENTRY, or any other labeled statement.) The figure you choose for "n" should be large enough to provide a usable trace of the flow of control through the program. Alternatively, if you do not specify the FLOW option explicitly, defaults for the FLOW option will be used.

The trace table can be obtained by any of the methods described below.

The trace is printed whenever an on-unit with the SNAP option or a PUT ALL statement is encountered. It gives both the statement numbers and the names of the containing procedures or on-units. For example, an ERROR on-unit that results in both the listing of the program variables and the statement number trace can be included in a PL/I program as follows:

```
ON ERROR SNAP BEGIN;
ON ERROR SYSTEM;
PUT DATA;
END;
```

A flow trace can be specified as part of the output from the PL/I dump facility PLIDUMP, discussed later in this chapter.

Dynamic Checking Facilities

It is possible for a syntactically-correct program to produce incorrect results without raising any PL/I error conditions. This can be attributed to the use of incorrect logic in the PL/I source program or to invalid input data. Detection of such errors from the resultant output (if any) can be a difficult task. It is sometimes helpful to have a record of each of the values assigned to a variable, particularly label, entry, loop control, and array subscript variables. This can be obtained by using the CHECK prefix option. Note that, unless care is exercised, the indiscriminate use of the facilities described below will result in a flood of unwanted and unusable printout.

A CHECK prefix option can specify program variables in a list. Whenever a variable that has been included in a check-list is assigned a new value, the CHECK condition is raised. The standard system action for the CHECK condition is to print the name and new value of the variable that caused the CHECK condition to be raised. An example of a CHECK prefix options list is:

```
(CHECK(A,B,C,L)):/* CHECKOUT PREFIX LIST */
    TEST: PROCEDURE OPTIONS(MAIN);
          DECLARE A etc.,
          .
          .
          .
```

If the CHECK condition is to be raised for all the variables used in a program, the CHECK prefix option can be more simply specified without a list of items. For example:

```
(CHECK):  TEST:  PROCEDURE;
```

Control of Exceptional Conditions

During execution of a PL/I object program, a number of exceptional conditions can be raised, either as a result of program-defined action, or as a result of exceeding a hardware limitation. PL/I contains facilities for detecting such conditions. These facilities can be used to determine the circumstances of an unexpected interrupt, perform a recovery operation, and permit the program to continue to run. Alternatively, the facilities can be used to detect conditions raised during normal processing, and initiate program-defined actions for the condition. Note that some of the PL/I conditions are enabled by default, some cannot be disabled, and others have to be enabled explicitly in the program. Refer to the language reference manual for this compiler for a full description of each condition.

Note that the SIGNAL statement can be used to raise any of the PL/I conditions. Such use permits any on-units in the program to be tested during debugging.

The standard system action for the ERROR condition for which there is no on-unit, is, in batched processing, to raise the FINISH condition, and in conversational processing, to give control to the terminal. The FINISH condition is also raised for the following:

1. When a SIGNAL FINISH statement is executed.
2. When a PL/I program completes execution normally.
3. On completion of an ERROR on-unit that does not return control to the PL/I program by means of a GOTO statement.
4. When a STOP statement is executed or when an EXIT statement is executed in a major task.

The standard system action for the FINISH condition in batched processing is to terminate the task, and, in conversational processing, to give control to the terminal.

Use of the PL/I Preprocessor in Program Checkout

During program checkout, it is often necessary to use a number of the PL/I conditions (and the on-units associated with them) and subsequently to remove them from the program when it is found to be satisfactory. The PL/I preprocessor can be used to include a standard set of program-checkout statements from the source statement library. When the program is fully operational, the %INCLUDE statement can be removed, and the resultant object program compiled for execution.

A standard set of PL/I program checkout statements would include both the enabling of any conditions that are disabled by default and the provision of the appropriate on-units. The %INCLUDE statement that causes the inclusion of the set of program checkout statements would usually be placed after any on-units that must remain in the program permanently in order to cancel their effect during program checkout.

On-codes

On-codes can indicate more precisely what type of error has occurred where a condition can be raised by more than one error. For example, the ERROR condition can be raised by a number of different errors, each of which is identified by an on-code. You can obtain the on-code by using the condition built-in function ONCODE in the on-unit. The on-codes are described in the language reference manual for this compiler.

Dumps

Should the checks given above fail to reveal the cause of the error, it may be necessary to obtain a printout, or dump, of the main storage region used by the program. A dump can display the contents of all buffers associated with PL/I files, the PL/I file attributes for each file open when the dump is taken, and a trace of the block invocations that occurred during execution before the dump was taken.

A hexadecimal dump can also be obtained to determine the machine instructions and data present in main storage when the failure occurred. The use of a hexadecimal storage dump requires a knowledge of assembler language programming and an understanding of object program organization.

Refer to the execution logic manual for this compiler for information about the organization of the object programs produced by the optimizing compiler, and how to interpret a storage dump.

To obtain a formatted PL/I dump, you must invoke the PL/I resident library dump module by calling PLIDUMP. Note that a DD statement with the ddname PLIDUMP must be supplied to define the data set for the dump.

PLIDUMP can be invoked with two optional arguments. The first argument is a character-string constant used to specify the types of information to be included in the dump. The second argument can be a character-string expression or a decimal constant with which you can identify the output produced by PLIDUMP. The format of the PLIDUMP statement is:

```
CALL PLIDUMP[('options-list'
     [,user-identification])];
```

The options-list is a contiguous string of characters that may include the following:

T To request a trace of active procedures, begin blocks, on-units, and library modules.

NT To suppress the output produced by T above.

F To request a complete set of attributes for all files that are open, and the contents of the buffers used by the files.

NF To suppress the output produced by F above.

S To request the termination of the program after the completion of the dump. Note: The FINISH condition is not raised.

C To request continuation of execution after completion of the dump.

H To request a hexadecimal dump of the main storage partition used by the program.

NH To suppress the hexadecimal dump.

B If T is specified, to produce a separate hexadecimal dump of control blocks such as the TCA and the DSA chain that are used in the trace analysis. If F is specified, to produce a separate hexadecimal dump of control blocks used in the file analysis, such as the FCB.

NB To suppress hexadecimal dumps of control blocks.

A To request information relevant to all tasks in a multitasking program.

E To request that an exit be made from the current task of a multitasking program and that execution of the program continues after completion of the requested dump.

O To request information relevant only to the current task in a multitasking program.

The defaults assumed for the above options not specified explicitly are:

```
T F C A NH NB
```

The user-identification permits you to specify a character-string expression or a decimal constant to identify individual dumps. It cannot be specified without the preceding argument in the argument list.

Trace Information

Trace information produced by PLIDUMP includes a trace through all the active DSAs. (DSAs will be present for compiled blocks, such as procedures and on-units, and for library routines.) For on-units, the dump gives the values of any condition built-in functions that could be used in the on-unit, regardless of whether the on-unit actually used the condition built-in function. If a hexadecimal dump is also requested, the trace information will also include:

The address of each DSA (Dynamic Storage Area).

The address of the TCA (Task Communications Area).

The contents of the registers on entry to the PL/I error-handler module (IBMCERR).

The PSW or the address from which the PL/I error handler module (IBMCERR) was invoked.

The addresses of the library module DSAs back to the most recently-used compiled code DSA.

DSAs and the TCA are described in the execution logic manual for this compiler. A table of statement numbers indicating the flow of control through the program is always produced.

File Information

File information produced by PLIDUMP includes the default and declared attributes of all open files, and the contents of all buffers that are accessible to the dump routine. The information is given in BCD notation, and if hexadecimal output is also requested, in hexadecimal notation also. The address and contents of the FCB are then printed.

Hexadecimal Dump

The hexadecimal dump is a dump of the region of main storage containing the program. The dump is given as three columns of printed output. The left-hand and middle columns contain the contents of storage in hexadecimal notation. The third column contains a BCD translation of the first two columns. For hexadecimal characters that cannot be represented by a printable BCD character, a full stop is printed.

Return Codes

Both the compilation and the link editing of a PL/I program will result in a return code being passed to indicate the severity of any errors found. It is possible to pass a return code from a PL/I program, either for examination in a subsequent job step if execution of that step is conditional upon the value of the code returned, or merely to indicate conditions that were encountered during execution. Conditional execution of a job step is determined by use of the COND parameter of the JOB or EXEC statement.

Return Codes	Meaning
0000	Normal termination.
1-999	Return codes available for use with PLIRETC.
1000	Code returned if a STOP or EXIT statement is executed. This value will be added to any PLIRETC value.
2000	Code returned if ERROR is raised. This value will be added to any PLIRETC value.
4000	Code returned if an interrupt occurs in the PL/I error handler.
4004	Code returned if the PRV (pseudo register vector) is too large.
4008	Code returned if PL/I program has no main procedure.
4012	Not enough main storage available.
4020	Code returned if the program is about to enter a permanent wait state.
4024	Code returned if a task in a multitasking program has terminated without use of the PL/I termination routines.

Figure 11.1. Return codes from execution of a PL/I program

Return codes can be set in a PL/I program by passing as an argument to the CALL PLIRETC statement a code represented as a variable with the attributes FIXED BINARY(31,0). The range of codes used should be restricted to 1 through 999. Codes higher than 999 are returned if an error causes the program to terminate. In some cases the return code for the program will be added to any code created by use of the CALL PLIRETC statement. In other cases it will overwrite any code set by use of the CALL PLIRETC statement. Moreover, when the optimizing compiler is used in batched-processing mode, any return code resulting from the compilation step to

indicate a source program error will be overwritten by any larger return code generated by the execution step. Other error situations, listed in figure 11.1, will also cause a program-generated return code to be overwritten.

If a return code in the 4000-4024 range is encountered and the cause cannot be traced to a source program error, it may be necessary to call in IBM program support personnel. Appendix C, "Problem Determination and APAR Submission", describes the materials that will be required for examination by IBM in such circumstances.

Chapter 12: Linking PL/I and Assembler Language Modules

This chapter describes how to create programs that combine routines written in PL/I and assembler language. It explains how a PL/I program invokes an assembler-language routine and, conversely, how an assembler-language routine invokes a PL/I procedure.

Before describing any of the linkages in detail, the chapter discusses the PL/I environment that must be preserved when invoking an assembler-language routine from PL/I, and which must be created when invoking a PL/I procedure from an assembler-language routine.

The PL/I Environment

The PL/I environment is the term used to describe a number of control blocks created by routines that are provided by the OS PL/I Resident and Transient Libraries to satisfy the storage-management and error-handling requirements of a PL/I procedure.

When a PL/I program invokes an assembler-language routine, the invoked routine must ensure that the PL/I environment is preserved. The PL/I environment is preserved by observing the standard IBM System/360 linkage conventions, which include the storing of register values in a save area, and by ensuring that the content of register 12 is not modified by the assembler routine if PL/I is to handle interrupts that occur during execution of the assembler routine. Register 13 must be set to the address of a new save area established by the assembler routine.

ESTABLISHING THE PL/I ENVIRONMENT

The PL/I environment is established by the OS PL/I Resident Library routine IBMBPIR and the OS PL/I Transient Library routine IBMBPII for a non-multitasking program and by IBMTPIR and IBMTPII for a multitasking program. An assembler-language routine that invokes a PL/I procedure for which the PL/I environment has not been established can use one of two standard entry points to establish the environment. The routine IBMBPIR or IBMTPIR (with IBMPII or IBMTPII) is entered through a control section called PLISTART which in turn has two standard entry points, PLICALLA and PLICALLB; these are described later in this chapter.

Use of PLIMAIN to Invoke a PL/I Procedure

Once IBMBPIR or IBMTPIR (with IBMPII or IBMTPII) has created the environment, it transfers control to the PL/I procedure whose address is contained in PLIMAIN. Normally, after link editing, PLIMAIN will contain the entry point address of the first, or only, PL/I main procedure in the program. If the assembler-language routine is to invoke a PL/I procedure that is not the first, or only, main PL/I procedure in the program, it must insert in the compiler-generated control section PLIMAIN the address of the entry point of the procedure it is to invoke. The example in figure 12.6 shows how this is done.

If there is no main procedure in the program, the assembler routine should contain an entry point called PLIMAIN at which is held the address of the entry point of the PL/I routine to be invoked. The example in figure 12.7 shows how the appropriate address is inserted into the location represented by the entry point PLIMAIN. If the assembler program does not include an entry point called PLIMAIN in these circumstances, a dummy module called PLIMAIN will be included from the CS PL/I Resident Library.

Once the PL/I environment has been established, it can, as shown in the example in figure 12.3, be preserved, and any PL/I procedure can be invoked subsequently by loading the address of its entry point into register 15, and executing a branch-and-link-register instruction to it.

PLICALLA AND PLICALLB

PLICALLA: PLICALLA is used when the PL/I environment must be established for a PL/I procedure that can use for its dynamic storage as much of the available space in storage as it requires.

PLICALLB: PLICALLB is used when the PL/I environment must be established for a PL/I procedure that can use for its dynamic

storage only a specified amount of the available storage. PLICALLB can optionally specify where that storage is to begin.

Further details and examples using PLICALLA and PLICALLB are given later in this chapter.

THE DYNAMIC STORAGE AREA (DSA) AND SAVE AREA

Whenever a PL/I procedure is invoked, it requires for its own use a block of storage known as a dynamic storage area (DSA). A DSA for a PL/I procedure consists of a save area for the contents of registers, a backchain address that points to the save area for the previous routine, and storage for automatic variables and miscellaneous housekeeping items.

An assembler routine invoked from PL/I should take the following action to preserve the PL/I environment:

1. If the assembler routine is to use the PL/I error-handler, it must store the contents of all registers in the existing PL/I DSA and establish its own save area in which the backchain address of the PL/I DSA must be stored. The first byte of the save area must be set to zero. The second word of the save area is the backchain address. The remainder of the save area would only be used by a routine invoked from the assembler routine or by the PL/I error-handler, if used, for saving the assembler routine's registers.

2. If the assembler routine is not to use the PL/I error-handler and does not invoke a further function routine, the SPIE macro must be used to reset the interrupt handler but only those registers that it modifies must be stored. The SPIE macro is discussed later in this chapter.

Calling Assembler Routines from PL/I

The following section describes:

1. How to invoke a non-recursive or non-reentrant assembler routine.

2. How to invoke a recursive or reentrant assembler routine.

INVOKING A NON-RECURSIVE OR NON-REENTRANT ASSEMBLER ROUTINE

When a PL/I program invokes a non-recursive or non-reentrant assembler-language routine, the assembler-language routine must follow System/360 linkage conventions and save the registers for use by PL/I on return from the assembler-language routine. The register values are stored in the PL/I DSA, the address of which is contained in register 13 on entry to the assembler-language routine. This address must then be stored in the backchain word in a save area defined by the assembler routine itself. Before returning to the PL/I routine, the assembler routine must restore the registers to the values held when the PL/I routine invoked the assembler routine. The following assembler instructions should be executed immediately the assembler routine is invoked in order to achieve the given objectives. The example in figure 12.1 assumes that the assembler routine uses register 10 as its base register.

```
         STM   14,11,12(13)     STORE PL/I REGISTERS IN PL/I DSA
         BALR  10,0             ESTABLISH BASE REGISTER
         USING *,10
         LA    4,SAVEAREA
         ST    13,SAVEAREA+4    STORE PL/I DSA ADDRESS IN SAVE AREA
         LA    13,SAVEAREA       LOAD SAVE AREA ADDRESS
         .
         .                      ASSEMBLER
         .                      ROUTINE
         .
         L     13,4(13)         RESTORE PL/I REGI
         LM    14,11,12(13)     -STERS  AND
         BR    14               RETURN TO PL/I
SAVEAREA DC    20F'0'           ALLOCATE 80 BYTE SAVE AREA
```

Figure 12.1 Invoking a non-recursive or non-reentrant assembler routine

INVOKING A RECURSIVE OR REENTRANT ASSEMBLER ROUTINE

A recursive or reentrant assembler routine invoked from PL/I can use the PL/I storage overflow routine to attempt to obtain further storage when the storage initially available for dynamic use by the program is used up.

A DSA established by the assembler routine must have its first byte set to X'00' if it is to handle any program interrupts. Such a DSA must be at least 80 bytes in length to accommodate both the save area and two fullwords required by PL/I for its housekeeping. If the PL/I error-handler is to service any program interrupts in the assembler-language routine, the DSA should be at least 88 bytes in length, the first byte of which should be set to X'80' and bytes 87 and 88 (the PL/I error-handler enable cells) set to X'91C0'. In addition, a DSA can be as long as is needed to store any values that are to be preserved for use by a particular invocation.

Termination of a recursive or reentrant assembler-language routine will release its DSA and cause control to be returned to the invoking routine.

The example in figure 12.2 shows how to create and release a DSA in a recursive or reentrant assembler routine.

USE OF REGISTER 12

If an assembler routine that modifies register 12 is to be invoked by a PL/I procedure, any program-check interrupts will result in an unpredictable program failure unless the routine establishes its own error handling for program-check interrupts. Consequently, the routine should be amended to use a register other than register 12 so that the PL/I error-handler can be used, or it can issue a supervisor SPIE or STAE macro to establish its own program interrupt or abnormal termination handling facilities. The routine must subsequently restore PL/I error-handling facilities before returning to PL/I. This is discussed further in "Overriding and Restoring PL/I Error-handling in an Assembler-language Routine" later in this chapter. (A routine that changes the content of register 12

```
         STM   14,11,12(13)  STORE CALLER'S REGISTERS IN CALLER'S DSA
         BALR  10,0          ESTABLISH BASE REGISTER
         USING *,10
         LR    4,1           SAVE ANY PARAMETER LIST ADDRESS
*                            PASSED FROM CALLING ROUTINE
         LA    0,90          PUT THE LENGTH OF THE REQUIRED DSA IN REG 0
         L     1,76(13)      LOAD THE ADDRESS OF THE NEXT AVAILABLE
*                            BYTE OF STORAGE AFTER THE CURRENT DSA
         ALR   0,1           ADD ADDRESSES
         CL    0,12(12)      COMPARE RESULT WITH ADDRESS OF LAST AVAILABLE
*                            BYTE IN STORAGE THAT CAN BE USED
         BNH   ENOUGH
         L     15,116(12)    LOAD AND BRANCH TO THE PL/I STORAGE CVERFLOW
         BALR  14,15         ROUTINE TO ATTEMPT TO OBTAIN MORE STORAGE
ENOUGH   EQU   *
         ST    0,76(1)       STORE THE ADDRESS OF THE NEXT AVAILABLE
*                            BYTE IN STORAGE AFTER THE NEW DSA
         ST    13,4(1)       STORE THE CHAIN-BACK ADDRESS OF THE PREVIOUS
*                            DSA IN THE CURRENT DSA
         MVC   72(4,1),72(13) COPY ADDRESS OF LIBRARY
*                            WORKSPACE
         LR    13,1          STORE THE ADDRESS OF THE NEW DSA IN REGISTER 13
         MVI   0(13),X'80'   SET FLAGS IN DSA TO
         MVI   86(13),X'91'  PRESERVE PL/I ERROR-HANDLING
         MVI   87(13),X'C0'  IN THE ASSEMBLER ROUTINE
         -
         -                   ASSEMBLER
         -                   ROUTINE
         -
         L     13,4(13)      RELEASE CURRENT DSA
         LM    14,11,12(13)  RESTORE CALLER'S REGISTERS
         BR    14
```

Figure 12.2. Invoking a recursive or reentrant assembler routine

should also store it on entry and restore it on return.)

Calling PL/I Procedures from Assembler Language

The simplest way to invoke a single external PL/I procedure from an assembler-language routine is to give the PL/I procedure the MAIN option and invoke it using entry point PLICALLA. All that is required is to load the address of PLICALLA into register 15 and then to branch and link to it. When PLICALLA is used in this way, the PL/I environment is created and control is then passed by way of PLIMAIN to the first (or only) main PL/I procedure in the program. Use of this technique will cause the PL/I environment to be established separately for each invocation.

ESTABLISHING THE PL/I ENVIRONMENT FOR MULTIPLE INVOCATIONS

If the assembler routine is to invoke either a number of PL/I routines or the same PL/I routine repeatedly, the creation of the PL/I environment for each invocation will be unnecessarily inefficient. The solution is to create the PL/I environment once only for use by all invocations of PL/I procedures. This can be achieved by invoking a main PL/I procedure which immediately reinvokes the assembler routine. The assembler routine must preserve the PL/I environment and is then able to invoke any number of PL/I procedures directly. The example in figure 12.3 contains an assembler-language routine that establishes the PL/I environment once only for multiple invocations of PL/I procedures.

```
//OPT12#3  JOB
//STEP1 EXEC HASMHC,PARM.ASM='LOAD,NODECK'
//ASM.SYSLIN DD DSN=&&LOADSET,UNIT=2314,DISP=(NEW,PASS),
//         SPACE=(80,(200,100)),DCB=BLKSIZE=80
//ASM.SYSIN DD *
MYPROG   CSECT
         ENTRY ASSEM
         STM   14,12,12(13)            ESTABLISH SUPERVISOR REGISTERS
         BALR  10,0                    ESTABLISH ADDRESSABILITY
         USING *,10
         LA    4,SAVEAREA              CURRENT SAVE AREA ADDRESS
         ST    13,4(4)                 STORE CHAINBACK ADDRESS
         ST    4,8(13)                 STORE CHAIN FORWARD ADDRESS
         LR    13,4                    STORE CURRENT SAVE AREA ADDRESS
*
         SR    1,1                     SET REGISTER 1 TO ZERO WHEN
*                                      A PARAMETERLESS ENTRY POINT TO
*                                      PROCEDURE THAT DOES NOT RETURN
*                                      A VALUE IS TO BE INVOKED
*
         L     15,=V(PLICALLA)         CALL THE PL/I PROCEDURE WHICH-
         BALR  14,15                   -HAS OPTIONS(MAIN) AND SO SET-
*                                      -UP THE PL/I ENVIRONMENT AND-
*                                      -THEN CALL ASSEM.
*
         L     13,4(13)                ON RETURNING FROM PL/I-
         L     14,12(13)               -RESTORE REGISTERS-
         LM    1,12,24(13)             -AND
         BR    14                      -RETURN TO THE SUPERVISOR.
*
*
         DC    C'ASSEM'                THE NAME IN PL/I FORMAT
         DC    AL1(5)
ASSEM    EQU   *
         STM   14,12,12(13)             STORE PL/I REGISTERS
         BALR  10,0                    FOR PROCEDURE "MAIN"
         USING *,10                    ESTABLISH ADDRESSABILITY
*                                      GET STORAGE FOR A NEW DSA
         LA    0,100                   LENGTH REQUIRED 100 BYTES
         L     1,76(13)                ADDRESS OF START OF CURRENTLY-
         ALR   0,1                     AVAILABLE STORAGE
         CL    0,12(12)                IS THERE ENOUGH SPACE LEFT?
         BNH   ENOUGH                  YES
         L     15,116(12)              LOAD ADDR. OF OVERFLOW ROUTINE-
         BALR  14,15                   -AND BRANCH TO IT.
ENOUGH   EQU   *
         ST    0,76(1)                 STORE ADDRESS OF START OF
*                                      REMAINING AVAILABLE STORAGE
*                                      IN NEW DSA AT OFFSET 76
         ST    13,4(1)                 SET BACK CHAIN
         ST    1,8(13)                 SET FORWARD CHAIN
         MVC   72(4,1),72(13)          COPY ADDRESS OF WORKSPACE FOR
*                                      USE BY THE PL/I LIBRARY
         LR    13,1                    POINT 13 AT NEW DSA
         MVI   0(13),X'80'             SET FLAGS IN THE DSA TO
         MVI   86(13),X'91'            PRESERVE PL/I ERROR-HANDLING
         MVI   87(13),X'C0'            IN THE ASSEMBLER ROUTINE
*
         SR    5,5                     R5 MUST BE ZERO WHEN CALLING-
*                                      -AN EXTERNAL PL/I PROCEDURE.
*
         SR    1,1                     SET REGISTER 1 TO ZERO WHEN
*                                      A PARAMETERLESS ENTRY POINT TO
*                                      PROCEDURE THAT DOES NCT RETURN
*                                      A VALUE IS TO BE INVOKED
```

Figure 12.3. (Part 1 of 2). Invoking PL/I procedures from an assembler-language rcutine

```
*
         L     15,=V(HEAD)              CALL PL/I TO 'HEAD' PAGE
         BALR  14,15
*
LOOP     EQU   *
         LA    1,ARGTLST1
         L     15,=V(PLIN)              CALL PL/I TO READ AND ADD
         BALR  14,15
*
         L     3,RESULT
         LTR   3,3                      TEST RESULT-
         BM    OUTLOOP                  -BRANCH OUT IF IT IS NEGATIVE.
*
         LA    1,ARGTLST2
         L     15,=V(PLOUT)             CALL PL/I TO OUTPUT RESULT
         BALR  14,15
         B     LOOP
*
OUTLOOP  EQU   *
         SR    1,1                      SET REGISTER 1 TO ZERO
         L     15,=V(FOOT)              CALL PL/I TO 'FOOT' PAGE
         BALR  14,15
*
         L     13,4(13)                 RETURN TO THE PL/I PROC WITH-
         LM    14,12,12(13)             -OPTIONS(MAIN).
         BR    14
*
ARGTLST1 DC    A(DATA)
ARGTLST2 DC    X'80'
         DC    AL3(RESULT)
DATA     DC    F'123'
RESULT   DC    F'0'
SAVEAREA DC    18F'0'
         END   MYPROG
/*
//STEP2 EXEC PLIXCLG
//PLI.SYSCIN DD *
* PROCESS;
  MANE:  PROC OPTIONS(MAIN);
         DCL ASSEM ENTRY;
         CALL ASSEM;
         END;
* PROCESS;
  PLIN:  PROC(I) RETURNS(FIXED BIN(31));
         DCL (I,J) FIXED BIN(31);
         GET LIST(J);
         RETURN(I+J);
  HEAD:  ENTRY;
         PUT LIST('THE FIRST LINE OF OUTPUT AT THE TOP OF THE PAGE')
               PAGE;
         PUT SKIP(2);
         END;
* PROCESS;
  PLOUT: PROC(K);
         DCL K FIXED BIN(31);
         PUT LIST(K);
         RETURN;
  FOOT:  ENTRY;
         PUT LIST('END OF THE OUTPUT FOR THIS JOB') SKIP(2);
         END;
/*
//GO.SYSIN DD *
 50  77  123  234  345  456  -23  -100  -123  -234
/*
```

Figure 12.3. (Part 2 of 2). Invoking PL/I procedures from an assembler-language routine

In this example, the assembler routine MYPROG receives control initially from the supervisor, and invokes the PL/I main procedure MAIN using the entry point PLICALLA to the PL/I initialization routine. The PL/I procedure MAIN immediately reinvokes the same assembler routine at the entry point ASSEM. Note that, in this example, this name must be an odd number of characters to ensure that the next instruction is halfword aligned. At this entry point, the PL/I environment is stored, and a new DSA, 100 bytes in length, is created in a manner similar to that previously given for creating a DSA in a recursive or reentrant assembler-language routine. If there is insufficient room for the new DSA, the PL/I overflow routine is invoked to attempt to obtain storage for the DSA elsewhere in storage.

The instructions in the assembler routine following the label ENOUGH through to the instruction that loads the address of the PL/I entry point HEAD are concerned with setting up the DSA so that the correct environment exists when the routine invokes the external PL/I procedures PLIN and PLOUT and the secondary entry points within them. These instructions should always be present in order to preserve the PL/I environment set up by the main procedure for subsequent use by any assembler-invoked PL/I procedures.

Note that when an external PL/I procedure is invoked, register 5 must be set to zero, and that a PL/I procedure, such as PLIN in this example, that returns a value will assign the value to the last address in the argument list, ARGTLST1. This address is the address of the assembler-defined storage for RESULT. The constant X'80' in the first byte of the fullword containing the address of RESULTS in ARGTLST1 indicates that it is the last fullword in the argument list.

If an assembler-language routine invokes a PL/I procedure without passing any parameters to it and without expecting any value to be returned from it, register 1 must be set to zero. In this example, the procedure PLIN contains a RETURN (expression) statement, but when invcked through the parameterless entry point HEAD, does not return a value to the invcking routine. Similarly, the procedure PLCUT contains the parameterless entry point FOOT and does not return a value.

ESTABLISHING THE PL/I ENVIRONMENT SEPARATELY FOR EACH INVCCATION

If it is necessary to reestablish the PL/I environment each time a PL/I procedure is invoked, use the entry point PLICALLA cr PLICALLB to invoke the PL/I initialization routines. The two entry points are used as follows:

For PLICALLA, the assembler-language routine must insert in register 1 the address of the argument list that contains the addresses of any arguments to be passed to the PL/I procedure. For PLICALLB, the assembler-language routine must insert in register 1 the address of an argument list that contains the following:

1. The address of the argument list containing addresses to be passed to PL/I, and optionally,
2. The address of the value for the amount of storage to be made available to the PL/I procedure and, optionally,
3. The start address of the storage to be used by the PL/I procedure. This storage must be doubleword aligned.

Note that the first byte in the last address word in each of these argument lists must contain X'80'. The examples in figures 12.4 and 12.5 show the use of PLICALLA and PLICALLB to invoke the first (or only) main PL/I procedure in the program.

```
         LA    1,ARGLIST
         L     15,=V(PLICALLA)
         BALR  14,15
         .
         .
         .
ARGLIST  DC    A(arg1)        ADDRESS OF FIRST ARGUMENT PASSED TO PL/I
         DC    A(arg2)        ADDRESS OF SECOND ARGUMENT PASSED TO PL/I
         .
         .
         .
         DC    X'80'           END OF ARGUMENT LIST FLAG
         DC    AL3(argn or return-value) ADDRESS OF LAST ARGUMENT
*                              OR RETURNED VALUE
```

Figure 12.4. Use of PLICALLA

```
         LA    1,ALIST
         L     15,=V(PLICALLB)
         BALR  14,15
         .
         .
         .
ALIST    DC    A(ARGLIST)      ADDRESS OF ARGUMENT LIST
         DC    A(LENGTH)       LENGTH OF STORAGE FOR PL/I
*                              ON DOUBLE WORD BOUNDARY
         DC    X'80'
         DC    AL3(AREA)       START OF PL/I STORAGE AREA
ARGLIST  DC    A(arg1)        ADDRESS OF FIRST ARGUMENT
         DC    A(arg2)        ADDRESS OF SECOND ARGUMENT
         DC    X'80'           END OF ARGUMENT LIST FLAG
         DC    AL3(argn or return-value) ADDRESS OF LAST ARGUMENT
*                              OR RETURNED VALUE
LENGTH   DC    F'8192'         ROUTINE'S STORAGE LIMITED TO 8K BYTES
AREA     DS    1024D           ROUTINE'S STORAGE STARTS HERE
```

Figure 12.5. Use of PLICALLB

```
         LA    1,ARGLIST
         L     2,=V(PLIMAIN)   CHANGE ADDRESS IN PLIMAIN
         L     3,=V(MYPROG)    TO THAT OF
         ST    3,0(2)          MYPROG
         L     15,=V(PLICALLA)
         BALR  14,15
         .
         .
         .
ARGLIST  DC    A(arg1)        FIRST ARGUMENT PASSED TO MYPROG
         DC    X'80'
         DC    AL3(arg2)        LAST ARGUMENT PASSED TO MYPROG
```

Figure 12.6 Inserting a PL/I entry point address in PLIMAIN

If it is necessary to reestablish the PL/I environment for each invocation of a PL/I procedure that is not the first (or only) main procedure in the program, the user of either entry point PLICALLA or PLICALLB must insert in PLIMAIN the address of the appropriate entry point to the required PL/I procedure. The example in figure 12.6 sets the address in PLIMAIN to that of the external entry name MYPROG.

If it is necessary to reestablish the PL/I environment for each invocation of a PL/I procedure where there is no main PL/I procedure in the program, the use of either entry point PLICALLA or PLICALLB must be accompanied by the use of an entry point called PLIMAIN in the assembler-language routine. This entry point must contain the address of the PL/I routine to be invoked. Figure 12.7 shows how this is inserted.

```
          ENTRY PLIMAIN
          LA    1,ARGLIST
          L     2,=A(PLIMAIN)  INSERT ADDRESS IN PLIMAIN
          L     3,=V(MYPROG)   OF ENTRY TO
          ST    3,0(2)         MYPROG
          L     15,=V(PLICALLA)
          BALR  14,15
          .
          .
          .
ARGLIST   DC    A(arg1)        FIRST ARGUMENT PASSED TO MYPROG
          DC    X'80'
          DC    AL3(arg2)      LAST ARGUMENT PASSED TO MYPROG
PLIMAIN   DS    F
```

Figure 12.7 Establishing PLIMAIN as an entry in the assembler-language routine

PL/I Calling Assembler Calling PL/I

The information given in the preceding sections should be sufficient to write programs that include a PL/I procedure that invokes an assembler-language routine that invokes a further PL/I procedure. Figure 12.3 contains an example of a program which performs this type of processing.

Assembler Calling PL/I Calling Assembler

The information given in the preceding sections should be sufficient to write programs that include an assembler-language routine that invokes a PL/I procedure that in turn invokes an assembler-language routine. Figure 12.3 contains an example of a program which performs this type of processing.

Overriding and Restoring PL/I Error Handling

An assembler-language routine invoked from PL/I can override PL/I error-handling by issuing its own SPIE macro to handle program interrupts or STAE macro to handle abnormal terminations. If the SPIE macro is issued, the address of the PL/I PICA must be saved. A routine that cancels PL/I error-handling must restore the PL/I error-handling facilities before returning to the PL/I program. It does this by issuing either a STAE macro with an operand of zero or an execute form of the SPIE macro restoring the saved PL/I PICA, according to the macros used to cancel the PL/I error-handling. The example in figure 12.8 shows how these macros are used to cancel and subsequently restore PL/I error-handling.

```
PROGA     CSECT
          ENTRY ASSEM            ENTRY-POINT INVOKED FROM PL/I
          STM   14,12,12(13)     STORE PL/I ENVIRONMENT
          BALR  10,0             ESTABLISH BASE REGISTER
          USING *,10
          STAE  (operands)       ESTABLISH NEW ABEND HANDLER
          SPIE  (operands)       ESTABLISH INTERRUPT HANDLER
          ST    1,SAVESPIE       STORE OLD PICA ADDRESS
          .
          .
          .
          STAE  0                RESTORE PL/I ERROR HANDLING
          L     1,SAVESPIE       RESTORE PICA ADDRESS
          SPIE  MF=(E(1))
          L     13,4(0,13)       RESTORE PL/I ENVIRONMENT
          LM    14,12,12(13)
          BR    14               RETURN TO PL/I
SAVESPIE  DS    A
```

Figure 12.8. Method of overriding and restoring PL/I error-handling

Arguments and Parameters

Arguments are passed between PL/I and assembler routines in lists which contain the addresses of the data items, not their values.

PASSING ARGUMENTS FROM AN ASSEMBLER-LANGUAGE ROUTINE

In order to pass one or more arguments to a PL/I routine, register 1 must be set to the address of a list that contains the address of each argument involved. If the PL/I routine executes a RETURN(expression) statement to return a value, the last address in the argument list must be the address which the PL/I routine is to use when it returns the value. The last fullword in an argument list must have X'80' in its first byte.

RECEIVING PARAMETERS IN AN ASSEMBLER-LANGUAGE ROUTINE

An assembler-language routine that is to receive parameters from a PL/I routine will be passed the address of a parameter list in register 1. The parameter list contains the addresses of the parameters; if the assembler routine has been invoked by a function reference in the PL/I procedure, the last address in the parameter list will be the address to which the assembler-language routine must assign the returned value. The last fullword in the parameter list will have X'80' in its first byte. The internal mapping of PL/I data types and the mechanism for addressing elements of arrays and structures are given in the execution logic manual for this compiler.

TYPES OF ARGUMENTS AND PARAMETERS

All PL/I data types (both problem data and program control data) can be passed as arguments to an assembler-language routine.

Problem Data: Only arithmetic element variables are passed as arguments by passing the addresses of their locations in storage. All other problem data types are passed as arguments by passing the address of a block of storage known as a locator/descriptor. A locator/descriptor contains the address and other relevant information about the data item that it represents. The address of the first byte of the data item is always present in the first fullword of the associated locator/descriptor. Locator/descriptors are employed for string, area, and aggregate data. For a varying-length string, the locator contains the address of a 2-byte field that contains the current length of the string and immediately precedes the data part of the string in storage. The format of locator/descriptors is given in the execution logic manual for this compiler.

Unless the techniques described below are adopted, an assembler-language routine must either cater for or create the appropriate locator/descriptor for a particular PL/I aggregate or string variable.

Program Control Data: Program control data constants are represented in storage as control blocks, the addresses of which are passed when used as arguments. The same applies to program control variables, such as entry and file variables, except that the address passed is the address of a control block that contains the address of the currently-assigned constant, and any additional information that is relevant to the use of the program control constant. The format of the control blocks for program control data is also given in the execution logic manual for this compiler.

USE OF LOCATOR/DESCRIPTORS

For those arguments passed to an assembler-language routine as locator/descriptors, obtain the address of the first byte of the data from the first fullword of the locator/descriptor.

For unaligned bit strings, the bit offset is in the last three bits in the second word of the string descriptor.

The current length of varying-length strings is in the first two bytes addressed from the descriptor.

The current length of an area argument is in the second word of its locator/descriptor.

The current extents of an adjustable array will be found in the array descriptor. However, a simple method of obtaining the current extents of an adjustable array is to pass, in addition to the array itself, values representing the results of the HBOUND and LBOUND built-in functions for each of its extents.

There are several other methods of avoiding the use of locator/descriptors when passing arguments to or from a PL/I program. Some of these are suggested below:

1. To obtain the address of the first element in an array or structure without recourse to its locator/descriptor, pass the first element in its subscripted or fully-qualified form rather than an unsubscripted or unqualified reference to the entire array or structure. The addresses of the remaining elements of the array or structure can be obtained if the characteristics of the aggregate are known in the assembler-language routine.

2. It is also possible in most cases to avoid the use of locator/descriptors in an assembler-language routine by ensuring that the PL/I procedure uses a based arithmetic argument or parameter in association with a string, area, or aggregate. Examples follow:

```
PP:PROC;
   DCL A(20) FIXED,
       B FIXED BASED(P),
       C CHAR(20),
       D FIXED BASED(Q),
       X ENTRY(FIXED,FIXED);
       P=ADDR(A);
       Q=ADDR(B);
       .
       .  /* SET VALUES IN A AND C */
       .
       .
       .
       CALL X(B,D) /*INVOKE X WITH ELEMENT
                  ARITHMETIC ARGUMENTS */
       .
       .
       .
```

This example causes the addresses of array A and character string C to be passed to assembler-language routine X. The invocation of X uses arithmetic variables B and D, which have been effectively overlaid on A and C. Note that varying-length strings from PL/I contain the current length in the first two bytes. The technique described above cannot be used for passing unaligned bit strings as arguments.

The following example shows the treatment of two parameters in a PL/I procedure invoked from an assembler-language routine:

```
PP: PROC(X,Y);
   DCL (X,Y) FIXED,
       A(20) FIXED BASED(P);
       B CHAR(20) BASED(Q);
       P=ADDR(X);
       Q=ADDR(Y);
```

The assembler-language routine passes the addresses of the first element in an aggregate or of the first byte in a string; the associated parameters can be declared as arithmetic element variables. String or aggregate variables can then be declared as based variables qualified implicitly by the pointers to which the addresses of the parameters are subsequently assigned. This technique will work for all types of PL/I data except unaligned bit strings. Note that a varying-length string should contain the current length of the string as a binary integer in the first two bytes before it is passed to the PL/I routine.

PL/I LANGUAGE FACILITIES FOR ASSEMBLER INTERFACE

Although the PL/I language does not provide direct facilities for communication between PL/I and assembler-language modules, use of the facilities for communicating with COBOL modules can simplify argument passing between PL/I and assembler-language modules. The PL/I interlanguage communication routines associated with these facilities can be used to avoid the previously-described problems associated with addressing PL/I data types. The PL/I interlanguage communication facilities are described in the language reference manual for this compiler.

A PL/I routine that invokes an assembler-language routine can declare the entry point to the assembler-language routine with the options COBOL, NOMAP, and INTER. The COBOL option ensures that the address of the data and not that of a locator/descriptor of a PL/I variable is passed; the NOMAP option ensures that no dummy arguments are created and that the argument is passed directly; the INTER option ensures that the program interrupts in the assembler-language routine are handled by PL/I unless the routine modifies the error-handling itself.

Similarly, a PL/I PROCEDURE or ENTRY statement invoked from an assembler-language routine can have the options COBOL and NOMAP. The COBOL option ensures that the address expected by the PL/I routine for a parameter is that of the data and not that of a locator/descriptor of a PL/I variable; NOMAP ensures that no dummy argument is created and that the

parameter is passed directly to the PL/I routine.

Note that because certain types of PL/I data have no equivalent in COBOL, a message may be produced by the compiler when such a data type is to be passed as an argument or received as a parameter.

Chapter 13: PL/I Sort

If you intend to use the PL/I sort facilities, the version of OS generated for your installation must include either a copy of the OS type 1 sort/merge program (Program Number 360S-SM-023) or a copy of the OS program product sort/merge program (Program Number 5734 SM1). The PL/I sorting facilities make use of either OS sort/merge program to arrange records according to a predetermined sequence. The sort/merge program includes user exit points to enable user-written routines to be entered at particular stages during the sorting operation and which provide access to records that are being sorted.

The PL/I sort facilities provide an interface to enable the sort/merge program to be invoked and to call PL/I procedures through two of the user exits, E15 and E35. This chapter describes the method of invoking sort/merge from PL/I and the use of the user exits E15 and E35.

Storage Requirements

The minimum storage requirements for the sort program when used in conjunction with a PL/I program compiled by the optimizing compiler is 12000 bytes or 26000 bytes in an MVT environment. Additional storage requirements exist if the sort program handles records that are greater than 400 bytes in length and if it uses direct-access devices for input, output, or intermediate storage. Efficiency is enhanced if additional main storage can be provided.

ENTRY NAMES

A PL/I program invokes the sort program by means of a CALL statement that names one of four entry points to a PL/I sort interface subroutine provided by the OS PL/I Resident Library. The CALL statement also passes arguments that specify the requirements for the sorting operation. The arguments include a sequence of sort/merge control statements in the form of character-string expressions. The PL/I sort interface subroutine has entry points for four types of processing:

PLISRTA — Invokes the sort/merge program to retrieve records from a data set (SORTIN), sort them, and write them in sorted sequence onto anchter data set (SORTOUT).

PLISRTB — Invokes the sort/merge program and specifies the use of user exit E15. A PL/I procedure invoked at user exit E15 will supply all the records to be sorted. The sorted records are written directly onto the data set SORTOUT.

PLISRTC — Invokes the sort/merge program and specifies the use of user exit E35. A PL/I procedure invoked at user exit E35 will receive all the records from the sort and handle any output that is required.

PLISRTD — Invokes the sort/merge program and specifies the use of user exit E15 and user exit E35. The use of these user exits is exactly as described for PLISRTB and PLISRTC.

After completion of the sort, the sort/merge program passes a return code to the invoking program to indicate whether the sort is successful or not. The invoking procedure must include a variable with the attributes FIXED BINARY(31) to receive this return code, and the name of the variable must always be included in the argument list of the CALL statement that invokes sort/merge. The return codes and their meanings, are:

0 Sort successful

16 Sort unsuccessful

PROCEDURES INVOKED BY WAY OF SORT USER EXITS

Both external and internal PL/I procedures can be invoked by way of sort user exits. The use of external PL/I procedures should present no problems so long as their entry names are declared in the main PL/I procedure and they are link edited with the main PL/I procedure to form a single executable program.

All records passed to a PL/I procedure from the sort/merge program, and all

records passed to the sort/merge program, must be in the form of character strings. A PL/I procedure invoked by way of user exit E35 must include a character-string parameter; a PL/I procedure invoked from user exit E15 must pass a record to the sort/merge program by means of a RETURN statement with a character-string expression as its argument. Varying-length character strings cannot be returned from an E15 exit procedure or received as parameters in an E35 exit procedure. Fixed-length character strings only can be returned by E15 exit procedures. However, a variable-length record passed to an E35 exit procedure can be declared as an adjustable-length character string. For example:

```
E35X: PROC (VREC);
      DCL VREC CHAR(*);
      .
      .
      .
```

A PL/I procedure invoked by way of a sort/merge user exit must pass a return code to the sort program to indicate what action should be taken when the PL/I procedure next relinquishes control. This is effected by invoking from within the procedure the PL/I library interface subroutine PLIRETC as follows:

```
CALL PLIRETC(n);
```

where "n" can have one of the following values to specify the action required:

For procedures invoked by means of user exit E15:

8 Do not return to this procedure.

12 Includes the record returned from the procedure in the sort.

16 Stop the sort and return immediately to the invoking procedure. (OS program product sort/merge program only.)

For procedures invoked by means of user exit E35:

4 Pass the next sorted record to the E35 procedure.

8 Do not return to this procedure.

16 Stop the sort and return immediately to the invoking procedure. (OS program product sort/merge program only.)

DATA SETS USED BY SORT/MERGE

The execution step for a PL/I program that uses PL/I sort requires job control DD statements for some or all of the following data sets in addition to those required by the PL/I program.

Input Data Sets

If the sort/merge program is to read the records to be sorted from a data set, include a DD statement for the data set, using the ddname SORTIN.

Work Data Sets

The sort/merge program requires at least three magnetic-tape or direct-access data sets for use as intermediate storage; you can increase efficiency by specifying the direct-access data sets on separate direct-access devices. If the volume of records to be sorted demands more intermediate storage, you can specify up to 32 data sets. Provide a DD statement for each work data set, using the ddnames SORTWK01 to SORTWK32.

Output Data Sets

If the sort/merge program is to write the sorted records onto an output data set, include a DD statement for the data set, using the ddname SORTOUT.

Other Data Sets

For the sort program to execute successfully, it must have access to the following data sets:

SORTLIB	The system sort/merge program library.
SYSOUT	For sort/merge program diagnostic messages.

The following data sets are needed if the associated facility is to be used:

SORTCKPT	If the sort/merge program is to make use of the checkpoint/restart facility.

SYSUDUMP For dumps of main storage if required for debugging the sort program.

PLIDUMP For dumps of main storage if required for debugging the PL/I program.

Invoking Sort/Merge from PL/I

The sort/merge program is invoked from a PL/I program by one of the CALL statements listed below. The number of arguments required depends on the entry name invoked.

The arguments include sort/merge program control statements that define the processing to be carried out and describe the records to be sorted. (When the sort/merge program is invoked as an independent job step, these control statements are submitted by way of the SYSIN input stream.) The control statements are described in the appropriate sort/merge publication for the version of the sort/merge program to be used. Note that the MERGE statement cannot be used when invoking the sort/merge program through the PL/I sort interface. The general syntax of the CALL statement for each of the four entry points is:

```
CALL PLISTRA(arg1,arg2,arg3,arg4);

CALL PLISTRB(arg1,arg2,arg3,arg4,arg5);

CALL PLISRTC(arg1,arg2,arg3,arg4,arg6);

CALL PLISRTD(arg1,arg2,arg3,arg4,arg5,
arg6);
```

The arguments are:

arg1 Sort/merge SORT statement; this statement may be preceded and followed by an optional blank character.

arg2 Sort/merge RECORD statement; this statement may be preceded and followed by an optional blank character.

arg3 Amount of main storage for the sort/merge program.

arg4 Name of the variable in the invoking procedure that is tc receive the sort return code.

arg5 Entry point name of the PL/I procedure to be invoked from user exit E15.

arg6 Entry point name of the PL/I procedure to be invoked from user exit E35.

In addition to these arguments, there are three optional arguments that can be specified for each entry point. These optional arguments permit you to override the sort/merge program defaults for the following:

1. Sort/merge program ddnames
2. Sort/merge program listing options
3. Sort/merge program sorting techniques

If used, these arguments must be specified in the above order. If an optional argument is not used, it need not be specified unless another argument that follows it in the given order is specified. In this case, the unused argument must be specified as a null string. Descriptions of the individual optional arguments follow.

Sort/Merge Program DD Names

For multiple invocations of the sort program from a single job step, the standard ddnames of sort data sets (SORTIN, SORTOUT, SORTWK, and SORTCKPT) can be changed by replacing up to the first four characters of the ddnames with a similar number of different characters. This is achieved by adding an extra argument to the CALL statements that invoke the sort program. For the invocation of the sort program that uses the standard ddnames, the additional argument should represent a null string. For the invocation of the sort program that uses the modified ddnames, the additional argument should be a character string that contains the replacement characters. Note that the first character of the replacement string must be alphabetic.

Example:

```
MSORT: PROC OPTIONS(MAIN);

       /* INVOKE THE SORT PROGRAM FOR THE FIRST TIME */

       CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                     ' RECORD TYPE=F,LENGTH=(80) ',
                     100000,
                     RETURN_CODE,
                     '');
                    .
                    .
                    .
       /* INVOKE THE SORT PROGRAM FOR THE SECOND TIME */

       CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                     ' RECORD TYPE=F,LENGTH=(80) ',
                     100000,
                     RETURN_CODE,
                     'TASK');
                    .
                    .
                    .
       END MSORT;
```

In this example the first invocation of the sort program requires DD statements with the ddnames:

```
//SORTIN DD ...
//SORTOUT DD ...
//SORTWK01 DD ...
etc.
```

For the second invocation, the sort program requires DD statements with the following ddnames:

```
//TASKIN DD ...
//TASKOUT DD ...
//TASKWK01 DD ...
etc.
```

Sort/Merge Program Listing Options

It is possible to select one of five options for specifying how the sort/merge program diagnostic messages are to be produced. The selected option can be specified as an optional argument to the entry point used. The optional argument should contain one of the following character strings:

NO No messages to be printed

AP All messages to be printed on the printer

AC All messages to be printed on the system console

CP Critical messages only to be printed on the printer

CC Critical messages only to be printed on the system console

according to the option that is required. An example of a CALL PLISRTA statement that does not modify the sort/merge ddnames but which does specify a sort/merge program listing option follows:

```
CALL PLISTRA (' SORT FIELDS=(7,74,CH,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
              100000,
              RETURN_CODE,
              '',  /* NULL DDNAME ARGUMENT */
              'CP');
```

Sort/Merge Program Sorting Techniques

It is possible to select one of four sorting techniques for use by the sort/merge program. The techniques are described in the sort/merge program publication. The selected technique must be specified in an optional argument to the entry point used. The optional argument should contain one of the character strings BALN, CRCX, OSCL, or POLY according to the technique that is required.

An example of a CALL PLISRTA statement that neither modifies sort/merge ddnames nor specifies a sort/merge listing option but which does specify a sorting technique follows:

```
CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
              ' RECORD TYPE=F,LENGTH=(80) ',
              100000,
              RETURN_CODE,
              '',
         /* NULL DDNAME ARGUMENT */
              '',
         /* NULL LISTING OPTION ARGUMENT /*
              'POLY');
```

Examples of Using PL/I Sort

SORTING RECORDS DIRECTLY FROM ONE DATA SET TO ANOTHER (PLISRTA)

The example in figure 13.1 illustrates the use of entry point PLISRTA to retrieve records from an input data set (SORTIN), sort them, and write them directly in sorted sequence onto an output data set (SORTOUT). The PL/I program contains the following elements:

1. A declaration of the variable RETURN CODE to receive the return code from the sort/merge program.
2. A CALL statement to invoke the entry point PLISRTA.
3. Statements to test the return code.

The example uses the minimum of data sets; one for input, one for output, and three direct-access storage extents on a single disk storage drive.

```
//OPT13#1  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX106: PROC OPTIONS(MAIN);

           DCL RETURN_CODE FIXED BIN(31,0);

           CALL PLISRTA (' SORT FIELDS=(7,74,CH,A) ',
                        ' RECORD TYPE=F,LENGTH=(80) ',
                        45000,
                        RETURN_CODE);
           IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
           ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')
                                                      (A);
                ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);
           END EX106;
/*

//GO.SORTIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002886BOOKER R.R. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTOUT DD SYSOUT=A,DCB=(RECFM=F,BLKSIZE=80)
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
```

Figure 13.1. Invoking sort/merge via entry point PLISRTA

USER EXIT E15 (PLISRTB)

The example in figure 13.2 illustrates the use of entry point PLISRTB to enable records to be supplied to the sort by a PL/I procedure.

Like that in the previous example, the main procedure invokes the sort/merge program and tests the return code when processing is complete. Note that records to be sorted can only be supplied by the procedure invoked by way of user exit E15 (in this case, procedure E15X).

Each time procedure E15X is invoked by the sort/merge program, E15X reads a record from the input stream and passes it to the sort after the appropriate return code has been passed.

```
//OPT13#2  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX107:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTB (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                   45000,
                   RETURN_CODE,
                   E15X);
     IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
     ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E15X:   /*  THIS PROCEDURE OBTAINS RECORDS FROM THE INPUT STREAM */
           PROC RETURNS(CHAR(80));
                DCL SYSIN FILE RECORD INPUT,
                    INFIELD CHAR(80) INIT(' ');

                ON ENDFILE(SYSIN) BEGIN;
                  PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT')(A);
                  CALL PLIRETC(8);  /*  SIGNAL END OF SORT INPUT  */
                  GOTO ENDE15;
                  END;

                READ FILE (SYSIN) INTO (INFIELD);
                CALL PLIRETC(12);  /*  INPUT TO SORT CONTINUES */
  ENDE15:       RETURN (INFIELD);
                END E15X;
     END EX107;
/*
//GO.SYSIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002886BOOKER R.R. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
//GO.SORTOUT DD SYSOUT=A,DCB=(RECFM=F,BLKSIZE=80)
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
```

Figure 13.2. Invoking sort/merge via entry point PLISTRB

```
//OPT13#3  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX108:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTC (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                   45000,
                   RETURN_CODE,
                   E35X);
     IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
     ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E35X:   /* THIS PROCEDURE OBTAINS SORTED RECORDS */
       PROC (INREC);
            DCL INREC CHAR(80);
            PUT SKIP EDIT (INREC) (A);
            CALL PLIRETC(4); /* REQUEST NEXT RECORD FROM SORT */
            END E35X;
     END EX108;
/*
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002996BOOKER S.W. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
```

Figure 13.3. Invoking sort/merge via entry point PLISTRC

USING USER EXIT E35 TO HANDLE SORTED RECORDS (PLISRTC)

The example in figure 13.3 illustrates the use of entry point PLISRTC to enable records to be supplied from the sort to the PL/I procedure E35X. As in previous examples, the main procedure invokes the sort/merge program and tests the return code when processing is complete. Each time procedure E35X is invoked by the sort/merge program, it receives a sorted record as a parameter, prints it, and requests the next record from the sort/merge program by passing it the appropriate return code.

PASSING RECORDS TO BE SORTED, AND RECEIVING SORTED RECORDS (PLISRTD)

The example in figure 13.4 illustrates the use of entry point PLISRTD to enable records to be supplied to the sort from a PL/I procedure and sorted records to be supplied from the sort to a PL/I procedure. As in previous examples, the main procedure invokes the sort/merge program and tests the return code when processing is complete. The use of the E15 user exit is identical to that in figure 13.2; the use of the E35 user exit is identical to that in figure 13.3.

The sequence of events is as follows:

1. The PL/I program invokes the sort/merge program.
2. The sort/merge program invokes the E15 routine for each input record until the return code is set to 8.
3. The sort/merge program invokes the E35 routine for each sorted record until all the sorted records have been passed or until the E35 routine requests no more records.

```
//OPT13#4  JOB
//STEP1 EXEC PLIXCLG,PARM.PLI='SIZE(130K),OBJECT'
//PLI.SYSIN  DD  *
 EX109:  PROC OPTIONS(MAIN);

     DCL RETURN_CODE FIXED BIN(31,0);

     CALL PLISRTD (' SORT FIELDS=(7,74,CH,A) ',
                  ' RECORD TYPE=F,LENGTH=(80) ',
                   45000,
                   RETURN_CODE,
                   E15X,
                   E35X);
     IF RETURN_CODE = 16 THEN PUT SKIP EDIT ('SORT FAILED')(A);
     ELSE IF RETURN_CODE = 0 THEN PUT SKIP EDIT ('SORT COMPLETE')(A);
          ELSE PUT SKIP EDIT ('INVALID SORT RETURN CODE')(A);

 E15X:   /*  THIS PROCEDURE OBTAINS RECORDS FROM THE INPUT STREAM */
       PROC RETURNS(CHAR(80));

            DCL INFIELD CHAR(80) INIT(' ');

            ON ENDFILE(SYSIN) BEGIN;
                PUT SKIP(3) EDIT ('END OF SORT PROGRAM INPUT.  ',
                    'SORTED OUTPUT SHOULD FOLLOW')(A);
                CALL PLIRETC(8);  /*  SIGNAL END OF SORT INPUT  */
                GOTO ENDE15;
                END;

            GET FILE (SYSIN) EDIT (INFIELD) (A(80));
            PUT SKIP EDIT (INFIELD)(A);
            CALL PLIRETC(12);  /*  INPUT TO SORT CONTINUES */
 ENDE15:    RETURN (INFIELD);
            END E15X;


 E35X:   /* THIS PROCEDURE OBTAINS SORTED RECORDS */
       PROC (INREC);

            DCL INREC CHAR(80);
            PUT SKIP EDIT (INREC) (A);
 NEXT:      CALL PLIRETC(4); /* REQUEST NEXT RECORD FROM SORT */
            END E35X;
       END EX109;
/*
//GO.SYSOUT DD SYSOUT=A
//GO.SORTLIB DD DSN=SYS1.SORTLIB,DISP=SHR
//GO.SORTWK01 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK02 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SORTWK03 DD UNIT=2314,SPACE=(TRK,(60,20),,CONTIG)
//GO.SYSIN DD *
003329HOOKER S.W. RIVERDALE, SATCHWELL LANE, BACONSFIELD
002996BOOKER S.W. ROTORUA, MILKEDGE LANE, TOBLEY
003077ROOKER & SON, LITTLETON NURSERIES, SHOLTSPAR
059334HOOK E.H. 109 ELMTREE ROAD, GANNET PARK, NORTHAMPTON
073872HOME TAVERN, WESTLEIGH
000931FOREST, IVER, BUCKS
/*
```

Figure 13.4. Invoking sort/merge via entry point PLISTRD

Chapter 14: Checkpoint/Restart

The PL/I Checkpoint/Restart feature provides a convenient method of taking checkpoints during the execution of a long-running program in a batch environment. It cannot be used in a TSO environment.

At points specified in the program, information about the current status of the program is written as a record on a data set. If the program terminates due to a system failure, this information can be used to restart the program close to the point where the failure occurred, avoiding the need to rerun the program completely.

This restart can be either automatic or deferred. An automatic restart is one that takes place immediately (provided the operator authorizes it when requested by a system message). A deferred restart is one that is performed later as a new job.

You can request an automatic restart from within your program without a system failure having occurred.

PL/I Checkpoint/Restart uses the Advanced Checkpoint/Restart Facility of the operating system. This is fully described in the manual Advanced Checkpoint/Restart.

To use checkpoint/restart you must do the following:

- Request, at suitable points in your program, that a checkpoint record is written. This is done with the built-in subroutine PLICKPT.
- Provide a data set on which the checkpoint record can be written.
- Also, to ensure the desired restart activity, you may need to specify the RD parameter in the EXEC or JOB statement (see the manual JCL Reference).

Note: You should be aware of the restrictions affecting data sets used by your program. These are detailed in the manual Advanced Checkpoint/Restart.

Writing a Checkpoint Record

Each time you want a checkpoint record to be written, you must invoke, from your PL/I program, the built-in subroutine PLICKPT. The CALL statement has the form:

```
CALL PLICKPT(ddname,check-id[,code][,org]);
```

"ddname" is a character string constant or variable specifying the name of the DD statement defining the data set that is to be used for checkpoint records. It can be effectively omitted by specifying a null string, and the system will use the default ddname SYSCHK.

"check-id" is a character string constant or variable specifying the name that you want to assign to the checkpoint record so that you can identify it later, if required. You can effectively omit "check-id" by specifying a null string. The system will supply a unique identification and print it at the operator's console.

"code" is a variable with the attributes FIXED BINARY (31), which can receive a return code from PLICKPT. The return code has the following values:

0 A checkpoint has been successfully taken.

4 A restart has been successfully made.

8 Unsuccessful checkpoint due to I/O error.

12 Unsuccessful checkpoint due to program error.

16 Successful checkpoint, but some system information may have been omitted.

"org" is a character string constant or variable with the attributes CHARACTER(2) whose value indicates, in operating system terms, the organization of the checkpoint data set. PS indicates sequential (that is, CONSECUTIVE) organization, PO represents partitioned organization. If "org" is omitted, PS is assumed.

Checkpoint Data Set

A DD statement defining the data set on which the checkpoint records are to be placed, must be included in the job control procedure. This data set can have either

CONSECUTIVE or partitioned organization. Any valid ddname can be used. If you use the ddname SYSCHK, you do not need to specify the ddname when invoking PLICKPT.

A data set name need be specified only if you want to keep the data set for a deferred restart. The I/O device can be any magnetic-tape or direct-access device.

If you want to obtain only the last checkpoint record, then specify status as NEW (or OLD if the data set already exists). This will cause each checkpoint record to overwrite the previous one.

If you want to retain more than one checkpoint record, specify status as MOD. This will cause each checkpoint record to be added after the previous one.

If the checkpoint data set is a library, then "check-id" is used as the member-name. Thus a checkpoint will delete any previously-taken checkpoint with the same name.

For direct access storage, enough primary space should be allocated to store as many checkpoint records as you will retain. You can specify an incremental space allocation, but it will not be used. A checkpoint record is approximately 5000 bytes longer than the area of main storage allocated to the compiler.

No DCB information is required, but you can include any of the following, where applicable:

OPTCD=W, OPTCD=C, RECFM=UT, NCP=2, TRTCH=C

These subparameters are described in appendix A.

Performing a Restart

A restart can be automatic or deferred. Automatic restarts can be made after a system failure or from within the program itself. All automatic restarts need to be authorized by the operator when requested by the system.

AUTOMATIC RESTART AFTER A SYSTEM FAILURE

If a system failure occurs after a checkpoint has been taken, the automatic restart will occur at the last checkpoint if you have specified RD=R (or omitted the RD parameter) in the EXEC or JOB statement.

If a system failure occurs before any checkpoint has been taken, then an automatic restart, from the beginning of the job step, can still occur if you have specified RD=R in the EXEC or JOB statement.

If a system failure occurs after a checkpoint has been taken, then you can still force automatic restart from the beginning of the job step by specifying RD=RNC in the EXEC or JOB statement.

AUTOMATIC RESTART FROM WITHIN THE PRCGRAM

An automatic restart can be requested at any point in your program. The rules applying to the restart are the same as for a restart after a system failure. To request the restart, you must execute the statement:

```
CALL PLIREST;
```

To effect the restart, the compiler terminates the program abnormally, with a system completion code of 4092. Therefcre, to use this facility, the system completion code 4092 must not have been deleted frcm the table of eligible codes at system generation.

DEFERRED RESTART

To ensure that automatic restart activity is canceled, but that the checkpoints are still available for a deferred restart, specify RD=NR in the EXEC or JOB statement when the program is first executed.

If a deferred restart is subsequently required, the program must be submitted as a new job, with the RESTART parameter in the JOB statement. The RESTART parameter specifies the job step at which the restart is to be made and, if you want to restart at a checkpoint, the name of the checkpoint record. The RESTART parameter has the form:

```
RESTART=(stepname[,check-id])
```

For a restart from a checkpoint, you must also provide, immediately before the EXEC statement for the job step, a DD statement, with the name SYSCHK, defining the data set containing the checkpoint record.

MODIFYING CHECKPOINT/RESTART ACTIVITY

You can cancel automatic restart activity from any checkpoints taken in your program by executing the statement:

```
CALL PLICANC;
```

However, if you have specified RD=R or RD=RNC in the JOB or EXEC statement, automatic restart can still take place from the beginning of the job step.

Also, any checkpoints already taken will still be available for a deferred restart.

You can cancel any automatic restart, and also the taking of checkpoints, even if requested in your program, by specifying RD=NC in the JOB or EXEC statement.

Appendix A: DCB Subparameters

This appendix shows you how to code data set information in the DCB parameter of the DD statement and how to make use of existing DCB information. It also contains an alphabetic list of the subparameters that apply to a PL/I program. These subparameters are specified in the DCB parameter of the DD statement. Chapter 3 shows you how to write a DD statement and chapter 6 shows you how to use the name (ddname) of the DD statement. For a full description of the DD statement see the job control language publications.

DCB Parameter

The DCB parameter enables you to add information about your data set to the data control block (DCB) generated when the associated file in your PL/I program is opened. The information to be added is defined in one or more subparameters. These subparameters correspond to the operands of the DCB macro instruction and are specified in the same way. For a full description of macro instructions see the supervisor and data management macro instructions publication.

Code the DCB parameter as follows:

```
DCB=subparameter

or

DCB=(subparameter,subparameter)
```

For example:

```
DCB=BLKSIZE=80

DCB=(RECFM=FB,LRECL=80)
```

Using Existing DCB Information

You can use the DCB parameter to make use of DCB information that already exists either in the label of a similar data set, or that has been specified in the DCB parameter of an earlier DD statement.

INFORMATION IN SIMILAR DATA SETS

You can copy DCB information from the label of a similar data set by coding:

```
DCB=dsname
```

where "dsname" is the name of the data set containing the information you want to copy. This data set must be cataloged, it must be on a direct-access storage device, and the volume containing it must be mounted before execution of the job step.

INFORMATION IN AN EARLIER DATA SET

You can also copy the DCB information from an earlier DD statement in a job by coding:

```
DCB=*.stepname.ddname
```

where the asterisk tells the operating system that this is to be a backward reference, "stepname" is the name of the job step in which the earlier DD statement appears, and "ddname" is the name of the earlier DD statement. If the earlier DD statement is in a cataloged procedure you must include the procedure step name as well as the job step name, for example by coding:

```
DCB=*.stepname.procstepname.ddname
```

Overriding Existing DCB Information

If the existing DCB information does not meet your requirements exactly you can override any of the subparameters by specifying the required information in a new subparameter. For example, if an existing DD statement named IN in a job step named COMP has the following DCB parameter:

```
DCB=(RECFM=FB,LRECL=80)
```

and you want LRECL to be 100, simply code:

```
DCB=(*.COMP.IN,LRECL=100)
```

Subparameters of the DCB Parameter

The following is a summary of those subparameters that can apply to your PL/I program. The notation used in the descriptions is as follows:

- n unsigned decimal integer
- | indicates a choice
- {} braces indicate that you must select one line from the items enclosed
- [] brackets indicate that the item enclosed is optional.

Code capital letters and numbers exactly as shown.

BLKSIZE=n

specifies the length in bytes of a block. The maximum length is 32760 bytes.

For fixed-length records, the block size must be an integral multiple of the record length (LRECL); the minimum size is 1 byte.

For variable-length (V-format and VB-format) records, the block size must be at least eight bytes larger than the largest item of data that you expect to read or write (that is, four bytes larger than the record length specified in LRECL). However, if the records are spanned (VS-format and VBS-format), you can specify block size independently of record length. The minimum block size for variable-length records is 18 bytes.

BUFNO=n

specifies the number of buffers to be used in accessing the data set. The maximum number is 255 (unless another maximum has been determined for your installation during system generation). For a STREAM file or BUFFERED RECORD file, if you do not specify the number of buffers or you specify zero buffers, the number is assumed to be two.

CODE=A|B|C|F|I|N|T

specifies the code in which paper tape is punched. (Data is read into main storage and then converted from that code to EBCDIC.)

- A ASCII (8-track)
- B Burroughs (7-track)
- C NCR (8-track)
- F Friden (8-track)
- I IBM BCD perforated-tape transmission code (8-track)
- N No conversion required (F-format records only)
- T Teletype (5-track)

If no code is specified, I is assumed.

CYLOFL=n

specifies, for an INDEXED data set, the number of tracks of each cylinder to be reserved for the records that overflow from other tracks in that cylinder. The theoretical maximum is 99, but the practical limit varies with the particular device.

There must be at least one track in each cylinder to hold the prime data.

DEN=0|1|2|3

specifies the recording density for magnetic tape as follows:

Bytes per inch (bpi)

DEN	7-track	9-track
0	200	-
1	556	-
2	800	800
3	-	1600

The density assumed if you omit this subparameter is:

7-track: 200 bpi
9-track (single density); 800 bpi
9-track (dual density): 1600 bpi

(The subparameter TRTCH is required for 7-track tape.)

DSORG=IS|DA

specifies the organization of the data set you are creating:

IS (indexed sequential): INDEXED data set

DA (direct access): REGIONAL data set

This subparameter is not required for CONSECUTIVE data sets.

KEYLEN=n

specifies the length in bytes of the recorded key of records in INDEXED, REGIONAL(2), and REGIONAL(3) data sets. The maximum key length is 255 bytes.

LIMCT=n

limits the extent of the search for a record or space to add a record in a REGIONAL(2) or REGIONAL(3) data set beyond the region number specified in the source key.

If you do not specify a limit, the search starts at the specified region and continues through the whole of the data set.

For REGIONAL(2), LIMCT specifies the number of records to be searched. The search starts at the beginning of the track on which the record is situated and continues to the end of the track containing the last record to be searched.

For REGIONAL(3), LIMCT specifies the number of tracks to be searched.

LRECL=n

specifies the length of a record in bytes; the maximum length is 32760 bytes for F-format records, and 32756 bytes for V-format records. You must specify a record length for blocked records.

For F-format and FB-format records, the record length must not exceed the block size (BLKSIZE) value; the minimum length is 1 byte.

For V-format records, give the maximum record length including the four control bytes required by the operating system; the minimum record length for V-format records is 14 bytes (ten bytes of data and four control bytes). The record length for V-format and VB-format records must be at least four bytes less than the block size (BLKSIZE) value; however, for VS-format and VBS-format records, it can be specified independently of block size.

MODE=C|E

specifies the mode of operation for a card reader or punch. E indicates EBCDIC, and C specifies column binary. If you do not specify the mode, E is assumed.

NCP=n

specifies the number of channel programs allocated to a file when it is opened: the number of simultaneous input/output operations on the file (that is, the number of incomplete event variables) cannot exceed the number of channel programs. The NCP subparameter applies only to direct access to INDEXED data sets, or sequential access to CONSECUTIVE or REGIONAL data sets that are unbuffered. The maximum number of channel programs is 99 (unless another maximum was established for your installation at system generation); the default value assumed if you omit the subparameter is 1.

For DIRECT access to an INDEXED data set, simultaneous input/output operations in excess of the number of channel programs are queued until a channel program becomes available.

For UNBUFFERED SEQUENTIAL access to CONSECUTIVE or REGIONAL data sets, the ERROR condition is raised if there are too many concurrent operations.

The NCP subparameter overrides the BUFNO subparameter or the BUFFERS option of the ENVIRONMENT attribute. One buffer is allocated for each channel program.

NTM=n

specifies, for an INDEXED data set, the number of tracks in the cylinder index referred to by each master index entry, and the number of tracks within each level of the master index referred to by each entry in the next higher level. The maximum value for n is 99. (See also OPTCD=M later in this chapter.)

OPTCD=option list

lists optional data management services. To indicate the services you require, code the appropriate letters (see below) without separating blanks, in place of "option list" (for example, OPTCD=LY).

OPTCD=C requests chained scheduling, which improves input/output performance by reducing the time required to transmit blocks to and from auxiliary storage devices. In chained scheduling, the data management routines bypass the normal input/output scheduling routines and chain several input/output operations together; a series of read operations, for example, is issued as a single chain of commands instead of several separate commands.

Chained scheduling is most useful in programs whose performance is input/output limited. If you use this feature, you should request at least three buffers or at least three channel programs. Chained scheduling can be used with CONSECUTIVE or REGIONAL SEQUENTIAL data sets; it should not be used for INPUT or UPDATE with U-format records.

OPTCD=I requests an independent overflow area for an INDEXED data set; you must define this overflow area in a separate DD statement.

OPTCD=L requests that a record in an INDEXED data set be recognized as deleted if its first byte contains (8)'1'B.

OPTCD=M requests the creation of a master index in accordance with the information given in the NTM subparameter.

OPTCD=U suppresses the raising of the TRANSMIT condition when an invalid character is passed to a printer with the universal character set feature. A blank is printed in place of the invalid character.

OPTCD=W requests a write validity check for a direct-access device.

OPTCD=Y requests that the data management routines use the cylinder overflow area for overflow records in an INDEXED data set. The size of the overflow area is established by CYLOFL=n.

```
RECFM=  {F[B]  [S]}
        {V[B]  [S]}   [T]   [A|M]
        {U        }
```

indicates the record format as follows:

F Fixed-length records

V Variable-length records

U Undefined-length records

If you do not specify a record format, U-format is assumed, except for PRINT files, for which V-format is the default assumption.

The optional subfields are:

B Blocked records.

D Standard (fixed-length records only). No blocks, except possibly the last, will be shorter than the specified block size.

D Spanned (variable-length records only). If variable-length records are spanned, the record length specified by LRECL can exceed the block size specified by BLKSIZE; if necessary, the records are segmented and the segments are placed in consecutive blocks. If the records are unblocked, each block contains only one record or segment; if the records are blocked, each block contains as many records or segments as it can accommodate.

T Track overflow. Track overflow is an operating system feature that can be incorporated during system generation. It allows a block to overflow from one track of a direct-access device to another. Track overflow is useful in achieving greater data-packing efficiency, and also allows the size of a record to exceed the capacity of a track.

Note: You cannot use track overflow for REGIONAL(3) data sets with U-format or V-format records or for INDEXED data sets.

A The first byte of each record contains an ANS printer/punch control code.

M The first byte of each record contains an IBM System/360 printer/punch control code.

RKP=n

specifies for an INDEXED data set, the position (n) of the first byte of an embedded key relative to the beginning of the record (byte 0). RKP=0 implies that the key is not embedded. (For example, if "XYZ" is the key embedded in the record "ABCXYZDEF", RKP=3.)

STACK=1|2

refers to a card reader or punch:

1 All cards read or punched are to be fed into stacker 1.

2 All cards read or punched are to be fed into stacker 2.

Stacker 1 is assumed if you omit this subparameter. If you want stacker 3, specify the ANS machine-code character in the RECFM parameter of the DD statement, and insert the appropriate character as the first data byte.

TRTCH=C|T|E|ET

is required when a data set is recorded or is to be recorded on 7-track tape. It specifies the recording technique to be used as shown in the following table:

	Data Conversion	Parity	Translation
C	Yes	Odd	No
T	No	Odd	Yes
E	No	Even	No
ET	No	Even	Yes
default	No	Odd	No

Notes

Data conversion and translation: data on 9-track magnetic tape, like that in main storage, is held in 8-bit bytes, a ninth bit being used for parity checking; data on 7-track tape is held in the form of 6-bit characters with a parity bit. The conversion feature of the 2400 series magnetic-tape drives treats all data as if it were in the form of a bit string, breaking the string into groups of six bits for writing on 7-track tape, or into groups of eight bits for reading into main storage. The translation feature changes the form in which character data is held from 8-bit EBCDIC to 6-bit BCD or vice versa. If you specify neither conversion nor translation, only the last six bits of each 8-bit byte are transmitted; the first two are lost on output and are set to zero on input.

Parity: Odd parity checking is normally used in IBM System/360, but you should specify even parity if you want to read a tape that was written by a system using even parity, or to write a tape for a system that demands even parity.

Choice of technique: The use of a technique other than C restricts the character set in which data can be written if it is subsequently to be reread and result in the same bit configuration in main storage. (An 8-bit code offers 256 possible configurations, but a 6-bit code only 64.) For stream-oriented or record-oriented transmission of character strings or pictured data, you can use technique C or T; you can also specify ET if your program is written in the 48-character set. (Seven-track tape recording systems indicate a zero bit by the absence of magnetization of the tape. Even parity checking does not allow the code 000000 to be used to represent the character zero, since an unmagnetized band is not acceptable on the tape. Therefore the code that would otherwise represent a colon (:) is used for the character zero, precluding the use of the full PL/I 60-character set.) For record-oriented transmission of arithmetic data, you must specify technique C.

Appendix B: Compatibility with the PL/I (F) Compiler

Some features of the PL/I Optimizing Compiler implementation are incompatible with the PL/I (F) Compiler implementation. The most significant incompatibilities are listed below. In every case, the description given is of the optimizing compiler implementation. Programs which were written for the (F) compiler and which use any of these features should be reviewed before compiling them with the optimizing compiler to ensure that they will return the same results.

Arrays and Structures

- The maximum number of dimensions in an array is 15.
- The maximum depth of a structure is 15.

Built-in Functions

- Built-in functions are recognized on the basis of context only, so that all programmer-defined external procedures must be declared explicitly. Built-in functions and pseudovariables without arguments, such as TIME and ONCHAR, must also be declared explicitly with the BUILTIN attribute, or contextually with a null argument list, for example: TIME( ).
- For a variable to be a valid argument to the ADDR built-in function it must be connected and its left extremity must not lie within bytes that contain data belonging to other variables.
- The ALLOCATION built-in function returns a fixed-binary value giving the number of generations of the argument that exist in the current task.
- The NULLO built-in function is not implemented in the optimizing compiler. The NULL built-in function can be used for offset variables as well as for pointer variables.
- The ONCOUNT built-in function can be used in any on-unit and gives the number of interrupts remaining to be processed at any stage in the execution of the current task. In particular, this includes event and non-event I/O and multiple computational interrupts. In the case of event I/O, the value of ONCOUNT is the number of remaining exceptional conditions to be processed as a result of the execution of the WAIT statement.
- When using REGIONAL(1) organization, the value returned by the ONKEY built-in function for a specification error consists of the last eight bytes of the source key, padded on the right with blanks if necessary. This value is returned for all I/O conditions other than ENDFILE, or other than ERROR raised as standard system action for an I/O condition.

  In a RECORD I/O statement with the KEY or KEYFROM option, the ONKEY built-in function returns a null string when the ERROR condition is raised.

  In a RECORD I/O statement referring to a KEYED file (but with no KEY, KEYFROM, or KEYTO option specified) the ONKEY built-in function returns the recorded key.
- The PROD built-in function accepts arguments that are arrays of either fixed-point or floating-point elements. The value returned has the same scale as the argument given, except for fractional fixed-point arguments for which the result is in floating-point.
- If the first argument of the ROUND built-in function is a string, it is converted to arithmetic and rounded; the first argument must be convertible to arithmetic. Also, a different formula is used to determine the precision of a fixed-point result.
- The SUBSTR built-in function returns a non-varying string.
- The SUM built-in function accepts arguments that are arrays of either fixed-point or floating-point elements. The value returned has the same scale as the argument given.
- The arguments of the TRANSLATE built-in function are converted to character-strings in all cases.
- The first 16 bits of the result returned by the UNSPEC built-in

function for a varying string argument represent the current length of the string.

Checkout/Restart

- The arguments to the function PLICKPT are mandatory.

Conditions

- When used with arrays, the CHECK condition is raised after assignment to each element. The standard system action when an assignment is made to a single element of an array is to print the value of only the element assigned.
- If the SIZE, SUBSCRIPTRANGE, or STRINGRANGE condtions occur when disabled, standard system action is taken.
- The STRINGRANGE condition is not raised for SUBSTR(string, i, 0) when "i" is one greater than the length of "string". A null string is returned.

Control Variable in DO statement

- The pseudovariables COMPLETION, COMPLEX, PRIORITY, and STRING are not allowed as the control variable of a DO statement.

DEFINED Attribute

- Simple defining of strings and areas on a larger base is allowed.

  For example:

```
DECLARE A (6) CHAR (6),
        B (3) CHAR (3) DEFINED A;
```

  This example will result in simple defining - B(1) will refer to the first three characters of A(1), B(2) to the first three characters of A(2), and so on.

  If string overlay defining is required, the user must specify POSITION (1) on the declaration of the defined item (B in the example above).

  If the string lengths or bounds of the defined item cannot be contained in the base, then string overlay defining will be assumed, as with the PL/I (F) Compiler.

  For example:

```
DECLARE A (6) CHAR (6),
        B (7) CHAR (3) DEFINED (A);
```

  In this example, string overlay defining will be used because the bounds of array B exceed the bounds of array A.

- If the DEFINED attribute is used with an array of pictures, the defined item must match the base item exactly.

Dependent Declarations

- Only one level of dependent declaration is allowed.

DISPLAY Statement

- The maximum length of the reply is 72 characters.

Entry Names, Parameters, and Returned Values

- Each alternative entry expression in a GENERIC attribute is followed by a WHEN clause. The appearance of an entry name alternative does not constitute a declaration of the entry name. The alternative selected is the first for which each descriptor is a subset of the attributes of the corresponding argument in the generic reference.
- The dimension attribute is not allowed in a generic descriptor.
- In general, an entry name in parentheses causes a dummy variable to be created; for the function to be invoked, a null argument list is required. However, an entry name argument in parentheses, or an entry name without arguments, will be invoked

if passed to a procedure whose parameter descriptor for the corresponding argument specifies an attribute other than ENTRY.

- External entry names must always be explicitly declared.
- Area and string extents in the RETURNS attribute or option must be represented by a decimal integer constant.
- The maximum depth of nesting in a descriptor list in the ENTRY attribute is 2.
- An aggregate expression involving strings may not be passed as an argument unless there is a corresponding parameter descriptor in which all string lengths are specified as decimal integer constants.
- An internal entry constant cannot be declared in a DECLARE statement. REDUCIBLE and IRREDUCIBLE may be specified on PROCEDURE and ENTRY statements. A scalar cannot be passed to an array parameter of an internal entry constant if the parameter's bounds are specified by asterisks.

ENVIRONMENT Attribute

- The optimizing compiler will recognize and convert the previously-implemented forms of the above options as shown below, and will issue a message stating that they are obsolete.

Old form	Converted to
F(b)	F BLKSIZE(b) RECSIZE(b)
F(b,r)	F BLKSIZE(b) RECSIZE(r)
U(b)	U BLKSIZE(b) RECSIZE(b)
V(b)	V BLKSIZE(b) RECSIZE(b-4)
V(b,r)	V BLKSIZE(b) RECSIZE(r)
VBS(b,r)	VBS BLKSIZE(b) RECSIZE(r)
VS(b,r)	VS BLKSIZE(b) RECSIZE(r)

There are two new data set organizations, TP(M) and TP(R), associated with teleprocessing. TP(M) implies the transmission of whole messages; TP(R) implies the transmission of records. Both are valid only for TRANSIENT files. These data-set organizations are equivalent to the options G(m) and R(r) available in Version 5 of the PL/I (F) compiler. The optimizing compiler will recognize and convert as follows:

Old form	Converted to
G(m)	V TP(M) RECSIZE(m)
R(r)	V TP(R) RECSIZE(r)

Error Correction

- The error correction logic differs from that used by the PL/I (F) compiler. Invalid programs that are compiled and corrected by the (F) compiler may not give the same results on the optimizing compiler.

EXCLUSIVE Attribute

- The EXCLUSIVE attribute implies only the RECORD attribute; DIRECT, UPDATE, and KEYED will apply only by default.
- The EXCLUSIVE attribute can be used in non-tasking programs, and jobs in the system can affect each other.

Expression Evaluation

- In a concatenation operation, a BINARY operand is converted to BIT if the other operand is BINARY or BIT.

FIXED BINARY Expressions

- The length of FIXED BINARY constants and intermediate results with a precision less than 16 is 2 bytes. The UNSPEC built-in function returns a result whose length is 16 bits.

LIKE Attribute

- The LIKE attribute is not allowed in specifying a minor structure that is contained in a major structure of which some other minor structure is declared with the LIKE attribute.

Link-editing

- Programs translated by the optimizing compiler cannot be link-edited with object modules produced by the PL/I (F) compiler.

Locked Records

- The locking action takes place at the data set level.
- If an on-unit is entered as a result of a REWRITE or DELETE statement, the record is unlocked if the on-unit is terminated by a GOTO statement as well as normal completion.
- The ERROR condition is raised if a file is closed while subtasks currently have records in it locked.
- A record is not locked due to "key not found" or "key outside data" conditions.

Operating System Facilities

- The operating system facilities for sorting, for checkpoint/restart, for generating a return code, and for obtaining a dump are all invoked by means of a CALL statement with the appropriate entry-point name; for example CALL PLISRTA. The entry point names, which are listed below, have the BUILTIN attribute and need not be declared explicitly.

Facility	Entry-point Name
Sort	PLISRTA
	PLISRTB
	PLISRTC
	PLISRTD
Checkpoint/Restart	PLICKPT
	PLIREST
	PLICANC
Return Code	PLIRETC
Dump	PLIDUMP

The optimizing compiler does not recognize the entry names used by the PL/I (F) compiler, that is, IHESRTx, IHESARC, IHEDUMx and IHECKPT. Existing programs for the PL/I (F) compiler that use these entry names must be amended so that the DECLARE statements for them are removed completely.

Pictures

- Sterling picture data is not implemented. Therefore the following picture characters are not allowed:

  G, H, M, P, 6, 7, 8.

Preprocessor

- Text replaced by preprocessor statements does not have blanks appended to either end of the replacement value.
- A parameter descriptor list is not allowed in the declaration of a preprocessor variable with the ENTRY attribute.
- The RETURNS attribute may not be specified in a preprocessor DECLARE statement.

Pseudovariables

- For a varying string, the first 16 bits of the value of the UNSPEC pseudovariable represent the current length of the string.

Record I/O

- If READ...KEY is used with a sequential data set and no record with the specified key exists in the data set, the KEY condition is raised and the file is positioned at the next record in ascending sequence.
- If an embedded key in a record is not identical to that specified in a WRITE...KEYFROM or LOCATE statement, the latter is moved into the record.
- READ, REWRITE, and DELETE statements are invalid for REGIONAL DIRECT OUTPUT files.
- There is no default record format for RECORD files. If the record format is not specified, the UNDEFINEDFILE condition is raised.

Return Code

- The maximum return code that may be set using PLIRETC is 999.

Standard File SYSPRINT

- The name SYSPRINT is reserved as the name of an output file used by the compiler. This file can also be used as the standard output file in the PL/I program. It always has the attributes STREAM, OUTPUT, PRINT and EXTERNAL.

  The default record characteristics are: record format = VB, record length = 125, and block size = 129. The default number of buffers is two. Using the DCB parameter of the DD statement, record format can be changed to VBA, and record length, block size, and the number of buffers can be changed to any valid value.

  SYSPRINT is opened and closed by the compiler, however, the OPEN statement can be used to specify the LINESIZE, PAGESIZE and TITLE options for use with the PL/I program.

Statements

- The approximate maximum number of statements in a program is 10,000.

Statement Labels

- A label on a DECLARE statement is treated as if it were on a null statement.

Stream Transmission

- A filemark (or end of string mark for the STRING option) is a valid item delimiter for list- and data-directed input. An item thus delimited is processed intact, and ENDFILE (ERRCR for string) is raised on attempting to read a further item from the file cr string.

- After processing a GET LIST statement, a file is positioned to the next non-blank character or, if this is a comma, to the character following the comma. A GET EDIT statement following a GET LIST on the same file must take into account the position of the file.

- The NAME condition (ERRCR for the STRING option) is raised for all errcrs (including out of range subscripts) detected on the left-hand side of an item of data-directed input.

- The COPY option causes all items to be copied, including any skipped by the SKIP option. A contextual declaration of SYSPRINT is caused if no file name is specified for the COPY option.

- When transmitting DATA-directed cutput to a PRINT file, data items less than or equal to the line size will not be split between lines. Data items greater than the line size will, if possible, be split between the equals sign and the data value.

- Execution of a PUT statement in which the LINE option specifies the current line and the current column is not 1 does not cause the ENDPAGE condition to be raised. No new current line is established; the file is repositioned to column 1 of the current line.

WAIT Statement

- If a WAIT statement requires the completion of an inactive and incomplete event variable in a non-tasking program, then after any I/O event variables named in the same statement are completed, a message is printed and the program is terminated. In a TSO environment, control passes to the terminal.

Appendix C: Requirements for Problem Determination and APAR Submission

When a member of IBM programming support personnel is called to examine the suspected malfunctioning of an IBM program product, he will first determine whether or not the malfunction really is a problem in the program product. If he decides that the program product is at fault, he must then check to see if the fault is a known fault for which he can obtain an existing fix-up. If the fault is not known, he must refer the problem to the appropriate program maintenance group within IBM for analysis and correction. The process of referring a problem to IBM involves submitting a report known as an APAR (Authorized Program Analysis Report), which must be accompanied by material to enable the program maintenance personnel to analyze the problem.

To enable IBM program maintenance personnel to analyze a problem, it must be possible to reproduce it at the IBM program maintenance center. It will therefore be essential to supply with the APAR the source program to enable the problem to be reproduced and analyzed. Faster resolution of the APAR may be possible if some or all of the material listed in figure C.1 is supplied and if the source program is

Material Required	Compiler Option	When Required
Original source program		C,E
Job Control Statements		C,E
Operating Instructions/ Console Log		
Listings:		
Source listing	SOURCE (S)	C,E
Cross-reference listing	XREF (X)	C,E
Attribute table	ATTRIBUTES (A)	C,E
Aggregate table	AGGREGATE (AG)	C,E
Storage table	STORAGE (STE)	C,E
Compiler options	OPTIONS (OP)	C,E
Compiler terminal dump	DUMP (DU)	C
Linkage editor map	MAP (linkage editor option)	E
Execution-time dump		E
User subroutines		E
User data sets		E
Preprocessor input listing	INSOURCE (IS)	P
Preprocessor output	MDECK (MD)	C,E
Partition/Region size		C,E
List of applied PTFs		C,E

Note: "C" indicates the requirements for a compile-time error;
"E" indicates requirements for an execution-time error;
"P" indicates the requirements for a preprocessor error.

Figure C.1. Summary of requirements for APAR submission

reduced to the smallest, least complex form which still contains the problem.

All listings that are supplied must relate to a particular execution of the compiler, in the case of a suspected compiler failure, or to the relevant link editing and execution steps, in the case of the failure of the PL/I program during execution. Listings derived from separate compilations or executions are of no value and may, in fact, be misleading to the programming support personnel.

Original Source Program

The original PL/I source program must be supplied in a machine-readable form such as a deck of punched cards or a reel of magnetic tape. The copy of the program supplied must be identical to the listing that is also supplied.

Use of the Preprocessor

If the compilation includes preprocessing, the source program submitted should include, either as a card deck or on magnetic tape, the source module obtained by means of the compiler MDECK option.

If the problem is known to have occurred during preprocessing, a listing of the source program being preprocessed must be supplied. If the preprocessing involves the use of the %INCLUDE statement, a copy of the PL/I source statement module(s) included should be supplied in a machine-readable form. If source statement modules are not supplied in the original submission of the APAR, the APAR will be put into abeyance until they are supplied.

Job Control Statements

Listings of job control statements used to run the program must be supplied. For OS installations, any local cataloged procedures should be shown in expanded form, obtained by specifying MSGLEVEL=1 in the JOB statement. Where there are a large number of job control statements, supply these also in a machine-readable form such as on punched cards or on magnetic tape. This will assist the program maintenance personnel to reproduce the problem more quickly.

Operating Instructions/Console Log

In the case of an execution-time failure of a program that processes a number of data sets or that operates in a complicated environment, such as a teleprocessing application, it is essential that adequate description of the processing and the environment is given to enable it to be recreated. Although it may be impossible to supply console logs and operating procedures, a complete description of the application, the organization of the data sets, and adequate operating instructions are vital for the IBM program maintenance personnel to reproduce the problem.

Listings

A listing of the source program is essential. Other compiler-generated listings, while not essential, may assist in producing a faster resolution of the APAR. If any of the compiler options that must be specified in order to obtain material for submission with an APAR have been deleted at system generation, they can be restored for temporary use by means of the compiler CONTROL option.

Linkage Editor Map

When a problem occurs at execution time, a linkage editor map that was obtained when the copy of the program that has failed was link edited is essential. The linkage editor map will be used in the analysis of the storage dump that must also be obtained when the program failed.

Execution-time Dumps

If the problem occurs during execution of the PL/I program, a storage dump must be supplied. A dump can be obtained by using a stand-alone dump program. However, if possible, a formatted PL/I dump produced by the PL/I error-handling facilities should be provided. A PL/I dump is obtained by including the following statement in an ERROR on-unit that will be entered when the program fails:

```
CALL PLIDUMP('TFHB');
```

Applied PTFs

A list of any program temporary fixes (PTF) and local fixes (s/zaps) applied to either the compiler or its libraries must be supplied. The IBM service aid program IMAPTFLS, described in the publication OS Service Aids, Order No. GC28-6719, can be used to obtain from a program library a listing showing those members of the library that have PTF or local fixes, provided that when the fix was made, the correct system status index (SSI) was included in the library directory. However, if a module contains more than one temporary fix, only the last fix to be applied will be listed by the IMAPTFLS program.

Submitting the APAR

When submitting material for an APAR to IBM, ensure that any magnetic tapes and decks of punched cards that are supplied containing source programs, job stream data, data sets, or libraries are carefully packed and clearly identified.

Each magnetic tape submitted should have the following information attached and visible:

- The APAR number assigned by IBM.
- The contents of the volume (source program, job control statements, or data, etc.).
- The recording mode and density.
- All relevant information about the labels used for the volume and its data sets.
- The record format and blocking sizes used for each data set.
- The name of the program that created each data set.

Each card deck submitted must have the following information attached and visible:

- The APAR number assigned by IBM.
- The contents of the card deck (source program, job control statements, or data, etc.).

This information will ensure that a magnetic tape or card deck will not be lost if it becomes separated from the rest of the APAR material, and that its contents are readily accessed.

Appendix D: IBM System/360 Models 91 and 195

This appendix explains how exceptions and interrupts in Models 91 and 195 are handled by the operating system. An exception is a hardware occurrence (such as an overflow error) which can cause a program interrupt. An interrupt is a suspension of normal program activities. There are many possible causes of interrupts, but the following discussion is concerned only with interrupts resulting from hardware exceptions.

IBM System/360 Models 91 and 195 are high-speed processing systems in which more than one instruction may be executed concurrently. As a result, an exception may be detected and an interrupt occur when the address of the instruction which caused the exception is no longer held in the central processing unit. Consequently, the instruction causing the interrupt cannot be precisely identified. Interrupts of this type are termed imprecise. When an exception occurs, the machine stops decoding further instructions and ensures that all instructions which were decoded prior to the exception are executed before honoring the exception. Execution of the remaining decoded instructions may result in further exceptions occurring. An imprecise interrupt in which more than one exception has occurred is known as a multiple-exception imprecise interrupt.

The optimizing compiler permits processing of imprecise interrupts only when the compiler option IMPRECISE is in effect. This is useful when debugging a program. The effect of the option is:

1. To cause the compiler to insert special "no-operation" instructions at certain points in the program to localize imprecise interrupts to a particular segment of the program, thus ensuring that interrupt processing results in the action specified in the source program. These "no-operation" instructions are generated:

   - Before an ON-statement.
   - Before a REVERT statement.
   - Before internal code to set the SIZE condition.
   - Before internal code to change prefix options.
   - Between statements if GOSTMT or GONUMBER apply.
   - For a null statement. (This feature provides the programmer with source language control over the timing of program interrupts.)

2. To provide facilities for:

   - Detecting multiple-exception imprecise interrupts.
   - Setting the value that is returned by the ONCOUNT built-in function.
   - Raising the appropriate PL/I conditions.

The order of processing the exceptions is as follows:

1. PL/I conditions in the order:

   UNDERFLOW

   FIXEDOVERFLOW or SIZE

   ERROR (if system action is required for either FIXEDOVERFLOW cr SIZE)

   FINISH (if system action is required for the previous ERROR condition)

   OVERFLOW

   ERROR (if system action is required for OVERFLOW)

   FINISH (if system action is required for the previous ERROR condition)

   ZERODIVIDE

   ERROR (if system action is required for ZERODIVIDE)

   FINISH (if system action is required for the previous ERROR condition)

Note: The conditions FIXEDOVERFLOW and SIZE cannot occur together, since the same hardware condition raises both of them.

2. Hardware exceptions in the order:

   data

   specification

   addressing

   protection

Conditions and exceptions are raised in the above order until one of the following situations occurs:

1. A GO TO statement in an on-unit is executed. All other exceptions will then be lost.

2. The ERROR condition is raised. If the program is terminated as a result of this action (that is, system action causing the ERROR condition to be raised, followed by the FINISH condition), messages will be printed to indicate the nature of the unprocessed exceptions. The exceptions themselves will not be processed.

When an interrupt results from multiple exceptions, only one of the PL/I conditions is raised for each type of exception that occurred.

When a multiple-exception imprecise interrupt occurs, the ONCOUNT built-in function provides a binary integer count of the number of exception types (that have PL/I on-conditions associated with them) that remain to be processed. If the ONCOUNT built-in function is used when only a single exception has occurred, or if it is used outside an on-unit, a count value of zero is indicated.

Appendix E: Shared Library Cataloged Procedures

The shared library is a PL/I facility that allows an installation to load PL/I resident library modules into the link pack area (LPA) so that they are available to all PL/I programs. This reduces space overheads.

The resident library subroutines to be included in the shared library can be chosen by the installation; they must include the initialization routine, the error-handling routine, the open file routine, and all modules addressed from the TCA that are not identical for multitasking and non-multitasking programs. Further details of the shared library are given in the publications OS PL/I Optimizing Compiler: Execution Logic and OS PL/I Optimizing Compiler: System Information.

The routines in the shared library are held in two of three link-pack-area modules: IBMBPSM, and either IBMBPSL or its multitasking equivalent IBMTPSL. Each of the link-pack modules contains a number of library routines, and is headed by an addressing control block known as a transfer vector. IBMBPSM contains those modules in the shared library that are common to both multitasking and non-multitasking PL/I environments. IBMBPSL contains the non-multitasking versions of those modules that are not identical in multitasking and non-multitasking PL/I environments. This module has a multitasking counterpart, IBMTPSL, which holds the multitasking versions of such modules.

Two further modules are also involved in handling the shared library. These are the shared library addressing modules IBMBPSR and its multitasking counterpart IBMTPSR. One or other of these modules, each of which has the alias PLISHRE, is link-edited with compiled code and held in the program region: IBMBPSR for non-multitasking programs, or IBMTPSR for multitasking programs. IBMBPSR and its multitasking counterpart hold dummy entry points which duplicate the names of all entry points of modules within the shared library. References to such entry points in compiled code are resolved to the dummy entry points in IBMBPSR or IBMTPSR.

You can use the shared library by using standard IBM-supplied cataloged procedures and overriding the link-edit and loader procedure steps.

Execution when Using the Shared Library

Use of the shared library is specified by the linkage editor statement INCLUDE PLISHRE. PLISHRE is an alias for the program region modules IBMBPSR and IBMTPSR. The appropriate module will therefore be loaded by the linkage editor (IBMBPSR for non-multitasking programs; IBMTPSR for multitasking programs). All compiled code external references to shared library module entry points are then resolved to the dummy entry points in IBMBPSR (or IBMTPSR). Similarly WXTRNs in the program region module are resolved if compiled code issues an EXTRN for the entry point.

A load module created for use with one shared library will not execute with a different shared library. You will have to link-edit the object module again, including the dummy transfer vector module for the different shared library.

You must remember that the linkage editor or loader require a large amount of main storage for external symbol dictionary tables while processing the dummy transfer vector module. If you specify SIZE=200K in the PARM field of your EXEC statement for the linkage editor or loader (and use a region or partition of equivalent size), you will get sufficient main storage for processing with the largest possible shared library.

Your PL/I program may take slightly longer to execute when using a shared library, because all library calls have to pass through the transfer vectors. However, your main storage requirements for a region will be greatly reduced if you have carefully selected your shared library modules to suit the operating environment.

Multitasking Considerations

The shared library has been designed so that multitasking does not affect it. If PLI.TASK is specified before PLI.BASE, the linkage editor statement INCLUDE PLISHRE will result in the module IBMTPSR being loaded and linked in the program region. When control passes to the code following the IBMBPIR entry point in IBMTPSR, a request is made to the system to load the multitasking shared library module IBMTPSM. The program then runs in the usual manner, with the multitasking modules.

An installation may specify that it does not require either the multitasking or the non-multitasking modules in the shared library. However both multitasking and non-multitasking versions of the program region module will still be created. The module for the unwanted environment will be a dummy. This prevents problems should an INCLUDE PLISHRE statement be included in a program that is intended to run in the environment with no shared library. If this process was not carried out, such a statement could result in the incorrect environment being initialized.

USING STANDARD IBM CATALOGED PROCEDURES

Standard IBM-supplied cataloged procedures that use the linkage editor or loader (see chapter 10) can be used to specify the shared library. This is done by overriding the SYSLIN DD statement in the link-edit or load-and-go procedure steps to ensure that the shared library addressing module IBMBPSR is the first module to be included by the linkage editor or loader and that its entry point in the resulting load module has the name PLISHRE. For example, the cataloged procedure PLIXCL requires the following statements to make use of the shared library.

```
//STEP1       EXEC    PLIXCL
//LKED.SYSLIN DD      *
  INCLUDE     PLISHRE

 (add further input here)

/*
```

You can add other linkage-editor control statements by placing them as indicated. For example, to give the resulting load module the name MINE, add the statement:

```
NAME          MINE(R)
```

between the ENTRY and /* statements.

Appendix F: Programming Example

This appendix, consisting of a PL/I sample program, illustrates all the components of the listings produced by the compiler and the linkage editor. The listings themselves are described in chapters 4 and 5.

The function of the program is fully documented in both the preprocessor input and the source listing by means of PL/I comments. These comments consist of lines of text each preceded by /* and followed by */. Note that the /* must not appear in columns 1 and 2 of the input record because it will be taken as a job control delimiter statement.

Most pages of the listings contain brief notes explaining the contents of the pages.

OPTIONS SPECIFIED (1)

```
M,IS,MAR(2,72,1),LO(55),SZ(50K),AG,A,X,LIST,STG,OF,ESD
```

OPTIONS USED (2)

```
AGGREGATE       NODECK          CHARSET(60,EBCDIC)
ATTRIBUTES      NOFLOW          FLAG(I)
COMPILE         NOGONUMBER      LINECOUNT(55)
ESD             NOMARGINI       MARGINS(2,72,1)
GOSTMT          NOMDECK         SIZE(51200)
INSOURCE        NONUMBER
LIST            NOOPTIMIZE
LMESSAGE        NOIMPRECISE
MACRO           NOTERMINAL
MAP
NEST
OBJECT
OFFSET
OPTIONS
SOURCE
STMT
STORAGE
SYNTAX
XREF
```

Start of the compiler listing.

(1) List of options specified in the PARM parameter of the EXEC statement.

(2) List of options used, whether obtained by default, or by being specified explicitly.

PREPROCESSOR INPUT

```
LINE
   1      /***** PL/I SAMPLE PROGRAM. *****/                                  00000100

   2      %/*****************************************************************/ 00000200
   3       /*                                                               */ 00000300
   4       /* USES COMPILE-TIME PREPROCESSOR TO MODIFY PL/I (F) SOURCE FOR   */ 00000400
   5       /* USE WITH THIS COMPILER.   THE PREPROCESSOR STATEMENTS FOLLOWING */ 00000500
   6       /* COULD BE PLACED ON A LIBRARY AND USED TO MODIFY SEVERAL SOURCE  */ 00000600
   7       /* PROGRAMS BY MEANS OF THE PREPROCESSOR %INCLUDE STATEMENT. THEY  */ 00000700
   8       /* PERFORM THE FOLLOWING FUNCTIONS:                               */ 00000800
   9       /*                                                               */ 00000900
  10       /*  1. CONVERT CALLS TO FOLLOWING PL/I (F) IHE... ROUTINES TO THE */ 00001000
  11       /*     EQUIVALENT NEW PL/I... ROUTINES-                          */ 00001100
  12       /*           IHECUMP/J/C/T  TO  PLICUMP,                         */ 00001200
  13       /*           IHESRTA/B/C/D  TO PLISRTA/B/C/D,                    */ 00001300
  14       /*           IHECKPS/T  TO  PLICKPT,                             */ 00001400
  15       /*           IHERESN/T  TO  PLIREST/PLICANC,                     */ 00001500
  16       /*           IHESARC/IHETSAC  TO  PLIRETC.                       */ 00001600
  17       /*                                                               */ 00001700
  18       /*  2. CHANGE FIRST DECLARE/DCL STATEMENT FOUND TO INCLUDE        */ 00001800
  19       /*     BUILTIN ATTRIBUTE FOR FOLLOWING BUILT-IN FUNCTIONS(WHICH   */ 00001900
  20       /*     DO NOT TAKE ARGUMENTS, AND SO ARE NOT IMPLICITLY DECLARED  */ 00002000
  21       /*     BUILTIN FOR THIS COMPILER - AS THEY WOULD BE FOR PL/I (F))- */ 00002100
  22       /*           DATE, TIME, ONCODE, ONCHAR, ONSOURCE, ONLOC,        */ 00002200
  23       /*           ONFILE, ONKEY, EMPTY, NULL.                         */ 00002300
  24       /*     NOTE: THE ONCOUNT BIF IS OMITTED FROM THIS LIST, & IS USED */ 00002302
  25       /*           LATER TO SHOW THE EFFECT OF NOT DECLARING IT BUILTIN. */ 00002304
  26       /*           ANY REFERENCES TO IHE--- ROUTINES MUST BE REMOVED    */ 00002306
  27       /*           FROM DECLARE STATEMENTS BEFORE THE SOURCE PROGRAM IS */ 00002308
  28       /*           PREPROCESSED, OTHERWISE FAILURES MAY OCCUR WHEN THE  */ 00002310
  29       /*           CONVERTED PROGRAM IS LINK-EDITED.                   */ 00002312
  30       /*                                                               */ 00002350
  31       /*  3. CHANGE 'NULLC' TO 'NULL' - THERE IS NO NULLO BUILTIN      */ 00002352
  32       /*     FUNCTION FOR THIS COMPILER; NULL MUST BE USED BOTH WITH    */ 00002354
  33       /*     POINTER AND OFFSET VARIABLES.                             */ 00002356
  34       /*                                                               */ 00002400
  35       /*****************************************************************/;00002500
```

Source statements for the sample program, exactly as they appear in the input stream. These statements form the input data for the preprocessor. Preprocessor statements are identified by the % symbol.

1. The first line of the input is included as part of the heading for all pages of the preprocessor and compiler listing.

2. Each input record is numbered sequentially.

3. If an input record has a sequence number, this number is printed.

```
LINE
  36      *       DCL   (IHEDUMP, IHEDUMJ, IHEDUMC, IHEDUMT, DECLARE, DCL,        00002600
  37                     IHECKPT, IHECKPS) ENTRY;                                00002605

  38      *       DCL   (IHESRTA, IHESRTB, IHESRTC, IHESRTD, IHEREST,             00002700
  39                     IHERESN, IHESARC, IHETSAC, NULLO) CHAR;                 00002800

  40      *       DCL   COUNT FIXED;                                              00002900


  41      *       COUNT = 0                    /* FIRST-TIME-IN SWITCH.      */;00003000

  42      *       DEACTIVATE DECLARE, DCL      /* ENSURE MODIFIED STATEMENTS */;00003100
  43      *       ACTIVATE DECLARE,            /* ARE NOT RESCANNED DURING   */ 00003200
  44                       DCL NORESCAN       /* PREPROCESSOR REPLACEMENT.  */;00003300
```

```
LINE
  45       % DECLARE: DCL:                          /* GENERATE BUILTIN DECLARES. */ 0000340
  46                PROC RETURNS(CHAR);                                              0000350
  47                COUNT = COUNT + 1              /* COUNT = 1 IF 1ST TIME IN. */;0000360
  48                IF COUNT = 1                                                     0000370
  49                  THEN RETURN('DCL (DATE,TIME,ONCHAR,ONSOURCE,ONCODE,' ||        0000380
  50                              'ONLOC,ONFILE,ONKEY,EMPTY,NULL) BUILTIN, ' ||      0000390
  51                              'CKPT_RETC FIXED BIN(31),');                       0000392
  52                  ELSE RETURN('DCL');                                            0000400
  53       %       END;                                                              0000410

  54       % IHEDUMP: IHEDUMJ: IHEDUMC: IHEDUMT: /* REPLACED BY CALL TO        */ 0000420
  55                PROC(ID#) RETURNS(CHAR)       /* PLIDUMP ROUTINE, INCLUDING */;0000430
  56                DCL ID# CHAR                  /* ORIGINAL ID(IF PRESENT).   */;0000440
  57                IF ID# = '' THEN RETURN('PLIDUMP');                            0000450
  58                           ELSE RETURN('PLIDUMP(''TFCA''," || ID# || ")');     0000460
  59       %       END;                                                            0000470

  60       % IHECKPS: IHECKPT:                      /* CHANGE TO PLICKPT. PL/I(F) */ 0000474
  61                PROC(ARG1, ARG2, ARG3, ARG4)  /* DEFAULTS GENERATED WHERE   */ 0000474
  62                    RETURNS(CHAR)             /* NO ARGUMENTS ORIGINALLY.   */;0000474
  63                DCL (ARG1, ARG2, ARG3, ARG4) CHAR;                             0000474
  64                IF ARG1 = '' THEN ARG1 = '''SYSCHK''';                         0000474
  65                IF ARG2 = '' THEN ARG2 = ' ''''';                              0000475
  66                IF ARG3 = '' THEN ARG3 = ' ''PS''';                            0000475
  67                IF ARG4 = '' THEN ARG4 = ' CKPT_RETC';                         0000475
  68                RETURN('PLICKPT(' || ARG1 || ',' || ARG2 || ','                0000475
  69                                  || ARG3 || ',' || ARG4 || ')');              0000475
  70       %       END;                                                            0000476

  71       %       IHESRTA = 'PLISRTA'           /* REPLACE                    */;0000480
  72       %       IHESRTB = 'PLISRTB'           /*  CALLS TO                  */;0000490
  73       %       IHESRTC = 'PLISRTC'           /*   IHE---                   */;0000500
  74       %       IHESRTD = 'PLISRTD'           /*    RCUTINES                */;0000510
  75       %       IHEREST = 'PLIREST'           /*     BY                     */;0000520
  76       %       IHERESN = 'PLICANC'           /*      CALLS TO              */;0000530
  77       %       IHESARC = 'PLIRETC'           /*       PLI---               */;0000540
  78       %       IHETSAC = 'PLIRETC'           /*         RCUTINES. .        */;0000550

  79       %/*     THERE IS NO NULLO BUILTIN FUNCTION FOR THIS COMPILER;          0000580
  80                NULL MUST BE USED INSTEAD.                                  */;0000590

  81       %       NULLO = 'NULL';                                                 0000600
```

```
LINE
  82       %/* END OF PREPROCESSOR STATEMENTS;  SOURCE STATEMENTS FOLLOW HERE: */;00006100

  83       SAMPLE:                                                            00006200
  84               PROC OPTIONS(MAIN);                                        00006300

  85               DECLARE (PDATE, PTIME) CHAR(6);                            00006400

  86               DECLARE CVAR CHAR(255) VAR;                                00006500

  87               DCL      1  BINVAR,                                        00006600
  88                           2  RETCODE FIXED BIN(31,0),                   00006700
  89                           2  FBVAR FIXED BIN;                           00006800

  90               PDATE = DATE;                                              00006900
  91               PTIME = TIME;                                              00007000
  92               PUT SKIP EDIT('SAMPLE PROGRAM: DATE = ', PDATE, ', TIME = ',  00007100
  93                            PTIME) (A(23), P'99/99/99', A(9), P'Z9.99.99');  00007200
  94               RETCODE = 0101;                                            00007300

  95               ON ERROR                                                   00007500
  96         BEGIN;                                                           00007600
  97               CALL IHEDUMP;                                              00007700

  98       /* THESE STATEMENTS ILLUSTRATE PREPROCESSOR REPLACEMENT AND USE OF    00007800
  99          BUILTIN FUNCTIONS.    THEY WILL NEVER BE EXECUTED.              */00007900

 100               CALL IHEDUMJ(127);                                         00008000
 101               CALL IHEDUMC(RETCODE);                                     00008100
 102               CALL IHEDUMT;                                              00008200

 103               FBVAR = ONCODE;                                            00008300
 104               CVAR = ONCHAR;                                             00008400
 105               CVAR = ONSOURCE;                                           00008500
 106               CVAR = ONLOC;                                              00008600
 107               CVAR = ONFILE;                                             00008700
 108               CVAR = ONKEY;                                              00008800
```

```
LINE
 109      /* THIS STATEMENT, WHICH WILL NEVER BE EXECUTED, USES 'ONCOUNT' WHICH  00008900
 110         IS NEITHER EXPLICITLY NOR IMPLICITLY DECLARED BUILTIN.  THE EFFECT  00009000
 111         IS SHOWN IN THE ATTRIBUTE LISTING AND DIAGNOSTIC MESSAGES.        */00009100

 112               FBVAR = ONCOUNT;                                             00009200
 113           END;                                                             00009300


 114      /* THIS IS A DUMMY PROCEDURE TO ILLUSTRATE OTHER PREPROCESSOR          00009400
 115         REPLACEMENTS/NON-IMPLICITLY DECLARED BUILTIN FUNCTIONS.            00009500
 116         IT WILL NEVER BE EXECUTED.                                        */00009600

 117      DUMMY:                                                               00009700
 118               PROC;                                                       00009800

 119               DCL   AVAR AREA BASED(PVAR),                                00009900
 120                     OVAR OFFSET(AVAR),                                    00010000
 121                     A ENTRY RETURNS(CHAR(80)),                            00010050
 122                     SIZE FIXED BIN(31,0);                                 00010100

 123               AVAR = EMPTY;                                               00010200
 124               PVAR = NULL;                                                00010300
 125               CVAR = NULLC;                                               00010400

 126               CALL IHESRTA('ARG1', 'ARG2', SIZE, RETCODE);       /*  S     */00010500
 127               CALL IHESRTB('ARG1', 'ARG2', SIZE, RETCODE, A);    /*   O    */00010600
 128               CALL IHESRTC('ARG1', 'ARG2', SIZE, RETCODE, B);    /*    R   */00010700
 129               CALL IHESRTD('ARG1', 'ARG2', SIZE, RETCODE, A, B); /*     T  */00010800
 130               CALL IHECKPS('ARG1', 'ARG2', 'PS', RETCODE); /* CHECKPOINT   */00010900
 131               CALL IHECKPT; /* CHECKPOINT   */                             00011000
 132               CALL IHEREST;                                 /* FORCE RESTRT */00011100
 133               CALL IHERESN;                                 /* CANCEL CKPT  */00011200
 134               CALL IHETSAC(RETCODE);        /* SET RETURN CODE(TASKING)    */00011300

 135      A:       PROC RETURNS(CHAR(80));   END;                /*  DUMMY EXIT  */00011400
 136                                                             /*  PROCEDURES  */00011450
 137      B:       PROC(RECORD);   DCL RECORD CHAR(80);   END;   /*  FOR  SORT.  */00011500

 138               END DUMMY;                                                  00011600


 139               CALL IHESAC(RETCODE);        /* SET RETURN CODE(NONTASKING) */00011800
 140               PUT SKIP LIST('END SAMPLE PROGRAM');                        00011900


 141               END SAMPLE;                                                 00012000
```

PREPROCESSOR DIAGNOSTIC MESSAGES

(1) (2) (3)

ERROR ID L LINE MESSAGE DESCRIPTION

SEVERE AND ERROR DIAGNOSTIC MESSAGES

IEL0217I E 97 MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHEDUMP'. PROCEDURE INVOKED WITHOUT ARGUMENTS.

IEL0217I E 102 MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHEDUMT'. PROCEDURE INVOKED WITHOUT ARGUMENTS.

IEL0217I E 131 MISSING LEFT PARENTHESIS FROM ARGUMENT LIST FOR PROCEDURE 'IHECKPT'. PROCEDURE INVOKED WITHOUT ARGUMENTS.

WARNING DIAGNOSTIC MESSAGES

IEL0184I W 97 TOO FEW ARGUMENTS TO FUNCTION 'IHEDUMP'. NULL STRINGS PASSED AS MISSING ARGUMENTS.

IEL0184I W 102 TOO FEW ARGUMENTS TO FUNCTION 'IHEDUMT'. NULL STRINGS PASSED AS MISSING ARGUMENTS.

IEL0184I W 131 TOO FEW ARGUMENTS TO FUNCTION 'IHECKPT'. NULL STRINGS PASSED AS MISSING ARGUMENTS.

END OF PREPROCESSOR DIAGNOSTIC MESSAGES

Diagnostic messages generated by the preprocessor. All messages generated by the optimizing compiler (including the preprocessor) are documented in the publication OS Optimizing Compiler: Messages.

(1) "ERROR ID" This identifies the message as originating from the optimizing compiler (IEL), and gives the message number.

(2) "L" This is the severity level of the message.

(3) "LINE" This gives the number of the line in which the error occurred.

SOURCE LISTING

```
                                                                                  (3)
                                                                                   R
STMT LEV NT                                                                  (2)
                                                                              I
      /***** PL/I SAMPLE PROGRAM. *****/                                      1
 1    SAMPLE:                                                                83
            PROC OPTIONS(MAIN);                                              84

 2  1         DCL (DATE,TIME,ONCHAR,ONSOURCE,ONCODE,ONLOC,ONFILE,ONKEY,EMPTY,  85  2
     NULL) BUILTIN, CKPT_RETC FIXED BIN(31), (PDATE, PTIME) CHAR(6);          85  1

 3  1         DCL CVAR CHAR(255) VAR;                                          86  2

 4  1         DCL     1  BINVAR,                                               87  1
                      2  RETCODE FIXED BIN(31,0),                            88
                      2  FBVAR FIXED BIN;                                     89


 5  1         PDATE = DATE;                                                    90
 6  1         PTIME = TIME;                                                    91
 7  1         PUT SKIP EDIT('SAMPLE PROGRAM: DATE = ', PDATE, ', TIME = ',     92
                      PTIME) (A(23), P'99/99/99', A(9), P'Z9.99.99');         93
 8  1         RETCODE = 0101;                                                  94


 9  1         ON ERROR                                                         95  (4)
       BEGIN;                                                                 96
10  2         CALL PLIDUMP;                                                    97  1E


      /* THESE STATEMENTS ILLUSTRATE PREPROCESSOR REPLACEMENT AND USE OF      98
         BUILTIN FUNCTIONS.   THEY WILL NEVER BE EXECUTED.              */    98
                                                                              99

11  2         CALL PLIDUMP('TFCA','127');                                    100  1
12  2         CALL PLIDUMP('TFCA','RETCODE');                                101  1
13  2         CALL PLIDUMP;                                                  102  1E

14  2         FBVAR = ONCODE;                                                103
15  2         CVAR = ONCHAR;                                                 104
16  2         CVAR = ONSOURCE;                                               105
17  2         CVAR = ONLOC;                                                  106
18  2         CVAR = ONFILE;                                                 107
19  2         CVAR = ONKEY;                                                  108
```

Source listing. This is the output from the preprocessor and the input to the compiler. All the preprocessor statements have been executed and all preprocessor comments have been deleted.

(1) Statement nesting levels.

(2) Line numbers brought forward from the preprocessor input.

(3) Maximum depth of replacement.

(4) "E" in this column indicates that an error has occurred during a replacement attempt.

```
STMT LEV NT                                                                    R

                /* THIS STATEMENT, WHICH WILL NEVER BE EXECUTED, USES 'ONCOUNT' WHICH      109
                   IS NEITHER EXPLICITLY NOR IMPLICITLY DECLARED BUILTIN.  THE EFFECT    109
                   IS SHOWN IN THE ATTRIBUTE LISTING AND DIAGNOSTIC MESSAGES.      */    109
                                                                                         111
 20   2                 FBVAR = ONCOUNT;                                                 112
 21   2           END;                                                                   113

                /* THIS IS A DUMMY PROCEDURE TO ILLUSTRATE OTHER PREPROCESSOR          114
                   REPLACEMENTS/NON-IMPLICITLY DECLARED BUILTIN FUNCTIONS.             114
                   IT WILL NEVER BE EXECUTED.                                      */  114
                                                                                         116
 22   1      DUMMY:                                                                     117
                 PROC;                                                                   118

 23   2                 DCL   AVAR AREA BASED(PVAR),                                     119  1
                            OVAR OFFSET(AVAR),                                           120
                            A ENTRY RETURNS(CHAR(80)),                                   121
                            SIZE FIXED BIN(31,0);                                        122

 24   2                 AVAR = EMPTY;                                                    123
 25   2                 PVAR = NULL;                                                     124
 26   2                 OVAR = NULL;                                                     125  1

 27   2                 CALL PLISRTA('ARG1', 'ARG2', SIZE, RETCODE);       /*  S     */  126  1
 28   2                 CALL PLISRTE('ARG1', 'ARG2', SIZE, RETCODE, A);    /*   O    */  127  1
 29   2                 CALL PLISRTC('ARG1', 'ARG2', SIZE, RETCODE, B);    /*    R   */  128  1
 30   2                 CALL PLISRTD('ARG1', 'ARG2', SIZE, RETCODE, A, B); /*     T  */  129  1
 31   2                 CALL PLICKPT('ARG1', 'ARG2', 'PS', RETCODE); /* CHECKPOINT  */  130  1
 32   2                 CALL PLICKPT('SYSCHK', '', 'PS', CKPT_RETC); /* CHECKPOINT  */  131  1E
                                                                                         131
 33   2                 CALL PLIFEST;                                 /* FORCE RESTRT */  132  1
 34   2                 CALL PLICANC;                                 /* CANCEL CKPT  */  133  1
 35   2                 CALL PLIRETC(RETCODE);        /* SET RETURN CODE(TASKING)    */  134  1

 36   2      A:         PROC RETURNS(CHAR(80));   END;                /*  DUMMY EXIT  */  135
                                                                     /*  PROCEDURES  */  136
 38   2      B:         PROC(RECORD);   DCL RECORD CHAR(80);   END;  /*  FOR  SORT.  */  137  1

 41   2                 END DUMMY;                                                       138

 42   1                 CALL PLIRETC(RETCODE);        /* SET RETURN CODE(NONTASKING) */  139  1
 43   1                 PUT SKIP LIST('END SAMPLE PROGRAM');                             140

 44   1                 END SAMPLE;                                                      141
```

ATTRIBUTE AND CROSS-REFERENCE TABLE

(1) DCL NO.	(3) IDENTIFIER	ATTRIBUTES AND REFERENCES
36	A	(4) ENTRY RETURNS(CHARACTER (80))
		(5) 28,30
23	AVAR	BASED (PVAR) ALIGNED AREA (1000)
		24
38	B	ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6))
		29,30
4	BINVAR	AUTOMATIC /* STRUCTURE */
2	CKPT_RETC	AUTOMATIC ALIGNED BINARY FIXED (31,0)
		32
3	CVAR	AUTOMATIC UNALIGNED CHARACTER (255) VARYING
		15,16,17,18,19
2	DATE	BUILTIN
		5
22	DUMMY	ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6))
2	EMPTY	BUILTIN
		24
4	FEVAR	/* IN BINVAR */ AUTOMATIC ALIGNED BINARY FIXED (15,0)
		14,20
2	NULL	BUILTIN
		25,26
2	ONCHAR	BUILTIN
		15
2	ONCODE	BUILTIN
		14
******** (2)	ONCOUNT	AUTOMATIC ALIGNED DECIMAL /* SINGLE */ FLOAT (6)
		20
2	ONFILE	BUILTIN
		18

Attributes and Cross-reference Table.

(1) Number of the statement in the source listing in which the identifier is explicitly declared.

(2) Asterisks indicate an undeclared identifier; all of its attributes are implied or supplied by default.

(3) All identifiers used in the program listed in alphabetic order.

(4) Declared and default attributes are listed. This list also includes descriptive comments.

(5) Cross references. These are the numbers of all other statements in which the identifier appears.

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
2	ONKEY	BUILTIN 19
2	ONLOC	BUILTIN 17
2	ONSOURCE	BUILTIN 16
23	OVAR	AUTOMATIC ALIGNED OFFSET (AVAR) 26
2	PDATE	AUTOMATIC UNALIGNED CHARACTER (6) 5,7
********	PLICANC	BUILTIN 34
********	PLICKPT	BUILTIN 31,32
********	PLIDUMP	BUILTIN 10,11,12,13
********	PLIREST	BUILTIN 33
********	PLIRETC	BUILTIN 42 35
********	PLISRTA	BUILTIN 27
********	PLISRTB	BUILTIN 28
********	PLISRTC	BUILTIN 29
********	PLISRTD	BUILTIN 30
2	PTIME	AUTOMATIC UNALIGNED CHARACTER (6) 6,7
********	PVAR	AUTOMATIC ALIGNED POINTER 24,25

DCL NO.	IDENTIFIER	ATTRIBUTES AND REFERENCES
39	RECORD	/* PARAMETER */ UNALIGNED CHARACTER (80)
4	RETCODE	/* IN BINVAR */ AUTOMATIC ALIGNED BINARY FIXED (31,0) 8,42 27,28,29,30,31,35
1	SAMPLE	EXTERNAL ENTRY RETURNS(DECIMAL /* SINGLE */ FLOAT (6))
23	SIZE	AUTOMATIC ALIGNED BINARY FIXED (31,0) 27,28,29,30
********	SYSPRINT	EXTERNAL FILE PRINT 7,43
2	TIME	BUILTIN 6

AGGREGATE LENGTH TABLE

(1) STATEMENT NO.	(2) IDENTIFIER	(3) LENGTH IN BYTES
4	BINVAR	6
	SUM OF CONSTANT LENGTHS (4)	6

Aggregate Length Table.

(1) Number of the statement in which the aggregate is declared, or, for a controlled aggregate, the number of the associated ALLOCATE statement.

(2) The elements of the aggregate as declared.

(3) Length of each element of the aggregate.

(4) Sum of the lengths of aggregates whose lengths are constant.

STORAGE REQUIREMENTS

(1) BLOCK, SECTION OR STATEMENT	(2) TYPE	(3) LENGTH	(HEX)	(4) DSA SIZE	(HEX)
*SAMPLE1	PROGRAM CSECT	2224	8B4		
*SAMPLE2	STATIC CSECT	880	378		
SAMPLE	PROCEDURE BLOCK	530	212	536	218
9	ON UNIT	626	276	208	D0
DUMMY	PROCEDURE BLOCK	832	340	224	E0
A	PROCEDURE BLOCK	106	6A	168	A8
B	PROCEDURE BLOCK	124	7C	176	B0

Storage requirements. This table gives the main storage requirements for the program. These quantities do not include the main storage that will be required by the resident and transient library subroutines that will be included by the linkage editor or loaded dynamically during execution.

(1) Name of the block, section, or number of the statement in the program.

(2) Description of the block, section, or statement.

(3) Length in bytes of the storage areas in both decimal and hexadecimal notation.

(4) Length in bytes of the dynamic storage area (DSA) in both decimal and hexadecimal notation.

EXTERNAL SYMBCL DICTIONARY

(1) SYMBOL	(2) TYPE	(3) ID	(4) ADDR	(5) LENGTH
PLISTART	SD	0001	000000	000038
*SAMPLE1	SD	0002	000000	0008B0
*SAMPLE2	SD	0003	000000	000370
PLITABS	WX	0004	000000	
IBMBPIRA	ER	0005	000000	
IBMEPIRB	ER	0006	000000	
IBMEPIRC	ER	0007	000000	
PLICALLA	LD		000006	
PLICALLB	LD		00000A	
PLIMAIN	SD	0008	000000	000008
IBMBKCPC	ER	0009	000000	
IBMBKCPA	ER	000A	000000	
IBMBKCPB	ER	000B	000000	
IBMBKCPA	ER	000C	000000	
IBMBKCPA	ER	000D	000000	
IBMBKSTC	ER	000E	000000	
IBMBKSTA	ER	000F	000000	
IBMBKSTC	ER	0010	000000	
IBMBKSTA	ER	0011	000000	
IBMBKSTB	ER	0012	000000	
IBMBKSTA	ER	0013	000000	
IBMBKSTA	ER	0014	000000	
IBMBKDMA	ER	0015	000000	
IBMBPRCA	ER	0016	000000	
IELCGCA	SD	0017	000000	000072
IELCGCB	SD	0018	000000	000070
IBMBSIOA	ER	0019	000000	
IBMBCCCA	ER	001A	000000	
IBMBCCSA	ER	001B	000000	
IBMBCHFC	ER	001C	000000	
IBMBCODE	ER	001D	000000	
IBMBCTHC	ER	001E	000000	
IBMBCLIC	ER	001F	000000	
IBMBECCA	ER	0020	000000	
IBMBECLA	ER	0021	000000	
IBMBJDTA	ER	0022	000000	
IBMBJTTA	ER	0023	000000	
IBMBCCLA	ER	0024	000000	
IBMBCCLC	WX	0025	000000	
IBMBSAOA	ER	0026	000000	
IBMBSECA	ER	0027	000000	
IBMBSICE	WX	0028	000000	
IBMBSICT	WX	0029	000000	
IBMBSLCA	ER	002A	000000	

External symbol dictionary.

(1) "SYMBOL" A list of all the external symbols that make up the object module.

(2) "TYPE" Type of external symbol as follows:
- CM Common area.
- ER External reference.
- LD Label definition.
- PR Pseudo-register.
- SD Section definition.
- WX Weak external reference.

Full definitions of all these terms are given in chapter 4.

(3) "ID" All entries, except LD-type entries, are identified by a hexadecimal number.

(4) "ADDR" Address (in hexadecimal) of LD-type entries only.

(5) "LENGTH" Length in bytes (in hexadecimal) of LD, CM, and PR type entries only.

IBMBSFLA	ER	C02B	000000	
IBMBSFCA	ER	CC2C	CCCCCC	
IBMBCKDC	ER	CC2D	CCCCCC	
IBMBSXCA	WX	CC2E	CCCCCC	
IBMBSXCB	WX	CC2F	CCCCCC	
IBMBSIST	WX	C030	CCCCCC	
SAMPLE	LD		CCCCC8	
SYSPINT	PR	C031	CCCCCC	CCCC74
SYSPINT	SD	0032	000000	CCC320

STATIC INTERNAL STORAGE MAP

(1)	(2)	(3)		
000000	00000018	PROGRAM ADCON	000CA	0001 CONSTANT
000004	00000078	PROGRAM ADCON	000CC	
000008	00000096	PROGRAM ADCON	000D0	80800208001700000 LOCATOR
00000C	00005214	PROGRAM ADCON	000D8	0000000000060000 LOCATOR, PDATE
000010	00000272	PROGRAM ADCON	000E0	0000021F00090000 LOCATOR
000014	00000490	PROGRAM ADCON	000E8	00800228001200C0 LOCATOR
000018	000004EE	PROGRAM ADCON	000F0	0000000000040000 LOCATOR
00001C	000007CC	PROGRAM ADCON	000F8	0000000000030000 LOCATOR
000020	00000822	PROGRAM ADCON	000100	0000000000070000 LOCATOR
000024	00000838	PROGRAM ADCON	000108	0000000000020000 LOCATOR
000028	000008A0	PROGRAM ADCON	000110	0000000000000000 LOCATOR
00002C	000008AC	PROGRAM ADCON	000118	91EC91EC CONSTANT
000030	000008A0	PROGRAM ADCON	00011C	00000001 CONSTANT
000034	000008A0	PROGRAM ADCON	000120	00000065 CONSTANT
000038	000008A0	PROGRAM ADCON	000124	46000030 CONSTANT
00003C	00000000	A.. IELCGOA	000128	00000010 CONSTANT
000040	00000000	A.. IELCGOB	00012C	FF000000 CONSTANT
000044	00000000	A.. IBMBCCCA	000130	00000000 A.. DCLCB
000048	00000000	A.. IBMBCCSA	000134	80000000 A. PDATE
00004C	00000000	A.. IBMBCHFC	000138	80000000 A.. TEMP
000050	00000000	A.. IBMBCCDE	00013C	00000000 A. DCLCB
000054	00000000	A.. IBMBCTHC	000140	00000000 A.. TEMP
000058	00000000	A.. IBMBCUIC	000144	80000110 A. CONSTANT
00005C	00000000	A.. IBMBEOCA	000148	80000000 A.. RETCODE
000060	00000000	A.. IBMBEOLA	00014C	00000000 A.. ENTRY PLIRETC
000064	00000000	A.. IBMBJCTA	000150	00000000 A.. DCLCB
000068	00000000	A.. IBMBJTTA	000154	00000000 A. TEMP
00006C	00000000	A.. IBMBOCLA	000158	80000110 A.. CONSTANT
000070	00000000	A.. IBMBOCLC	00015C	00000000 A.. ENTRY PLIDUMP
000074	00000000	A.. IBMBSACA	000160	00000000 A.. TEMP
000078	00000000	A.. IBMBSEOA	000164	80000000 A. TEMP
00007C	00000000	A.. IBMBSIGE	000168	00000000 A.. TEMP
000080	00000000	A.. IBMBSIOT	00016C	80000000 A.. TEMP
000084	00000000	A.. IBMBSLCA	000170	80000000 A.. FBVAR
000088	00000000	A.. IBMBSPLA	000174	80000000 A.. TEMP
00008C	00000000	A.. IBMBSFOA	000178	00000000 A.. TEMP
000090	00000000	A.. IBMBCKDD	00017C	00000000 A. TEMP
000094	00000000	A.. STATIC	000180	00000000 A.. SIZE
000098	2000	DED	000184	80000000 A.. RETCODE
00009A	58000017	FED	000188	00000000 A.. ENTRY PLISRTA
00009E	5420000E814F40E8	FED	00018C	00000000 A.. TEMP
	0E8800000000E8F0		000190	00000000 A.. TEMP
	00E88000		000194	00000000 A.. SIZE
0000B2	58000000	FED	000198	00000000 A.. RETCODE
0000B6	5420000814F40E82	FED	00019C	80000000 A.. TEMP
	0E8800000E007400		0001A0	00000000 A.. ENTRY PLISRTB
			0001A4	00000000 A.. TEMP

Static Internal Storage Map. This is a storage map of the static control section for the program. This control section is the third standard entry in the external symbol dictionary.

(1) Six-digit offset (in hexadecimal).

(2) Text (in hexadecimal).

(3) Comment indicating type of item to which the text refers. A comment appears only against the first line of the text for an item.

```
0001A8  00000000                 A..TEMP                  000000  0000000C41201000    DCLCB
0001AC  00000000                 A..SIZE                          02D70F0000000000
0001B0  00000000                 A..RETCODE                       003700140008E2E8
0001B4  80000000                 A..TEMP                          E2D7D9C9D5E34040
0001B8  00000000                 A..ENTRY PLISRTC
0001BC  00000000                 A..TEMP
0001C0  00000000                 A..TEMP
0001C4  00000000                 A..SIZE
0001C8  00000000                 A..RETCODE
0001CC  00000000                 A..TEMP
0001D0  80000000                 A..TEMP
0001D4  00000000                 A..ENTRY PLISRTD
0001D8  00000000                 A..TEMP
0001DC  00000000                 A..TEMP
0001E0  00000000                 A..TEMP
0001E4  80000000                 A..RETCODE
0001E8  00000000                 A..ENTRY PLICKPT
0001EC  00000000                 A..TEMP
0001F0  00000000                 A..TEMP
0001F4  00000000                 A..TEMP
0001F8  80000000                 A..CKPT_RETC
0001FC  00000000                 A..ENTRY PLIREST
000200  00000000                 A..ENTRY PLICANC
000204  80000000                 A..RETCODE
000208  E2C1D4D7D3C540D7         CONSTANT
        D9D6C7D9C1D47A40
        C4C1E3C5407E40
00021F  6B40E3C9D4C5407E         CONSTANT
        40
000228  C5D5C440E2C1D4D7         CONSTANT
        D3C540D7D9D6C7D9
        C1D4
00023A  E3C6C3C1                 CONSTANT
00023E  F1F2F7                   CONSTANT
000241  D9C5E3C3D6C4C5           CONSTANT
000248  C1D9C7F1                 CONSTANT
00024C  C1D9C7F2                 CONSTANT
000250  D7E2                     CONSTANT
000252  E2E8E2C3C8D2             CONSTANT
000258  0C16000000000214         STATIC ONCB


                    STATIC EXTERNAL CSECTS
```

TABLES OF OFFSETS AND STATEMENT NUMBERS

WITHIN PROCEDURE SAMPLE

OFFSET (HEX)	0000E8	0000A4	000000	000190	0001A4	0001A8	0001C0	0001FA	000200
STATEMENT NO	5	6	7	8	9	42	43	44	9

WITHIN ON UNIT

OFFSET (HEX)	0000EE	000068	0000B0	0000F8	000102	00	118	000138	000180	0001C4	000206	000248	000262	000274
STATEMENT NO	10	11	12	13	14	15	16	17	18	19	20	21	22	

WITHIN PROCEDURE DUMMY

OFFSET (HEX)	0000EE	00006E	000076	00007A	0000D2	000138	0001AA	00022A	000296	0002FC	000306	000310	000328	000338
STATEMENT NO	24	25	26	27	28	29	30	31	32	33	34	35	41	36

WITHIN PROCEDURE A

OFFSET (HEX)	000056	000068
STATEMENT NO	37	38

WITHIN PROCEDURE B

OFFSET (HEX)	000068
STATEMENT NO	40

```
  OBJECT LISTING
       (1)                                        (2)
* COMPILER GENERATED SUBROUTINE IELCOOA
000000  50 E0 1 00C              ST    14,12(0,1)
000004  58 F0 1 014              L     15,20(0,1)
000008  91 10 1 011              TM    17(1),X'10'
00000C  47 10 7 014              BC    *+8
000010  95 04 C 002              CI    2(12),X'04'
000014  D2 03 1 008 F 04C        MVC   8(4,1),76(15)
00001A  48 E0 F 05E              LH    14,80(0,15)
00001E  4B E0 E 002              SH    14,2(0,14)
000022  07 B6                   BCR   11,6
000024  96 40 1 010              CI    16(1),X'40'
000028  58 E0 D 04C              L     14,76(0,13)
00002C  50 E0 1 008              ST    14,8(0,1)
000030  4A E0 E 002              AH    14,2(0,14)
000034  4A E0 7 070              AH    14,112(0,7)
000038  54 E0 7 06C              N     14,108(0,7)
00003C  55 E0 C 00C              CL    14,12(0,12)
000040  47 20 7 04A              BH    *+1
000044  50 E0 D 04C              ST    14,76(0,13)
000048  07 F6                   BR    6
00004A  50 00 1 01C              ST    0,28(0,1)
00004E  18 71                   LR    7,1
000050  18 CF                   LR    12,15
000052  58 10 D 04C              L     1,76(0,13)
000056  58 E0 C 048              L     14,72(0,12)
00005A  05 EF                   BALR  14,15
00005C  50 00 D 04C              ST    0,76(0,13)
000060  50 10 7 008              ST    1,8(0,7)
000064  18 17                   LR    1,7
000066  58 00 1 01C              L     0,28(0,1)
00006A  07 F6                   BR    6
00006C  FFFFFFF8                 DC    X'FFFFFFF8'
000070                           DC    AL2(7)

* END OF COMPILER GENERATED SUBROUTINE

* COMPILER GENERATED SUBROUTINE IELCOOB
000000  94 FB C 002              NI    2(12),X'FB'
000004  91 40 1 010              TM    16(1),X'40'
000008  47 10 7 052              BC    *+74
00000C  58 F0 1 014              L     15,20(0,1)
000010  50 70 1 01C              ST    7,28(0,1)
000014  58 70 1 00C              L     7,12(0,1)
000018  48 E0 F 05C              LH    14,88(0,15)
00001C  4B E0 7 002              SH    14,2(0,7)
000020  40 E0 F 052              STH   14,80(0,15)
000024  58 E0 F 04C              L     14,76(0,15)
000028  4A E0 7 002              AH    14,2(0,7)
00002C  50 E0 F 04C              ST    14,76(0,15)
000030  48 E0 1 02C              LH    14,32(0,1)
000034  41 E0 E 001              LA    14,1(0,14)
000038  40 E0 1 02C              STH   14,32(0,1)
00003C  40 E0 F 052              STH   14,82(0,15)
000040  91 10 1 010              TM    16(1),X'10'
000044  07 B6                   BCR   8,6
000046  58 70 1 01C              L     7,28(0,1)
00004A  58 E0 7 068              L     14,104(0,7)
00004E  05 EF                   BALR  14,15
000050  07 F6                   BR    6
000052  58 E0 7 06C              L     14,108(0,7)
000056  05 EF                   BALR  14,15
000058  58 E0 1 008              L     14,8(0,1)
00005C  50 E0 D 04C              ST    14,76(0,13)
000060  94 BF 1 010              NI    16(1),X'BF'
000064  07 F6                   BR    6
000066  07 00                   NOPR  0
000068                           DC    AL4(0)
00006C                           DC    AL4(0)

* END OF COMPILER GENERATED SUBROUTINE


* STATEMENT NUMBER  1
000000                           DC    C' SAMPLE'
000007                           DC    AL1(6)

* PROCEDURE                              SAMPLE

* REAL ENTRY
000008  90 EC D 00C              STM   14,12,12(13)
00000C  47 F0 F 014              B     *+16
000010  00000000                 DC    A(STMT, NO, TABLE)
000014  00000218                 DC    F'536'
000018  00000000                 DC    A(STATIC CSECT)
00001C  58 30 F 010              L     3,16(0,15)
000020  58 10 D 04C              L     1,76(0,13)
000024  58 C0 F 00C              L     0,12(0,15)
000028  1E 01                   ALR   0,1
00002A  55 00 C 00C              CL    0,12(0,12)
00002E  47 D0 F 03C              BNH   *+10
000032  58 F0 C 074              L     15,116(0,12)
000036  05 EF                   BALR  14,15
000038  58 E0 D 048              L     14,72(0,13)
```

Object listing. This is a listing of the machine instructions generated by the optimizing compiler from the PL/I source program.

(1) Machine instructions (in hexadecimal).

(2) Assembler-language form of the machine instructions.

```
0000BC  18 F0                LR    15,0
0000BE  90 E0 1 C48          STM   14,0,72(1)
0000C2  50 D0 1 0C4          ST    13,4(0,1)
0000C6  41 D1 0 000          LA    13,0(1,0)
0000CA  50 50 D 058          ST    5,88(0,13)
0000CE  41 60 D 0A8          LA    6,168(0,13)
0000D2  50 60 D 070          ST    6,112(0,13)
0000D6  D7 00 D 0A8 D 0A8    XC    168(1,13),168(13)
0000DC  92 01 D 0A9          MVI   169(13),X'01'
0000E0  92 00 D 000          MVI    (13),X'00'
0000E4  92 24 D 001          MVI   1(13),X'24'
0000E8  41 80 3 258          LA    8,600(0,3)
0000EC  50 80 D 05C          ST    8,92(0,13)
0000F0  D2 03 D 054 3 118    MVC   84(4,13),280(3)
0000F6  05 20                BALR  2,0

* PROLOGUE BASE
0000F8  D2 07 D 0B0 3 0D8    MVC   LOCATOR..PDATE(8),
                                   216(3)
0000FE  41 90 D 0D4          LA    9,PDATE
000102  50 90 D 0B0          ST    9,LOCATOR..PDATE
000106  D2 07 D 0B8 3 0D8    MVC   LOCATOR..PTIME(8),
                                   216(3)
00010C  41 A0 D 0DA          LA    10,PTIME
000110  50 A0 D 0B8          ST    10,LOCATOR..PTIME
000114  05 20                BALR  2,

* PROCEDURE BASE


* STATEMENT NUMBER  5
000116  41 90 D 0D4          LA    9,PDATE
00011A  50 90 3 134          ST    9,308(0,3)
00011E  96 80 3 134          OI    308(3),X'80'
000122  41 10 3 134          LA    1,308(0,3)
000126  58 F0 3 064          L     15,A..IBMBJCTA
00012A  05 EF                BALR  14,15


* STATEMENT NUMBER  6
00012C  41 90 D 1F0          LA    9,496(0,13)
000130  50 90 3 138          ST    9,312(0,3)
000134  96 80 3 138          OI    312(3),X'80'
000138  41 10 3 138          LA    1,312(0,3)
00013C  58 F0 3 068          L     15,A..IBMBJTTA
000140  05 EF                BALR  14,15
000142  D2 05 D 0DA D 1F0    MVC   PTIME(6),496(13)

* STATEMENT NUMBER  7
000148  41 90 D 1F0          LA    9,496(0,13)
00014C  50 90 3 140          ST    9,320(0,3)
000150  92 20 D 201          MVI   513(13),X'20'
000154  41 10 3 130          LA    1,304(0,3)
000158  58 F0 3 070          L     15,A..IBMBSIOE
00015C  05 EF                BALR  14,15
00015E  41 A0 2 090          LA    10,CL.7
000162  41 E0 3 0D0          LA    14,208(0,3)
000166  41 F0 3 098          LA    15,152(0,3)
00016A  41 10 D 1F0          LA    1,496(0,13)
00016E  50 10 D 1E8          ST    1,488(0,13)
000172  90 EF 1 000          STM   14,15,0(1)
000176  05 AA                BALR  10,10
000178  41 E0 D 0B0          LA    14,176(0,13)
00017C  41 F0 3 098          LA    15,DED..PDATE
000180  90 EF 1 000          STM   14,15,0(1)
000184  05 AA                BALR  10,10
000186  41 E0 3 0E0          LA    14,224(0,3)
00018A  41 F0 3 098          LA    15,152(0,3)
00018E  90 EF 1 000          STM   14,15,0(1)
000192  05 AA                BALR  10,10
000194  41 E0 D 0B8          LA    14,184(0,13)
000198  41 F0 3 098          LA    15,DED..PTIME
00019C  90 EF 1 000          STM   14,15,0(1)
0001A0  05 AA                BALR  10,10
0001A2  47 F0 2 1B4          B     CL.8
0001A6                 CL.7  EQU   *
0001A6  41 E0 3 09A          LA    14,154(0,3)
0001AA  58 10 D 1E8          L     1,488(0,13)
0001AE  58 70 3 03C          L     7,A..IELCGCA
0001B2  05 67                BALR  6,7
0001B4  58 F0 3 074          L     15,A..IBMBSAOA
0001B8  05 EF                BALR  14,15
0001BA  58 70 3 040          L     7,A..IELCGOB
0001BE  05 67                BALR  6,7
0001C0  05 AA                BALR  10,10
0001C2  41 E0 3 09E          LA    14,158(0,3)
0001C6  58 10 D 1E8          L     1,488(0,13)
0001CA  58 70 3 03C          L     7,A..IELCGOA
0001CE  05 67                BALR  6,7
0001D0  58 F0 3 08C          L     15,A..IBMBSPCA
0001D4  05 EF                BALR  14,15
0001D6  58 70 3 040          L     7,A..IELCGOB
0001DA  05 67                BALR  6,7
0001DC  05 AA                BALR  10,10
0001DE  41 E0 3 0B2          LA    14,178(0,3)
```

```
000162  58 10 D 1E8          L     1,488(0,13)
000166  58 70 3 03C          L     7,A(IELCGCA
00016A  05 67                BALR  6,7
00016C  58 F0 3 074          L     15,A(IBMBSAOA
000170  05 EF                BALR  14,15
000172  58 70 3 040          L     7,A(IELCGCB
000176  05 67                BALR  6,7
000178  05 AA                BALR  10,10
00017A  41 E0 3 0B6          LA    14,182(0,3)
00017E  58 10 D 1E8          L     1,488(0,13)
000182  58 70 3 03C          L     7,A(IELCGDA
000186  05 67                BALR  6,7
000188  58 F0 3 08C          L     15,A(IBMBSPOA
00018C  05 EF                BALR  14,15
00018E  58 70 3 040          L     7,A(IELCGCB
000192  05 67                BALR  6,7
000194  05 AA                BALR  10,10
000196  47 F0 2 090          B     CL.7
00019A                  CL.8 ECU   *
00019A  58 10 D 1E8          L     1,488(0,13)
00019E  58 F0 3 08C          L     15,A(IBMBSIOT
0001A2  05 EF                BALR  14,15

* STATEMENT NUMBER  8
0001A4  58 F0 3 120          L     15,288(0,3)
0001A8  50 F0 D 0C0          ST    15,BINVAR.RETCODE

* STATEMENT NUMBER  9
0001AC  92 0C D 0A8          MVI   168(13),X'0C'

* STATEMENT NUMBER  42
0001B0  41 90 D 0C0          LA    9,BINVAR.RETCODE
0001B4  50 90 3 148          ST    9,328(0,3)
0001B8  96 80 3 148          OI    328(3),X'80'
0001BC  1B 55                SR    5,5
0001BE  41 10 3 148          LA    1,328(0,3)
0001C2  58 F0 3 14C          L     15,332(0,3)
0001C6  05 EF                BALR  14,15

* STATEMENT NUMBER  43
0001C8  41 90 D 1F0          LA    9,496(0,13)
0001CC  50 90 3 154          ST    9,340(0,3)
0001D0  92 40 D 201          MVI   513(13),X'40'
0001D4  41 10 3 150          LA    1,336(0,3)
0001D8  58 F0 3 07C          L     15,A(IBMBSIOE
0001DC  05 EF                BALR  14,15
0001DE  41 E0 3 0E8          LA    14,232(0,3)
0001E2  41 F0 3 098          LA    15,152(0,3)
0001E6  41 10 D 1F0          LA    1,496(0,13)
0001EA  50 10 D 1E8          ST    1,488(0,13)
0001EE  90 EF 1 000          STM   14,15,0(1)
0001F2  58 F0 3 084          L     15,A(IBMBSLOA
0001F6  05 EF                BALR  14,15
0001F8  58 10 D 1E8          L     1,488(0,13)
0001FC  58 F0 3 080          L     15,A(IBMBSIOT
000200  05 EF                BALR  14,15

* STATEMENT NUMBER  44
000202  18 0D                LR    0,13
000204  58 D0 D 004          L     13,4(0,13)
000208  58 E0 D 00C          L     14,12(0,13)
00020C  98 2C D 010          LM    2,12,28(13)
000210  05 1E                BALR  1,14

* END PROCEDURE
000212  07 07                NOPR  7

* CA UNIT BLOCK
000214  90 EC D 00C          STM   14,12,12(13)
000218  47 F0 F 014          B     20(0,15)
00021C  00000000             DC    A(STMT. NO. TABLE)
000220  00000008             DC    F'8'
000224  00000000             DC    A(STATIC CSECT)
000228  58 30 F 010          L     3,16(0,15)
00022C  58 10 D 04C          L     1,76(0,13)
000230  58 C0 F 00C          L     0,12(0,15)
000234  1E 01                ALR   0,1
000236  55 00 C 00C          CL    0,12(0,12)
00023A  47 D0 F 030          BNH   48(0,15)
00023E  58 F0 C 074          L     15,116(0,12)
000242  05 EF                BALR  14,15
000244  58 E0 D 048          L     14,72(0,13)
000248  18 F0                LR    15,0
00024A  90 E0 1 048          STM   14,0,72(1)
00024E  50 D0 1 004          ST    13,4(0,1)
000252  41 D1 2 000          LA    13,0(1,0)
000256  50 50 D 058          ST    5,88(0,13)
```

```
000258  92 8C D 000          MVI   0(13),X'8C'
00025E  92 24 D 001          MVI   1(13),X'24'
000262  58 60 D 058          L     6,88(0,13)
000266  50 60 D 0A8          ST    6,168(0,13)
00026A  D2 03 D 054 3 118    MVC   84(4,13),280(3)
000270  05 20                BALR  2,0

* PROCEDURE BASE

* STATEMENT NUMBER  10
000272  1B 11                SR    1,1
000274  1B 55                SR    5,5
000276  58 F0 3 15C          L     15,348(0,3)
00027A  05 EF                BALR  14,15

* STATEMENT NUMBER  11
00027C  D2 03 D 0BC 3 23A    MVC   176(4,13),570(3)
000282  D2 07 D 0B4 3 0F0    MVC   180(8,13),240(3)
000288  41 80 D 0BC          LA    8,176(0,13)
00028C  50 80 D 0B4          ST    8,180(0,13)
000290  41 90 D 0B4          LA    9,180(0,13)
000294  50 90 3 160          ST    9,352(0,3)
000298  D2 02 D 0BC 3 23E    MVC   188(3,13),574(3)
00029E  D2 07 D 0C0 3 0F8    MVC   192(8,13),248(3)
0002A4  41 E0 D 0BC          LA    14,188(0,13)
0002A8  50 E0 D 0C0          ST    14,192(0,13)
0002AC  41 90 D 0C0          LA    9,192(0,13)
0002B0  50 90 3 164          ST    9,356(0,3)
0002B4  96 80 3 164          OI    356(3),X'80'
0002B8  1B 55                SR    5,5
0002BA  41 10 3 160          LA    1,352(0,3)
0002BE  58 F0 3 15C          L     15,348(0,3)
0002C2  05 EF                BALR  14,15

* STATEMENT NUMBER  12
0002C4  D2 03 D 0BC 3 23A    MVC   176(4,13),570(3)
0002CA  D2 07 D 0B4 3 0F0    MVC   180(8,13),240(3)
0002D0  41 80 D 0BC          LA    8,176(0,13)
0002D4  50 80 D 0B4          ST    8,180(0,13)
0002D8  41 90 D 0B4          LA    9,180(0,13)
0002DC  50 90 3 168          ST    9,360(0,3)
0002E0  D2 06 D 0BC 3 241    MVC   188(7,13),577(3)
0002E6  D2 07 D 0C4 3 100    MVC   196(8,13),256(3)
0002EC  41 80 D 0BC          LA    8,188(0,13)
0002F0  50 80 D 0C4          ST    8,196(0,13)
0002F4  41 90 D 0C4          LA    9,196(0,13)
0002F8  50 90 3 16C          ST    9,364(0,3)
0002FC  96 80 3 16C          OI    364(3),X'80'
000300  1B 55                SR    5,5
000302  41 10 3 168          LA    1,360(0,3)
000306  58 F0 3 15C          L     15,348(0,3)
00030A  05 EF                BALR  14,15

* STATEMENT NUMBER  13
00030C  1B 11                SR    1,1
00030E  1B 55                SR    5,5
000310  58 F0 3 15C          L     15,348(0,3)
000314  05 EF                BALR  14,15

* STATEMENT NUMBER  14
000316  41 90 6 0C4          LA    9,BINVAR.FBVAR
00031A  50 90 3 170          ST    9,368(0,3)
00031E  96 80 3 170          OI    368(3),X'80'
000322  41 10 3 170          LA    1,368(0,3)
000326  58 F0 3 05C          L     15,A..IBMBEGCA
00032A  05 EF                BALR  14,15

* STATEMENT NUMBER  15
00032C  58 80 D 048          L     8,72(0,13)
000330  4A 80 8 002          AH    8,2(0,8)
000334                       CL.18 EQU   *
000334  58 80 8 000          L     8,0(0,8)
000338  91 40 8 006          TM    6(8),X'40'
00033C  47 80 2 0C2          BZ    CL.18
000340  58 90 8 010          L     9,16(0,8)
000344  48 70 3 0CA          LH    7,202(0,3)
000348  40 70 6 0E0          STH   7,CVAR
00034C  D2 00 6 0E2 9 00     MVC   CVAR+2(1),0(9)

* STATEMENT NUMBER  16
000352  58 80 D 048          L     8,72(0,13)
000356  4A 80 8 002          AH    8,2(0,8)
00035A                       CL.19 EQU   *
00035A  58 80 8 000          L     8,0(0,8)
00035E  91 40 8 006          TM    6(8),X'40'
000362  47 80 2 0E8          BZ    CL.19
000366  58 90 8 018          L     9,24(0,8)
00036A  48 F0 8 01C          LH    15,28(0,8)
00036E  41 80 0 0FF          LA    8,255(0,0)
```

```
000372  19 8F                        CR    8,15
000374  47 D0 2 1C6                  BNH   CL.20
000378  18 8F                        LR    8,15
00037A                        CL.20   EQU   *
00037A  40 80 6 0E0                   STH   8,CVAR
00037E  48 80 3 0CA                   SH    8,202(0,3)
000382  47 40 2 122                   BM    CL.21
000386  44 80 2 110                   EX    8,CL.22
00038A  47 F0 2 122                   B     CL.23
00038E                        CL.22   EQU   *
00038E  D2 00 6 0E2 9 000             MVC   CVAR+2(1),0(9)
000394                        CL.21   EQU   *
000394                        CL.23   EQU   *

* STATEMENT NUMBER  17
000394  41 90 D 080                   LA    9,176(0,13)
000398  50 90 3 174                   ST    9,372(0,3)
00039C  96 80 3 174                   OI    372(3),X'80'
0003A0  41 10 3 174                   LA    1,372(0,3)
0003A4  58 F0 3 060                   L     15,A..IBMBECLA
0003A8  05 EF                         BALR  14,15
0003AA  58 90 D 080                   L     9,176(0,13)
0003AE  48 80 D 0B4                   LH    8,180(0,13)
0003B2  41 F0 0 0FF                   LA    15,255(0,0)
0003B6  19 F8                         CR    15,8
0003B8  47 D0 2 14C                   BNH   CL.24
0003BC  18 F8                         LR    15,8
0003BE                        CL.24   EQU   *
0003BE  40 F0 6 0E0                   STH   15,CVAR
0003C2  4B F0 3 0CA                   SH    15,202(0,3)
0003C6  47 40 2 166                   BM    CL.25
0003CA  44 F0 2 160                   EX    15,CL.26
0003CE  47 F0 2 166                   B     CL.27
0003D2                        CL.26   EQU   *
0003D2  D2 00 6 0E2 9 000             MVC   CVAR+2(1),0(9)
0003D8                        CL.25   EQU   *
0003D8                        CL.27   EQU   *

* STATEMENT NUMBER  18
0003DE  58 80 D 048                   L     8,72(0,13)
0003E2  4A 80 8 002                   AH    8,2(0,8)
0003E6                        CL.28   EQU   *
0003E6  58 80 8 000                   L     8,0(0,8)
0003E4  91 80 8 006                   TM    6(8),X'80'
0003E8  47 80 2 16E                   BZ    CL.28
0003EC  58 90 8 0C8                   L     9,8(0,8)

0003F0  48 F0 8 00C                   LH    15,12(0,8)
0003F4  41 80 0 0FF                   LA    8,255(0,0)
0003F8  19 8F                         CR    8,15
0003FA  47 D0 2 1EE                   BNH   CL.29
0003FE  18 8F                         LR    8,15
000400                        CL.29   EQU   *
000400  40 80 6 0E0                   STH   8,CVAR
000404  48 80 3 0CA                   SH    8,202(0,3)
000408  47 40 2 1A8                   BM    CL.30
00040C  44 80 2 1A2                   EX    8,CL.31
000410  47 F0 2 1A8                   B     CL.32
000414                        CL.31   EQU   *
000414  D2 00 6 0E2 9 000             MVC   CVAR+2(1),0(9)
00041A                        CL.30   EQU   *
00041A                        CL.32   EQU   *

* STATEMENT NUMBER  19
00041A  58 80 D 048                   L     8,72(0,13)
00041E  4A 80 8 002                   AH    8,2(0,8)
000422                        CL.33   EQU   *
000422  58 80 8 000                   L     8,0(0,8)
000426  91 10 8 006                   TM    6(8),X'10'
00042A  47 80 2 1B0                   BZ    CL.33
00042E  58 90 8 020                   L     9,32(0,8)
000432  48 F0 8 024                   LH    15,36(0,8)
000436  41 80 0 0FF                   LA    8,255(0,0)
00043A  19 8F                         CR    8,15
00043C  47 D0 2 1D0                   BNH   CL.34
000440  18 8F                         LR    8,15
000442                        CL.34   EQU   *
000442  40 80 6 0E0                   STH   8,CVAR
000446  4B 80 3 0CA                   SH    8,202(0,3)
00044A  47 40 2 1EA                   BM    CL.35
00044E  44 80 2 1E4                   EX    8,CL.36
000452  47 F0 2 1EA                   B     CL.37
000456                        CL.36   EQU   *
000456  D2 00 6 0E2 9 000             MVC   CVAR+2(1),0(9)
00045C                        CL.35   EQU   *
00045C                        CL.37   EQU   *

* STATEMENT NUMBER  20
00045C  78 00 6 0D8                   LE    0,ACCOUNT
000460  7E 00 3 124                   AU    0,292(0,3)
000464  70 00 D 0B0                   STE   0,176(0,13)
000468  48 90 D 0B2                   LH    9,178(0,13)
00046C  47 B0 2 200                   BNM   CL.38
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000470  13 99                    LCR   9,9
000472                    CL.38  EQU   *                  * PROCEDURE BASE
000472  40 90 6 0C4              STH   9,BINVAR.FBVAR

                                                          * STATEMENT NUMBER  24
* STATEMENT NUMBER  21                                    0004EE  58 90 6 0CC        L     9,PVAR
000476  18 CD                    LR    0,13               0004F2  92 00 9 000        MVI   AVAR,X'00'
00047E  58 D0 D 004              L     13,4(0,13)         0004F6  58 E0 3 128        L     14,296(0,3)
00047C  58 E0 D 00C              L     14,12(0,13)        0004FA  50 E0 9 0C4        ST    14,AVAR+4
000480  98 2C D 01C              LM    2,12,28(13)
000484  05 1E                    BALR  1,14
                                                          * STATEMENT NUMBER  25
* CN UNIT BLOCK END                                       0004FE  58 70 3 12C        L     7,300(0,3)
000486  07 07                    NOPR  7                  000502  50 70 6 0CC        ST    7,PVAR


* STATEMENT NUMBER  22                                    * STATEMENT NUMBER  26
0004E8                    DC    C'  DUMMY'               000506  50 70 D 0A8        ST    7,CVAR
0004EF                    DC    AL1(5)

* PROCEDURE                      DUMMY                    * STATEMENT NUMBER  27
                                                          00050A  D2 03 D 0B8 3 248  MVC   184(4,13),584(3)
* REAL ENTRY                                              000510  D2 07 D 0BC 3 0F0  MVC   188(8,13),240(3)
0004F0  90 EC D 00C              STM   14,12,12(13)       000516  41 80 D 0B8        LA    8,184(0,13)
0004F4  47 F0 F 014              B     *+16               00051A  50 80 D 0BC        ST    8,188(0,13)
0004F8  00000000                 DC    A(STMT. NO. TABLE) 00051E  41 80 D 0BC        LA    8,188(0,13)
0004FC  000000E0                 DC    F'224'             000522  50 80 3 178        ST    8,376(0,3)
000500  00000000                 DC    A(STATIC CSECT)    000526  D2 03 D 0C4 3 24C  MVC   196(4,13),588(3)
000504  58 30 F 010              L     3,16(0,15)         00052C  D2 07 D 0C8 3 0F0  MVC   200(8,13),240(3)
000508  58 10 D 04C              L     1,76(0,13)         000532  41 80 D 0C4        LA    8,196(0,13)
00050C  58 00 F 000              L     0,12(0,15)         000536  50 80 D 0C8        ST    8,200(0,13)
000510  1E 01                    ALR   0,1                00053A  41 80 D 0C8        LA    8,200(0,13)
000512  55 00 C 000              CL    0,12(0,12)         00053E  50 80 3 17C        ST    8,380(0,3)
000516  47 D0 F 030              BNH   *+10               000542  41 80 D 0AC        LA    8,                                  SIZE
00051A  58 F0 C 074              L     15,116(0,12)       000546  50 80 3 180        ST    8,384(0,3)
00051E  05 EF                    BALR  14,15              00054A  41 80 6 0C0        LA    8,BINVAR.RETCODE
000520  58 E0 D 048              L     14,72(0,13)        00054E  50 80 3 184        ST    8,388(0,3)
000524  18 F0                    LR    15,0               000552  96 80 3 184        OI    388(3),X'80'
000526  90 E0 1 048              STM   14,0,72(1)         000556  18 55              SR    5,5
00052A  50 D0 1 004              ST    13,4(0,1)          000558  41 10 3 178        LA    1,376(0,3)
00052E  41 D1 C 000              LA    13,0(1,12)         00055C  58 F0 3 188        L     15,392(0,3)
000532  50 50 D 058              ST    5,88(0,13)         000560  05 EF              BALR  14,15
000536  92 80 D 000              MVI   0(13),X'80'
00053A  92 24 D 001              MVI   1(13),X'24'
00053E  58 60 D 058              L     6,88(0,13)         * STATEMENT NUMBER  28
000542  50 60 D 0B0              ST    6,176(0,13)        000562  D2 03 D 0B8 3 248  MVC   184(4,13),584(3)
000546  D2 03 D 054 3 118        MVC   84(4,13),280(3)    000568  D2 07 D 0BC 3 0F0  MVC   188(8,13),240(3)
00054C  05 20                    BALR  2,0                00056E  41 80 D 0B8        LA    8,184(0,13)
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000572  50 80 D 0BC          ST    8,188(0,13)
000576  41 80 D 0BC          LA    8,188(0,13)
00057A  50 80 3 18C          ST    8,396(0,3)
00057E  D2 03 D 0C4 3 24C    MVC   196(4,13),588(3)
000584  D2 07 D 0C8 3 0F0    MVC   200(8,13),240(3)
00058A  41 E0 D 0C4          LA    14,196(0,13)
00058E  50 E0 D 0C8          ST    14,200(0,13)
000592  41 80 D 0C8          LA    8,200(0,13)
000596  50 80 3 190          ST    8,400(0,3)
00059A  41 80 D 0AC          LA    8,SIZE
00059E  50 80 3 194          ST    8,404(0,3)
0005A2  41 80 6 000          LA    8,BINVAR.RETCODE
0005A6  50 80 3 198          ST    8,408(0,3)
0005AA  50 D0 D 0D4          ST    13,212(0,13)
0005AE  58 80 3 01C          L     8,28(0,3)
0005B2  50 80 D 0D8          ST    8,208(0,13)
0005B6  41 80 D 0D8          LA    8,208(0,13)
0005BA  50 80 3 19C          ST    8,412(0,3)
0005BE  96 80 3 19C          CI    412(3),X'80'
0005C2  1B 55                SR    5,5
0005C4  41 10 3 18C          LA    1,396(0,3)
0005C8  58 F0 3 1A0          L     15,416(0,3)
0005CC  05 EF                BALR  14,15

* STATEMENT NUMBER  29
0005CE  D2 03 D 0B8 3 248    MVC   184(4,13),584(3)
0005D4  D2 07 D 0BC 3 0F0    MVC   188(8,13),240(3)
0005DA  41 80 D 0B8          LA    8,184(0,13)
0005DE  50 80 D 0BC          ST    8,188(0,13)
0005E2  41 80 D 0BC          LA    8,188(0,13)
0005E6  50 80 3 1A4          ST    8,420(0,3)
0005EA  D2 03 D 0C4 3 24C    MVC   196(4,13),588(3)
0005F0  D2 07 D 0C8 3 0F0    MVC   200(8,13),240(3)
0005F6  41 E0 D 0C4          LA    14,196(0,13)
0005FA  50 E0 D 0C8          ST    14,200(0,13)
0005FE  41 80 D 0C8          LA    8,200(0,13)
000602  50 80 3 1A8          ST    8,424(0,3)
000606  41 80 D 0AC          LA    8,SIZE
00060A  50 80 3 1AC          ST    8,428(0,3)
00060E  41 80 6 000          LA    8,BINVAR.RETCODE
000612  50 80 3 1B0          ST    8,432(0,3)
000616  50 D0 D 0D4          ST    13,212(0,13)
00061A  58 80 3 024          L     8,36(0,3)
00061E  50 80 D 0D8          ST    8,208(0,13)
000622  41 80 D 0D8          LA    8,208(0,13)
000626  50 80 3 1B4          ST    8,436(0,3)
00062A  96 80 3 1B4          CI    436(3),X'80'
00062E  1B 55                SR    5,5
000630  41 10 3 1A4          LA    1,420(0,3)
000634  58 F0 3 1B8          L     15,440(0,3)
000638  05 EF                BALR  14,15

* STATEMENT NUMBER  30
00063A  D2 03 D 0B8 3 248    MVC   184(4,13),584(3)
000640  D2 07 D 0BC 3 0F0    MVC   188(8,13),240(3)
000646  41 80 D 0B8          LA    8,184(0,13)
00064A  50 80 D 0BC          ST    8,188(0,13)
00064E  41 80 D 0BC          LA    8,188(0,13)
000652  50 80 3 1BC          ST    8,444(0,3)
000656  D2 03 D 0C4 3 24C    MVC   196(4,13),588(3)
00065C  D2 07 D 0C8 3 0F0    MVC   200(8,13),240(3)
000662  41 E0 D 0C4          LA    14,196(0,13)
000666  50 E0 D 0C8          ST    14,200(0,13)
00066A  41 80 D 0C8          LA    8,200(0,13)
00066E  50 80 3 1C0          ST    8,448(0,3)
000672  41 80 D 0AC          LA    8,SIZE
000676  50 80 3 1C4          ST    8,452(0,3)
00067A  41 80 6 000          LA    8,BINVAR.RETCODE
00067E  50 80 3 1C8          ST    8,456(0,3)
000682  50 D0 D 0D4          ST    13,212(0,13)
000686  58 80 3 01C          L     8,28(0,3)
00068A  50 80 D 0D8          ST    8,208(0,13)
00068E  41 80 D 0D8          LA    8,208(0,13)
000692  50 80 3 1CC          ST    8,460(0,3)
000696  50 D0 D 0DC          ST    13,220(0,13)
00069A  58 80 3 024          L     8,36(0,3)
00069E  50 80 D 0D8          ST    8,216(0,13)
0006A2  41 80 D 0D8          LA    8,216(0,13)
0006A6  50 80 3 1D0          ST    8,464(0,3)
0006AA  96 80 3 1D0          CI    464(3),X'80'
0006AE  1B 55                SR    5,5
0006B0  41 10 3 1BC          LA    1,444(0,3)
0006B4  58 F0 3 1D4          L     15,468(0,3)
0006B8  05 EF                BALR  14,15

* STATEMENT NUMBER  31
0006BA  D2 03 D 0B8 3 248    MVC   184(4,13),584(3)
0006C0  D2 07 D 0BC 3 0F0    MVC   188(8,13),240(3)
0006C6  41 80 D 0B8          LA    8,184(0,13)
0006CA  50 80 D 0BC          ST    8,188(0,13)
0006CE  41 80 D 0BC          LA    8,188(0,13)
0006D2  50 80 3 1D8          ST    8,472(0,3)
0006D6  D2 03 D 0C4 3 24C    MVC   196(4,13),588(3)
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000EEC  D2 07 D 0C8 3 0F0        MVC   200(8,13),240(3)
000EE2  41 E0 D 0C4              LA    14,196(0,13)
000EE6  50 E0 D 0C8              ST    14,200(0,13)
000EEA  41 80 D 0C8              LA    8,200(0,13)
000EEE  50 80 3 1DC              ST    8,476(0,3)
000EF2  D2 01 D 0D2 3 250        MVC   210(2,13),592(3)
000EF8  D2 07 D 0D4 3 1C8        MVC   212(8,13),264(3)
000EFE  41 80 D 0D2              LA    8,210(0,13)
000F02  50 80 D 0D4              ST    8,212(0,13)
000F06  41 80 D 0D4              LA    8,212(0,13)
000F0A  50 80 3 1E0              ST    8,480(0,3)
000F0E  41 80 6 0C0              LA    8,BINVAR.RETCODE
000F12  50 80 3 1E4              ST    8,484(0,3)
000F16  96 80 3 1E4              OI    484(3),X'80'
000F1A  1B 55                    SR    5,5
000F1C  41 10 3 1D8              LA    1,472(0,3)
000F20  58 F0 3 1E8              L     15,488(0,3)
000F24  05 EF                    BALR  14,15

* STATEMENT NUMBER  32
000F26  D2 05 D 0BA 3 252        MVC   186(6,13),594(3)
000F2C  D2 07 D 0C0 3 0D8        MVC   192(8,13),216(3)
000F32  41 E0 D 0BA              LA    14,186(0,13)
000F36  50 E0 D 0C0              ST    14,192(0,13)
000F3A  41 80 D 0C0              LA    8,192(0,13)
000F3E  50 80 3 1EC              ST    8,492(0,3)
000F42  D2 07 D 0C8 3 110        MVC   200(8,13),272(3)
000F48  41 E0 D 0C8              LA    14,200(0,13)
000F4C  50 E0 D 0C8              ST    14,200(0,13)
000F50  41 80 D 0C8              LA    8,200(0,13)
000F54  50 80 3 1F0              ST    8,496(0,3)
000F58  D2 01 D 0D2 3 250        MVC   210(2,13),592(3)
000F5E  D2 07 D 0D4 3 1C8        MVC   212(8,13),264(3)
000F64  41 80 D 0D2              LA    8,210(0,13)
000F68  50 80 D 0D4              ST    8,212( ,13)
000F6C  41 80 D 0D4              LA    8,212(0,13)
000F70  50 80 3 1F4              ST    8,500( ,3)
000F74  41 80 6 0C8              LA    8,CKPT_RETC
000F78  50 80 3 1F8              ST    8,504(0,3)
000F7C  96 80 3 1F8              OI    504(3),X'80'
000F80  1B 55                    SR    5,5
000F82  41 10 3 1EC              LA    1,492(0,3)
000F86  58 F0 3 1E8              L     15,488(0,3)
000F8A  05 EF                    BALR  14,15

* STATEMENT NUMBER  33
000F8C  1B 11                    SR    1,1
000F8E  1B 55                    SR    5,5
000F90  58 F0 3 1FC              L     15,508(0,3)
000F94  05 EF                    BALR  14,15

* STATEMENT NUMBER  34
000F96  1B 11                    SR    1,1
000F98  1B 55                    SR    5,5
000F9A  58 F0 3 200              L     15,512(0,3)
000F9E  05 EF                    BALR  14,15

* STATEMENT NUMBER  35
000FA0  41 80 6 0C0              LA    8,BINVAR.RETCODE
000FA4  50 80 3 204              ST    8,516(0,3)
000FA8  96 80 3 204              OI    516(3),X'80'
000FAC  1B 55                    SR    5,5
000FAE  41 10 3 204              LA    1,516(0,3)
000FB2  58 F0 3 14C              L     15,332(0,3)
000FB6  05 EF                    BALR  14,15

* STATEMENT NUMBER  41
000FB8  18 CD                    LR    ?,13
000FBA  58 D0 D 004              L     13,4(0,13)
000FBE  58 E0 D 00C              L     14,12(0,13)
000FC2  98 2C D 01C              LM    2,12,28(13)
000FC6  05 1E                    BALR  1,14

* END PROCEDURE

* STATEMENT NUMBER  36
000FC8                           DC    C' A'
000FCB                           DC    AL1(1)

* PROCEDURE                              A

* REAL ENTRY
000FCC  90 EC D 00C              STM   14,12,12(13)
000FD0  47 F0 F 014              B     *+16
000FD4  00000000                 DC    A(STMT. NO. TABLE)
000FD8  000000A8                 DC    F'168'
000FDC  00000000                 DC    A(STATIC CSECT)
000FE0  58 30 F 010              L     3,16(0,15)
000FE4  58 10 D 040              L     1,76(0,13)
000FE8  58 00 F 00C              L     0,12(0,15)
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000E7EC  1E 01          ALR   0,1
000E7EE  55 00 C 00C    CL    0,12(0,12)
000E7F2  47 D0 F 030    BNH   **+16
000E7F6  58 E0 C 074    L     14,116(0,12)
000E7FA  05 EF          BALR  14,15
000E7FC  58 E0 D 048    L     14,72(0,13)
000E800  18 F0          LR    15,0
000E802  90 EC 1 048    STM   14,12,72(1)
000E806  50 D0 1 004    ST    13,4(0,1)
000E80A  41 D1 0 000    LA    13,0(1,0)
000E80E  50 50 D 058    ST    5,88(0,13)
000E812  92 80 D 000    MVI   0(13),X'80'
000E816  92 24 D 001    MVI   1(13),X'24'
000E81A  D2 03 D 054 3 118  MVC   84(4,13),280(3)
000E820  05 20          BALR  2,0

* PROCEDURE BASE

* STATEMENT NUMBER  37
000E822  18 0D          LR    0,13
000E824  58 D0 D 004    L     13,4(0,13)
000E828  58 E0 D 00C    L     14,12(0,13)
000E82C  98 2C D 01C    LM    2,12,28(13)
000E830  05 1E          BALR  1,14

* END PROCEDURE
000E832  07 07          NOPR  7

* STATEMENT NUMBER  38
000E834                 DC    C' B'
000E837                 DC    AL1(1)

* PROCEDURE                     B

* REAL ENTRY
000E83E  90 EC D 00C    STM   14,12,12(13)
000E842  47 F0 F 014    B     *+16
000E846  00000000       DC    A(STMT, NO, TABLE)
000E844  00000080       DC    F'176'
000E848  00000000       DC    A(STATIC CSECT)
000E84C  58 30 F 010    L     3,16(0,15)
000E850  58 10 D 04C    L     1,76(0,13)
000E854  58 00 F 00C    L     0,12(0,15)
000E858  1E 01          ALR   0,1
000E85A  55 00 C 00C    CL    0,12(0,12)
000E85E  47 D0 F 030    BNH   *+16

000E862  58 E0 C 074    L     15,116(0,12)
000E866  05 EF          BALR  14,15
000E868  58 E0 C 048    L     14,72(0,13)
000E86C  18 F0          LR    15,0
000E86E  90 E0 1 048    STM   14,0,72(1)
000E872  50 D0 1 004    ST    13,4(0,1)
000E876  41 D1 0 000    LA    13,0(1,0)
000E87A  50 50 D 058    ST    5,88(0,13)
000E87E  92 80 D 000    MVI   0(13),X'80'
000E882  92 24 D 001    MVI   1(13),X'24'
000E886  D2 03 D 054 3 118  MVC   84(4,13),280(3)
000E88C  58 10 D 004    L     1,4(0,13)
000E890  58 10 1 018    L     1,24(0,1)
000E894  D2 03 D 0A8 1 000  MVC   168(4,13),0(1)
000E89A  92 00 D 0A8    MVI   168(13),X'00'
000E89E  05 20          BALR  2,0

* PROCEDURE BASE

* STATEMENT NUMBER  40
000E8A0  18 0D          LR    0,13
000E8A2  58 D0 D 004    L     13,4(0,13)
000E8A6  58 E0 D 00C    L     14,12(0,13)
000E8AA  98 2C D 01C    LM    2,12,28(13)
000E8AE  05 1E          BALR  1,14

* END PROCEDURE

* END PROGRAM
```

```
COMPILER DIAGNOSTIC MESSAGES
   (1)  (2)  (3)
ERROR ID L   STMT    MESSAGE DESCRIPTION

SEVERE AND ERROR DIAGNOSTIC MESSAGES

IEL0413I E   23      DECLARATION OF INTERNAL ENTRY NOT ALLOWED.    DECLARATION OF 'A' IGNORED.

WARNING DIAGNOSTIC MESSAGES

IEL0892I W   6       TARGET STRING SHORTER THAN SOURCE     RESULT TRUNCATED ON ASSIGNMENT.

IEL0518I W   23      'COCOUNT' IS THE NAME OF A BUILTIN FUNCTION BUT ITS IMPLICIT DECLARATION DOES NOT IMPLY
                     'BUILTIN'.

END OF COMPILER DIAGNOSTIC MESSAGES
   (4)                              (5)
COMPILE TIME    0.12 MINS        SPILL FILE:    27 RECORDS, SIZE  1091
```

Diagnostic messages and an end of compile step message generated by the compiler. All diagnostic messages generated by the optimizing compiler are documented in the publication OS Optimizing Compiler: Messages.

(1) "ERROR ID" This identifies the message as originating from the optimizing compiler (IEL), and gives the message number.

(2) "L" This is the severity level of the message.

(3) "STMT" This gives the number of the statement in which the error occurred.

(4) Compile time in minutes. This time includes the preprocessor.

(5) This gives the number of records "spilled" into auxiliary storage and the size in bytes of the spill file.

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F66-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST,LET,XREF        (1) DEFAULT OPTION(S) USED
          VARIABLE OPTIONS USED - SIZE=(104448,59392)-
```

(2) CROSS REFERENCE TABLE

(3) CONTROL SECTION

NAME	ORIGIN	LENGTH
FLISTART	00	38
FLIMAIN	38	8
SYSPINT	40	20
*SAMPLE2	60	378
IELCOCA	3D0	72
IELCOCB	448	78
*SAMPLE1	4E8	6B0
IBMBKCP1*	D68	238
IBMBKST1*	FA0	630
IBMBPIR1*	15EC	2D2
IBMBCCC1*	18B8	112
IBMBCCS1*	19C8	180
IBMBCH[illegible]1*	1B48	1D8
IBMBCC[illegible]1*	1D20	434
IBMBCT[illegible]1*	2158	290
IBMBCU[illegible]1*	23F8	308
IBMBEOC1*	2700	DA
IBMBKDM1*	27E0	E8
IBMBPRC1*	28C8	28
IBMBSIC1*	28F0	240
IBMBCK[illegible]1*	2B40	168
IBMBECL1*	2CB0	98

ENTRY

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
PLICALLA	6	PLICALLB	A				
SAMPLE	40						
IBMBKCPA	D68	IBMBKCPB	D6A	IBMBKCPC			
IBMBKSTA	FA0	IBMBKSTB	FA2	IBMBKSTC			
IBMBPIRA	15D2	IBMBPIRB	15D4	IBMBPIRC			
IBMBCCCB	18B8	IBMBCCCC	18BA	IBMBCCCA			
IBMBCCSA	19C8						
IBMBCHXE	1B48	IBMBCHFE	1B48	IBMBCHXP			
IBMBCHXY	1B58	IBMBCHFY	1B58	IBMBCHFH			
IBMBCHFD	1B68	IBMBCHXC	1B68	IBMBCHXF			
IBMBCODE	1D20	IBMBCCZE	1D20	IBMBCODP			
IBMBCTHD	2158	IBMBCTHX	2160	IBMBCTHF			
IBMBCTHE	2178						
IBMBCUIX	23F8	IBMBCUID	2400	IBMBCUIP			
IBMBCUIF	2418						
IBMBECCA	2700						
IBMBKDMA	27E0						
IBMBPRCA	28C8						
IBMBSICA	28F0	IBMBSICB	28F2	IBMBSICC	28F4	IBMBSICD	28F6
IBMBSICE	28F8	IBMBSICT	2AA6				
IBMBCKDP	2B40	IBMBCKZP	2B40	IBMBCKDD	2B48	IBMBCKZD	2B48
IBMBECLA	2CB0						

First page of the linkage editor listing.

(1) Statement identifying the version and level of the linkage editor and giving the options as specified in the PARM parameter of the EXEC statement that invokes the cataloged procedure.

(2) Cross reference table. This table consists of a module map and the cross-reference table.

(3) The module map shows each control section and its associated entry points, if any, listed across the page. An asterisk after the name means that these are library subroutines obtained by automatic library call.

(4) The cross-reference table gives all the locations in a control section at which a symbol is referenced. $UNRESOLVED(W) identifies a weak external reference that has not been resolved.

NAME	ORIGIN	LENGTH
IBMBJCT1*	2C4E	8C
IBMBJTT1*	2CDE	6E
IBMBCCL1*	2E4C	104
IBMBSAC1*	2F4E	AE
IBMBSEC1*	2FFC	EE
IBMBSLC1*	3CDE	6D4
IBMBSPL1*	37BC	28E
IBMBSPC1*	3A3E	12C
IBMBCEC1*	3B5E	2CC
IBMBCGT1*	3E2E	8E
IBMBEER1*	3EBC	4
IBMBERR1*	3EBE	6DA
IBMBPGC1*	4598	22
IBMBPGD1*	45BC	3C
IBMBSCV1*	45FC	21C
IBMBEEF1*	48CC	12C

NAME	LOCATION	NAME	LOCATION	NAME	LOCATION	NAME	LOCATION
IBMBJCTA	2C48						
IBMBJTTA	2CD8						
IBMBCCLA	2E4A	IBMBCCLB	2E42	IBMBCCLC	2E44	IBMBCCLD	2E46
IBMBSACA	2F48						
IBMBSECA	2FFA						
IBMBSLCA	3CD8	IBMBSLCB	3CDA				
IBMBSPLA	37BA	IBMBSPLB	37B2	IBMBSPLC	37B4		
IBMBSPCA	3A38						
IBMBCEZB	3B58	IBMBCECB	3B60	IBMBCEDX	3B68	IBMBCEDF	3B68
IBMBCEFX	3B68	IBMBCEZF	3B68	IBMBCEZX	3B68		
IBMBCGTA	3E28						
IBMBEERA	3EBA						
IBMBERRA	3EB8	IBMBERRB	3EF2	IBMBERRC	44E4		
IBMBPGCA	4598						
IBMBPGDA	45BA						
IBMBSCVA	45FA						
IBMBEEFA	48CA						

(4)

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
10	PLIMAIN	PLIMAIN
1C	PLITABS	$UNRESOLVED(W)
2C	IBMBPIRB	IBMBPIR1
38	*SAMPLE1	*SAMPLE1
64	*SAMPLE1	*SAMPLE1
6C	*SAMPLE1	*SAMPLE1
74	*SAMPLE1	*SAMPLE1
7C	*SAMPLE1	*SAMPLE1
84	*SAMPLE1	*SAMPLE1
8C	*SAMPLE1	*SAMPLE1
94	*SAMPLE1	*SAMPLE1
9C	IELCGCA	IELCGDA
A4	IBMBCCCA	IBMBCCC1
AC	IBMBCHFD	IBMBCHD1
B4	IBMBCTHC	IBMBCTH1

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
14	SYSPINT	SYSPINT
2E	IBMBPIRA	IBMBPIR1
3C	IBMBPIRC	IBMBPIR1
6C	*SAMPLE1	*SAMPLE1
6E	*SAMPLE1	*SAMPLE1
7C	*SAMPLE1	*SAMPLE1
7E	*SAMPLE1	*SAMPLE1
8C	*SAMPLE1	*SAMPLE1
8E	*SAMPLE1	*SAMPLE1
9C	*SAMPLE1	*SAMPLE1
9E	*SAMPLE1	*SAMPLE1
AC	IELCGCB	IELCGDB
AE	IBMBCCSA	IBMBCCS1
BC	IBMBCODE	IBMBCCD1
BE	IBMBCUID	IBMBCUD1

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
8C	IBMBFCCA	IBMBFCC1
C4	IBMBJCTA	IBMBJCT1
CC	IBMBOCLA	IBMBOCL1
D4	IBMBSAOA	IBMBSAO1
DC	IBMBSICE	IBMBSIO1
E4	IBMBSLOA	IBMBSLO1
EC	IBMBSPCA	IBMBSPC1
19C	SYSPINT	SYSPINT
1AC	IBMBFRCA	IBMBFRC1
1BC	IBMBKDMA	IBMBKDM1
2C	IBMBKSTB	IBMBKST1
234	IBMBKSTD	IBMBKST1
25C	IBMBKCPB	IBMBKCP1
2BC	*SAMPLE1	*SAMPLE1
2F8	*SAMPLE1	*SAMPLE1
384	*SAMPLE1	*SAMPLE1
48	IBMBSIST	$UNRESOLVED(W)
4C8	*SAMPLE2	*SAMPLE2
6D4	*SAMPLE2	*SAMPLE2
95	*SAMPLE2	*SAMPLE2
C8C	*SAMPLE2	*SAMPLE2
CF8	*SAMPLE2	*SAMPLE2
15D4	IBMCKEXA	$UNRESOLVED(W)
1854	IBMBJWTA	$UNRESOLVED(W)
185C	IBMBTOCB	$UNRESOLVED(W)
1818	IBMBCCLB	IBMBCCL1
184	IBMBCCLA	IBMBCCL1
1848	IBMBERRA	IBMBERR1
185	IBMBPQCA	IBMBPQC1
187C	IBMBEPRC	IBMBERR1
1A7C	IBMBCHXC	IBMBCH 1
1A8C	IBMBCHXP	IBMBCH 1
1A94	IBMBCHXE	IBMBCH 1
1ACC	IBMBCKDP	IBMBCK 1
1B8	IBMBCHFH	IBMBCH 1
1B1	IBMBCHFY	IBMBCH 1
1AB8	IBMBCEDX	IBMBCE 1
1AF8	IBMBCEFX	IBMBCE 1
1BC	IBMBCYFF	$UNRESOLVED(W)
1B3C	IBMBCMPC	$UNRESOLVED(W)
1B2C	IBMBCUIX	IBMBCU 1
1AEC	IBMBCTHX	IBMBCT 1
1AF4	IBMBCTHF	IBMBCT 1
1AD	IBMBCVDY	$UNRESOLVED(W)
1AA4	IBMBCRXB	$UNRESOLVED(W)
1B24	IBMBCRXB	$UNRESOLVED(W)
1AB	IBMBCGZA	$UNRESOLVED(W)
1A98	IBMBCACA	$UNRESOLVED(W)
1AA8	IBMBCACA	$UNRESOLVED(W)
1AE	IBMBCACA	$UNRESOLVED(W)
1B1	IBMBCACA	$UNRESOLVED(W)
1B28	IBMBCACA	$UNRESOLVED(W)

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
C	IBMBFCLA	IBMBFCL1
C8	IBMBJTTA	IBMBJTT1
D	IBMBOCLC	IBMBOCL1
D8	IBMBSEOA	IBMBSEC1
E	IBMBSIOT	IBMBSIO1
E8	IBMBSPLA	IBMBSPL1
F	IBMBCKDD	IBMBCK 1
19C	SYSPINT	SYSPINT
1B	SYSPINT	SYSPINT
1E8	IBMBKSTA	IBMBKST1
21	IBMBKSTC	IBMBKST1
24	IBMBKCPA	IBMBKCP1
26	IBMBKCPC	IBMBKCP1
2C4	*SAMPLE1	*SAMPLE1
33C	*SAMPLE1	*SAMPLE1
39C	*SAMPLE1	*SAMPLE1
4B4	IBMBSEOA	IBMBSEC1
4D	*SAMPLE2	*SAMPLE2
6DC	*SAMPLE2	*SAMPLE2
958	*SAMPLE2	*SAMPLE2
C94	*SAMPLE2	*SAMPLE2
D	*SAMPLE2	*SAMPLE2
15DE	IBMCKEXB	$UNRESOLVED(W)
1858	IBMBTOCA	$UNRESOLVED(W)
186	IBMBTPRA	$UNRESOLVED(W)
182C	IBMBCCLB	IBMBCCL1
1844	IBMBOCLC	IBMBCCL1
184C	IBMBERRB	IBMBERR1
1E64	IBMBPQDA	IBMBPQD1
1E4	IBMBEERA	IBMBEER1
1A8	IBMBCHXF	IBMBCH 1
1A9	IBMBCHXY	IBMBCH 1
1ABC	IBMBCKDD	IBMBCK 1
1AFC	IBMBCHFD	IBMBCH 1
1BC	IBMBCHFP	IBMBCH 1
1B14	IBMBCHFE	IBMBCH 1
1AC	IBMBCEDF	IBMBCE 1
1A78	IBMBCYXX	$UNRESOLVED(W)
1B38	IBMBCMPX	$UNRESOLVED(W)
1B4	IBMBCMPF	$UNRESOLVED(W)
1B34	IBMBCUIF	IBMBCU 1
1AF	IBMBCTHC	IBMBCT 1
1AD4	IBMBCODE	IBMBCO 1
1A	IBMBCRXB	$UNRESOLVED(W)
1B1C	IBMBCRXB	$UNRESOLVED(W)
1AC	IBMBCWDH	$UNRESOLVED(W)
1AB4	IBMBCGPA	$UNRESOLVED(W)
1AA	IBMBCACA	$UNRESOLVED(W)
1AC	IBMBCACA	$UNRESOLVED(W)
1AE8	IBMBCACA	$UNRESOLVED(W)
1B2	IBMBCACA	$UNRESOLVED(W)
1B44	IBMBCPBF	$UNRESOLVED(W)

LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION	LOCATION	REFERS TO SYMBOL	IN CONTROL SECTION
1A88	IBMBCHXH	IBMBCH01	1AAC	IBMBSCVA	IBMBSCV1
1ABC	IBMBCEDB	IBMBCE01	1AE4	IBMBCEDB	IBMBCE01
1B4C	IBMBCOZE	IBMBCC01	1B54	IBMBCKZP	IBMBCK01
1B5C	IBMBCVZY	$UNRESOLVED(W)	1B64	IBMBCWZH	$UNRESOLVED(W)
1B6C	IBMBCKZD	IBMBCK01	1D08	IBMBCGTA	IBMBCGT1
215C	IBMBCKZD	IBMBCK01	217C	IBMBCOZE	IBMBCC01
216C	IBMBCEZF	IBMBCE01	2174	IBMBCKZP	IBMBCK01
2164	IBMBCEZX	IBMBCE01	23F0	IBMBSCVA	IBMBSCV1
23FC	IBMBCEFX	IBMBCE01	2404	IBMBCHFD	IBMBCHC1
240C	IBMBCHFP	IBMBCH01	2414	IBMBCHFE	IBMBCH01
26F4	IBMBSCVA	IBMBSCV1	2B30	IBMBSPLA	IBMBSPL1
2B34	IBMBSPLB	IBMBSPL1	2B38	IBMBSPLC	IBMBSPL1
2B2C	IBMBCCLA	IBMBCCL1	2B44	IBMBCODP	IBMBCO01
2F24	IBMBRIOB	$UNRESOLVED(W)	2F28	IBMBRIOC	$UNRESOLVED(W)
2F2C	IBMBSCPA	$UNRESOLVED(W)	2FE0	IBMBCCCA	IBMBCCC1
2FE4	IBMBCBCA	$UNRESOLVED(W)	2FE8	IBMBCACA	$UNRESOLVED(W)
2FEC	IBMBCXOA	$UNRESOLVED(W)	3004	IBMBSIST	$UNRESOLVED(W)
37A8	IBMBCACA	$UNRESOLVED(W)	37A4	IBMBCBCA	$UNRESOLVED(W)
37AC	IBMBCZCA	$UNRESOLVED(W)	3790	IBMBCXOA	$UNRESOLVED(W)
3798	IBMBSIST	$UNRESOLVED(W)	3B18	IBMBCHXP	IBMBCH01
3B1C	IBMBCKDP	IBMBCK01	3B20	IBMBCHFP	IBMBCH01
3B20	IBMBCMPP	$UNRESOLVED(W)	3B34	IBMBCMPP	$UNRESOLVED(W)
3B38	IBMBCHXE	IBMBCH01	3B3C	IBMBCODE	IBMBCO01
3B40	IBMBCHFE	IBMBCH01	3B4C	IBMBCMPE	$UNRESOLVED(W)
3B54	IBMBCMPE	$UNRESOLVED(W)	3B44	IBMBCPBP	$UNRESOLVED(W)
3B48	IBMBCPBE	$UNRESOLVED(W)	3B50	IBMBCCSA	IBMBCCS1
3B5C	IBMBCRFB	$UNRESOLVED(W)	3B64	IBMBCRXB	$UNRESOLVED(W)
3E20	IBMBCGTA	IBMBCGT1	455C	IBMBERCA	$UNRESOLVED(W)
4560	IBMBEEFA	IBMBEEF1			

LOCATION 20 REQUESTS CUMULATIVE PSEUDO REGISTER LENGTH
PSEUDO REGISTERS

NAME	ORIGIN	LENGTH	NAME	ORIGIN	LENGTH	NAME	ORIGIN	LENGTH	NAME	ORIGIN	LENGTH
SYSPINT	00	4									

TOTAL LENGTH OF PSEUDO REGISTERS 4
ENTRY ADDRESS 00
TOTAL LENGTH 4930

****00 DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

```
SAMPLE PROGRAM: DATE = 71/08/09, TIME = 22.31.15
END SAMPLE PROGRAM
```

Index

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