File No. S360-31
Order No. GC28-6538-9

OS

IBM Systems Reference Library

IBM OS

Linkage Editor and Loader

Program Numbers 360S-ED-510
360S-ED-521
360S-LD-547

This publication provides the information necessary to use the linkage editor or loader program of the IBM System/360 Operating System to prepare the output of a language translator for execution. The intended audience is a customer applications programmer coding in a higher-level language or a system programmer responsible for installing and maintaining the operating system. An introductory knowledge of the concepts and facilities of the IBM System/360 Operating System is required to use this reference guide most effectively.

The linkage editor combines and edits modules to produce a single module that can be brought into main storage by program fetch for execution. It operates as a processing program rather than as part of the control program. The linkage editor provides several processing facilities that are either performed automatically or invoked in response to control statements prepared by the programmer.

The loader combines the basic editing and loading functions of the linkage editor and program fetch in one job step. It is designed for high-performance loading of modules that do not require the special processing facilities of the linkage editor and fetch, such as overlay. The loader does not produce load modules for program libraries.

Tenth Edition (January 1972)

This is a major revision of, and makes obsolete, Order No. GC28-6538-8. Information about CSECT Identification records has been added. Minor changes have been made throughout.

This edition corresponds to Release 21 of the IBM System/360 Operating System and to all subsequent releases until otherwise indicated in new editions or Technical Newsletters.

Changes are periodically made to the specifications herein; before using this publication in connection with the operation of IBM systems, refer to the latest SRL Newsletter, Order No. GN20-0360, for editions that are applicable and current.

Requests for copies of IBM publications should be made to your IBM representative or to the IBM Branch Office serving your locality.

A form for readers' comments is provided at the back of this publication. If the form has been removed, comments may be addressed to IBM Corporation, Programming Publications, Department D78, Monterey and Cottle Roads, San Jose, California 95114.

SUMMARY OF AMENDMENTS NUMBER 1

Date of Publication: January 1972
Form of Publication: Revision GC28-6538-9

CSECT Identification Records

New: Programming Feature

These records contain data describing the language translators and linkage editor that produced the program, any modifications to that program by IMASPZAP, and, optionally, up to forty characters of user data for each control section within the program. The IMBLIST service aid program can be used to access these records.

Programmer responses to linkage editor and loader messages are changed where applicable to reflect the problem determination aids offered by the IMBLIST service aid program.

Linkage Editor and Loader Messages

New: Programming and Documentation

- Two new messages define error conditions in relation to the SYSPRINT data set. IEW0984 occurs when the block size is too large. IEW0994 occurs when the SYSPRINT DD statement is missing.
- New message IEW0661 is added to occur when a control statement used to specify functions not available under the IBM System/360 Operating System is detected.
- New message IEW0714 is added to occur when the STOW routine cannot obtain the work space it needs to store a member in the specified library.
- New message IEW199I is issued when control is returned to the loader after the loaded program terminates abnormally in an MVT environment.

Maintenance: Documentation Only

- An additional programmer response is provided for message IEW0364.
- The descriptions of messages IEW0161, IEW0172, and IEW0182 are clarified to explain that the references identified in the messages are branch-type references.
- Additional programmer response information is provided for message IEW0222.

Linkage Editor Miscellaneous Changes

Maintenance: Programming and Documentation

- When different member names are used on the SYSLMOD DD statement and the NAME control statement, a cross reference table is printed.

Maintenance: Documentation Only

- The necessity for respecifying OVERLAY control statements when a module in overlay structure is reprocessed by the linkage editor is stated.
- ALIAS statement example is clarified.
- The MFT partition size, like the MVT region size, must be larger than $value_1$ when the SIZE option is used.
- The relationship of blocking factors to the values specified in the SIZE option is clarified.
- The result of misspelling an entry on a CHANGE or REPLACE statement is explained.
- Information about handling COBOL class test on TRANSFORM tables in an overlay structure is added.

Loader Miscellaneous Changes

Maintenance: Programming and Documentation

- The storage requirement for the loader is expanded.

Maintenance: Documentation Only

- The explanation of how the loader uses the SYSLIB data set to resolve external references is expanded.

Editorial changes that have no technical significance are not noted here.

Specific changes to the text made as of this publishing date are indicated by a vertical bar to the left of the text. These bars will be deleted at any subsequent republication of the page affected.

This publication provides applications programmers with the information necessary to use the linkage editor and loader of the IBM System/360 Operating System to prepare the output of a language translator for execution. Additional information on the operation and use of the linkage editor and loader is directed to the system programmer responsible for installing and maintaining the operating system.

The Introduction briefly defines the functions of the linkage editor and loader and gives recommendations for the use of each. Part 1 describes the linkage editor, and should be read before Part 2, which describes the loader.

The linkage editor combines and edits modules to produce a single module that can be brought into main storage by program fetch for execution. It operates as a processing program rather than as part of the control program. The linkage editor provides several processing facilities that are either performed automatically or invoked in response to control statements prepared by the programmer.

Part 1, which consists of six chapters and four appendixes, briefly describes the processing facilities and operation of the linkage editor. The introduction also defines linkage editor terms in reference to the source language statements that cause them to be created.

The six chapters describe the input to the linkage editor, the output from the linkage editor, module editing functions, design and specification of overlay programs, the job control language necessary to run a linkage editor job step, and the linkage editor control statements. The last two chapters are summaries of reference information to be used after the general information in the first four chapters is learned. The appendixes to Part 1 contain sample programs, diagnostic messages, a description of the linkage editor programs, and information on the invocation of the linkage editor.

The loader program combines the basic editing and loading functions of the linkage editor and program fetch in one job step. It is designed for high-performance loading of modules that do not require the special processing facilities of the linkage editor and fetch, such as overlay. The loader does not produce load modules for program libraries.

Part 2 of this publication describes the loader. The introduction to this part describes the functional characteristics of the loader, along with its compatibility with the linkage editor and restrictions on its use. The chapter on using the loader describes the job control language statements and invocation procedures for the loader, as well as loader input and output, and user program data. The appendixes to Part 2 contain sample input, diagnostic messages, a description of loader return codes, and storage considerations. All of these items are discussed in relation to the capabilities of the linkage editor; therefore, the reader must be familiar with Part 1 of this publication.

PREREQUISITES

To use this reference guide most effectively, the programmer must have a basic knowledge of the concepts and facilities of the IBM System/360 Operating System. In order to understand the information on the job control language specifications for the linkage editor and loader, the reader should also be familiar with the publication IBM System/360 Operating System: Job Control Language Reference, Order No. GC28-6704.

Time Sharing Option (TSO)

The following publication is needed to use the linkage editor or loader under the Time Sharing Option (TSO) of the IBM System/360 Operating System:

IBM System/360 Operating System: Time Sharing Option, Terminal User's Guide, Order No. GC28-6763.

This manual contains procedures for invoking the linkage editor or loader from the terminal and gives a brief description of the options that can be specified under TSO.

Further information on TSO can be found in the following two manuals:

IBM System/360 Operating System:

Time Sharing Option Guide, Order No. GC28-6698

Time Sharing Option Command Language Reference, Order No. GC28-6732

ADDITIONAL PUBLICATIONS

Within the text, references are made to the following publications:

IBM System/360 Operating System:

Data Management Services, Order No. GC26-3746
Maintenance, Order No. GC27-6918
Messages and Codes, Order No. GC28-6631
OS Service Aids, Order No. GC28-6791
Storage Estimates, Order No. GC28-6551
Supervisor Services and Macro Instructions, Order No. GC28-6646
System Control Blocks, Order No. GC28-6628
System Generation, Order No. GC28-6554
Utilities, Order No. GC28-6586

FIGURES

TABLES

The linkage editor and the loader are two of the processing programs of IBM System/360 Operating System. They prepare the output of language translators for execution. The linkage editor prepares a load module that is to be brought into main storage for execution by program fetch. The loader prepares the executable program in main storage and passes control to it directly.

The linkage editor provides several processing facilities such as creating overlay programs, and aiding program modification. (The linkage editor is also used to build and edit system libraries.) The loader provides high performance loading of programs that do not require the special processing facilities of the linkage editor.

Use of the linkage editor is recommended in the following cases:

- If the program requires linkage editor services in addition to the MAP, LET, NCAL, and SIZE options.
- If the program uses linkage editor control statements such as INCLUDE, NAME, OVERLAY, etc.
- If a load module is to be produced for a program library.

Use of the loader is recommended if the program only requires the use of the following linkage editor options: MAP, LET, NCAL, and SIZE. Because of its fewer options and because it can process a job in one job step, the loader reduces editing and loading time by about one half.

Linkage editor processing is performed in a link edit step. The linkage editor can be used for compile-link edit-go, compile-link edit, link edit, and link edit-go jobs. Loader processing is performed in a load step, which is equivalent to the link edit-go steps. The loader can be used for compile-load and load jobs.

Linkage editor processing is a necessary step that follows the source program assembly or compilation of any problem program. The linkage editor is one of the processing programs of the IBM System/360 Operating System, and is a service program used in association with the language translators.

Every problem program is designed to fulfill a particular purpose. To achieve that purpose, the program can generally be divided into logical units that perform specific functions. A logical unit of coding that performs a function, or several related functions, is a module. Ordinarily, separate functions should be programmed into separate modules, a process called modular programming. Each module can be written in the symbolic language that best suits the function to be performed. (The symbolic languages are assembler, ALGOL, COBOL, FORTRAN, PL/I, and RPG.)

Each module is separately assembled or compiled by one of the language translators. The input to a language translator is a source module; the output from a language translator is an object module. Before an object module can be executed, it must be processed by the linkage editor. The output of the linkage editor is a load module (Figure 1).

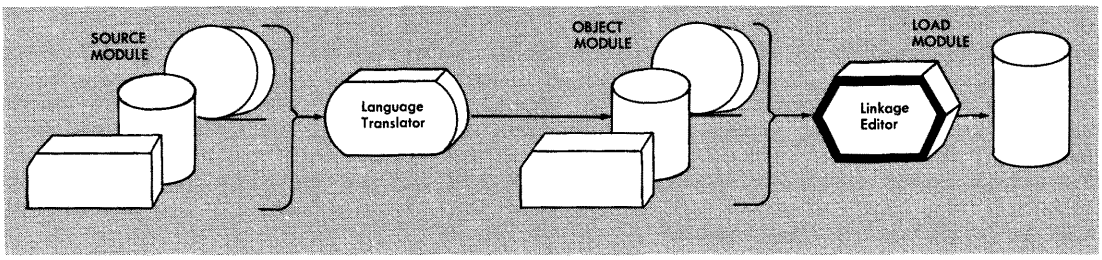


Figure 1. Preparing a Source Module for Execution

An object module is in relocatable format with unexecutable machine code. A load module is also relocatable, but with executable machine code. A load module is in a format that can be loaded into main storage and relocated by program fetch (Figure 2).

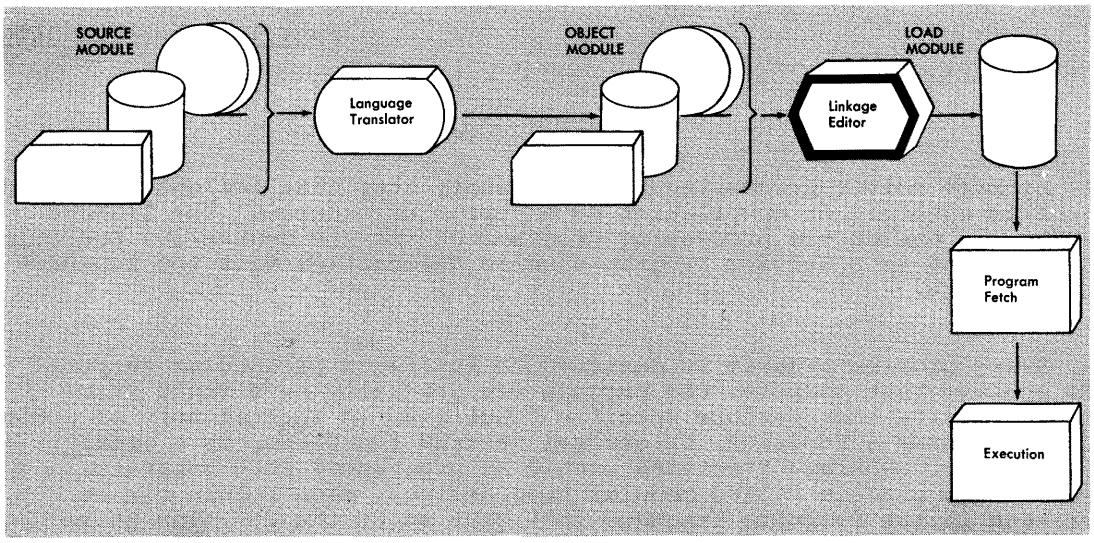


Figure 2. Preparing a Source Module for Execution and Executing the Load Module

Any module is composed of one or more control sections. A control section is a unit of coding (instructions and data) that is, in itself, an entity. All elements of a control section are loaded and executed in a constant relationship to one another. A control section is, therefore, the smallest separately relocatable unit of a program.

Each module in the input to the linkage editor may contain symbolic references to control sections in other modules; such references are called external references. These references are made by means of address constants (adcons). The symbol referred to by an external reference must be either the name of a control section or the name of an entry point in a control section. Control section names and entry names are called external names. By matching an external reference with an external name, the linkage editor resolves references between modules. External references and external names are called external symbols (Figure 3). An external symbol is one that is defined in one module and can be referred to in another.

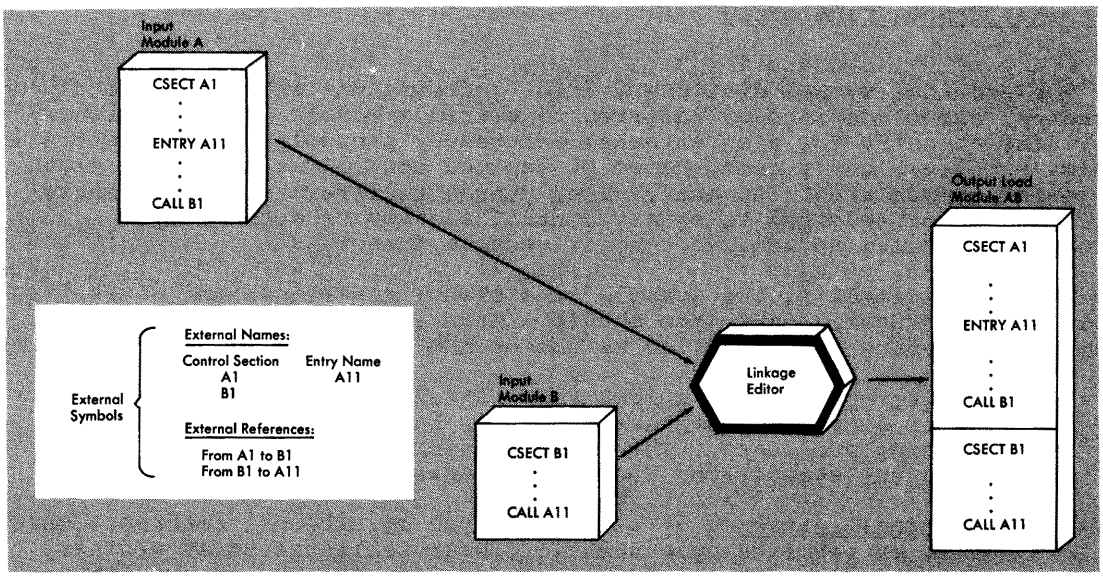


Figure 3. External Names and External References

OBJECT AND LOAD MODULES

Object modules and load modules have the same basic logical structure. Each consists of:

- Control dictionaries, containing the information necessary to resolve symbolic cross references between control sections of different modules, and to relocate address constants. Control dictionary entries are generated when external symbols, address constants, or control sections are processed by a language translator. Each language translator usually produces two kinds of control dictionaries: an external symbol dictionary (ESD) and a relocation dictionary (RLD).
- Text, containing the instructions and data of the program.
- An end of module indication: an END statement in an object module, an end-of-module indicator in a load module.

Each control dictionary and the text and end indication is described in greater detail in the following text.

Both object modules and load modules can contain data used by the linkage editor to create CSECT Identification (IDR) records. If the language translator creating an object module supports CSECT Identification, the input object module can contain translator data for Identification records on the END statement. Input load modules differ from object modules in the type of data they supply. Input load modules can also provide IMASPZAP data, linkage editor data, and user data to the Identification records that are built during linkage editor processing. During the link edit step, the optional IDENTIFY control statement is used to supply the optional user data for the CSECT Identification records.

External Symbol Dictionary

The external symbol dictionary (ESD) contains one entry for each external symbol defined or referred to within a module. The dictionary contains an entry for each external reference, pseudo register (external dummy section), entry name, named or unnamed control section, and blank or named common area. An entry name, pseudo register, or named control section can be referred to by any control section or separately processed module; an unnamed control section cannot.

Each entry identifies a symbol, or a symbol reference, and gives its location, if known, within the module. Each entry in the external symbol dictionary is classified as one of the following:

- External reference -- a symbol that is defined as an external name in another separately processed module, but is referred to in the module being processed. The external symbol dictionary entry specifies the symbol; the location is unknown.

- Weak external reference -- a special type of external reference that is not to be resolved by automatic library call unless an ordinary external reference to the same symbol is found. The external symbol dictionary entry specifies the symbol; the location is unknown.

- Entry name -- a name within a control section that defines an entry point. The external symbol dictionary entry specifies the symbol and its location, and identifies the control section to which it belongs.

- Control section name -- the symbolic name of a control section. The external symbol dictionary entry specifies the symbol, the length of the control section, and its location. In this case, the location represents the origin of the control section, which is the first byte of the control section.

- Blank or named common area -- a control section used to reserve a main storage area that can be referred to by other modules. The reserved storage area can be used, for example, as a communications region within a program or to hold data supplied at execution time. The external symbol dictionary entry specifies the name, if present, and the length of the area. If there is no name, the name field contains blanks.

- Private code -- an unnamed control section. The external symbol dictionary entry specifies the length of the control section, and the origin. The name field contains blanks.

- Pseudo register -- a special facility (corresponding to the external dummy section feature of Assembler F) that can be used to write re-enterable programs. A pseudo register is a dynamically obtained location in main storage that can be used as a pointer to dynamically acquired storage; that is, the space for such areas is not reserved in the load module but is acquired during execution. The external symbol dictionary contains the name, length, alignment, and displacement of the pseudo register.

When processing input modules, the linkage editor resolves references between modules by matching the referenced symbols to defined symbols. To do this, the linkage editor searches for the external symbol definition in the external symbol dictionary of each input module. As

shown in Figure 4, the linkage editor matches the external reference to B1 by locating the definition for B1 in the external symbol dictionary of Module B. In the same way, it matches the external reference to A11 by locating the definition for A11 in the external symbol dictionary of Module A.

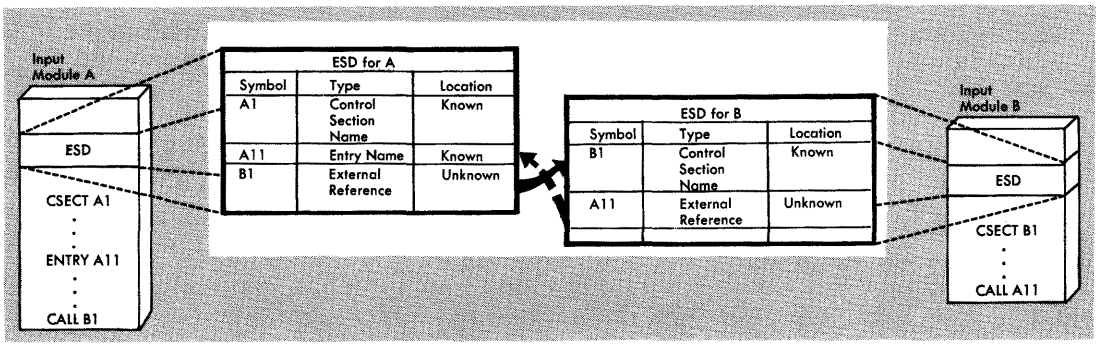


Figure 4. Use of the External Symbol Dictionary

Text

The text contains the instructions and data of the module.

Relocation Dictionary

The relocation dictionary (RLD) contains one entry for each relocatable address constant that must be modified before a module is executed. An entry identifies an address constant by indicating both its location within a control section and the external symbol whose value must be used to compute the value of the address constant. (The external symbol is defined in an external symbol dictionary entry in another control section or module.)

The linkage editor uses the relocation dictionary whenever it processes a module to adjust the address constants for references to other control sections and modules. This dictionary is also used to adjust these address constants again after program fetch reads an output load module from a library and loads it into main storage for execution.

End Indication

The end of a load module is marked by an end-of-module indicator (EOM). The EOM cannot, like the assembler END instruction, specify an entry point. Therefore, whenever a load module is reprocessed by the linkage editor, a main entry point should be specified on an ENTRY statement. If one is not specified, the linkage editor will assign the first byte of the first control section encountered as the entry point.

LINKAGE EDITOR PROCESSING

Two levels of the linkage editor are available: level E, which is designed to process programs in 15K or more of main storage (where K is equal to 1024 bytes); and level F, which is designed to process programs in 44K or more of main storage. A compatibility option is provided to ensure that programs processed by the level F editor can be reprocessed by the level E editor.

The rest of this section discusses the input and output sources of the linkage editor, and the way in which the linkage editor produces a load module.

INPUT AND OUTPUT SOURCES

The general input and output sources of both linkage editor programs are the same. The linkage editor can receive its input from several sources, as follows:

- The primary input, which can contain only object modules and linkage editor control statements (called control statements in the following text).
- Additional user-specified input, which can contain either object modules and control statements, or load modules. This input is either specified by the user as input, or incorporated automatically by the linkage editor from a call library.

During processing, the linkage editor generates intermediate data. The level E linkage editor always places this intermediate data on a direct access storage device; the level F linkage editor places intermediate data on a direct access storage device when main storage allocated for input data is exhausted.

Output of the linkage editor is of two types:

- A load module, which is always placed in a library (a partitioned data set) as a named member.
- Diagnostic output, which is produced as a sequential data set.

Figure 5 shows the input, intermediate, and output sources for the linkage editor program.

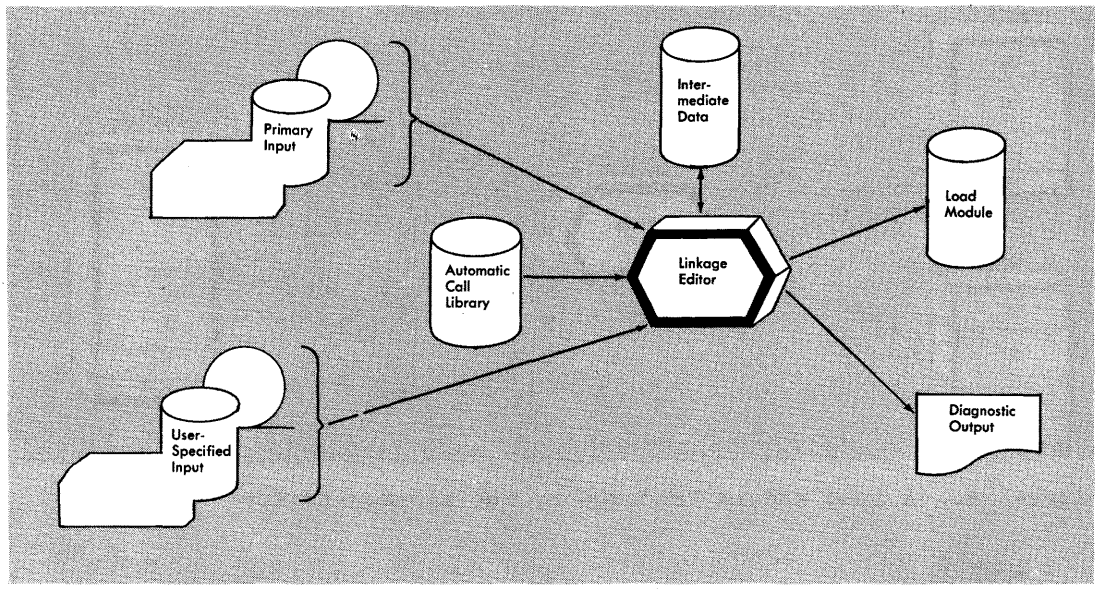


Figure 5. Input, Intermediate, and Output Sources for the Linkage Editor

LOAD MODULE CREATION

In processing object and load modules, the linkage editor assigns consecutive relative addresses to all control sections and resolves all references between control sections. Object modules produced by several different language translators can be used to form one load module.

An output load module is composed of all input object modules and input load modules processed by the linkage editor. The control dictionaries of an output module are therefore a composite of all the control dictionaries in the linkage editor input. The control dictionaries of a load module are called the composite external symbol dictionary (CESD) and the relocation dictionary (RLD). The load module also contains all of the text from each input module, and one end-of-module indicator (Figure 6).

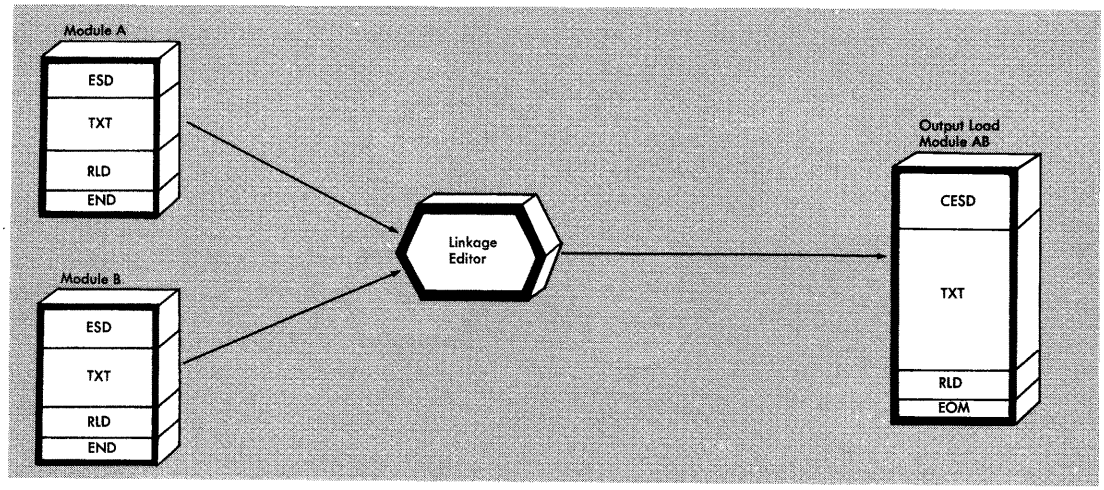


Figure 6. A Load Module Produced by the Linkage Editor

Assigning Addresses

Each module to be processed by the linkage editor has an origin that was assigned during assembly, compilation, or a previous execution of the linkage editor. When several modules, each with an independently assigned origin, are to be processed by the linkage editor, the sequence of the addresses is unpredictable; two input modules may even have the same origin.

Each input module can be made up of one or more control sections. To produce an executable output load module, the linkage editor assigns relative main storage addresses to each control section by assigning an origin to the first control section encountered and then assigning addresses, relative to that origin, to all other control sections to be included in the output load module. The value assigned as the origin of the control section is used to relocate each address dependent item in the control section.

Although the addresses in a load module are consecutive, they are relative to zero. When a load module is to be executed, program fetch prepares the module for execution by loading it at a specific main storage location. The addresses in the module are then increased by this base address. Each address constant must also be readjusted, another function of program fetch.

Resolving External References

The linkage editor also resolves external references in the input modules. Cross references between control sections in different modules are symbolic. They must be resolved relative to the addresses assigned to the load module. The linkage editor calculates the new address of each relocatable expression in a control section and determines the assigned origin of the item to which it refers.

FUNCTIONS OF THE LINKAGE EDITOR

Linkage editor input may consist of a combination of object modules, load modules, and control statements. The primary function of the linkage editor is to combine these modules, in accordance with the requirements stated on control statements, into a single output load module. Although this linking or combining of modules is its primary function, the linkage editor also:

- Edits modules by replacing, deleting, and rearranging control sections as directed by control statements.
- Accepts additional input modules from data sets other than the primary input data set, either automatically, or upon request.
- Reserves storage for the common control sections generated by assembler and FORTRAN language translators, and static external areas generated by PL/I.
- Computes total length and assigns displacements for all pseudo registers (external dummy sections).
- Creates overlay programs in a structure defined by control statements.
- Creates multiple output load modules as directed by control statements.
- Provides special processing and diagnostic output options.
- Assigns module attributes that describe the structure, content, and logical format of the output load module.
- Assigns storage hierarchies as directed by control statements.
- Allocates main storage areas for linkage editor processing as specified by the programmer (level F linkage editor only).
- Stores system status index information in the directory of the output module library (systems personnel only).
- Traces the processing history of a program.

Each of the linkage editor functions is described briefly in the following paragraphs.

Links Modules

Processing by the linkage editor makes it possible for the programmer to divide his program into several modules, each containing one or more control sections. The modules can be separately assembled or compiled. The linkage editor combines these modules into one output load module (Figure 7) with contiguous storage addresses. During processing by the linkage editor, references between modules within the input are resolved. The output module is placed in a library (partitioned data set).

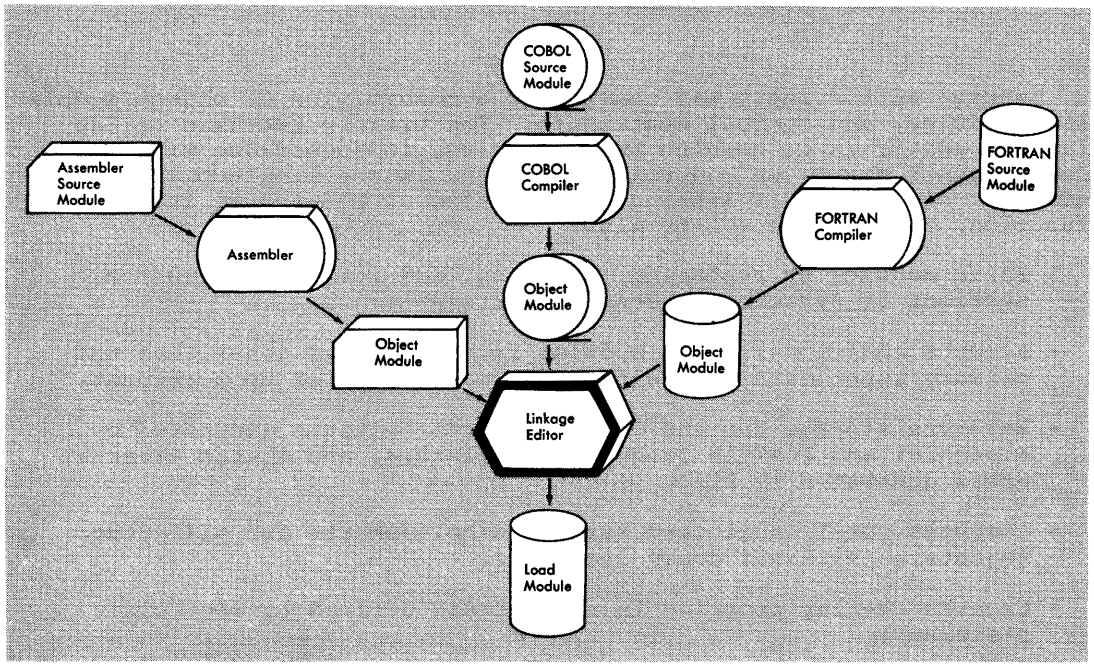


Figure 7. Linkage Editor Processing -- Module Linkage

Edits Modules

Program modification is made easier by the editing functions of the linkage editor. When the functions of a program are changed, the programmer modifies, then compiles and link edits again only the affected control sections instead of the entire source module.

Control sections can be replaced, renamed, deleted, or moved as directed by control statements. Control sections can also be automatically replaced by the linkage editor. External symbols can also be changed or deleted as directed by control statements.

Figure 8 illustrates the module editing function of the linkage editor.

Accepts Additional Input Sources

Standard subroutines can be included in the output module, thus reducing the work in coding programs. The programmer can specify that a subroutine be included at a particular time during the processing of his program by using a control statement. When the linkage editor processes a program that contains this statement, the module containing the subroutine is retrieved from the indicated input source, and made a part of the output module (Figure 9).

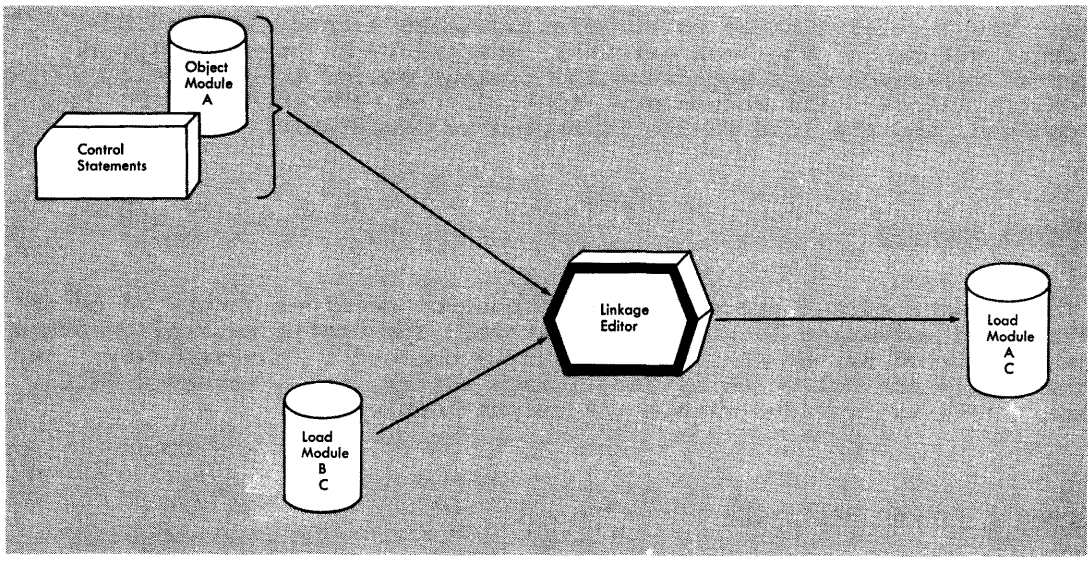


Figure 8. Linkage Editor Processing -- Module Editing

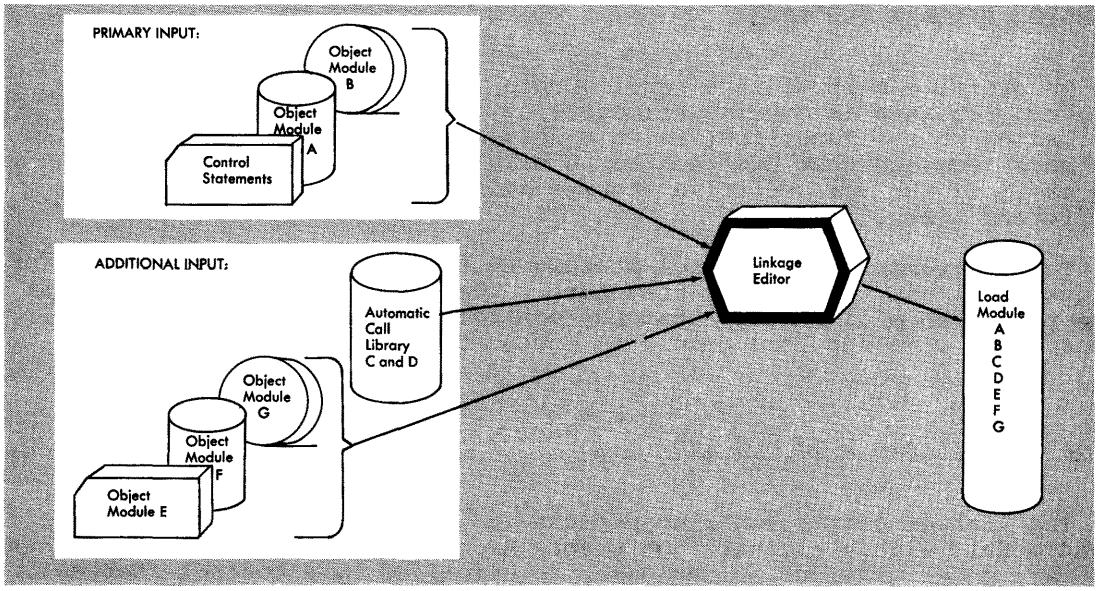


Figure 9. Linkage Editor Processing -- Additional Input Sources

Symbols that are still undefined after all input modules have been processed cause the automatic library call mechanism to search for modules that will resolve these references. When a module name is found that matches the unresolved symbol, the module is processed by the linkage editor and also becomes part of the output module (Figure 9).

Note: The level F linkage editor distinguishes a special type of external reference; the weak external reference. An unresolved weak external reference does not cause the linkage editor to use the automatic library call mechanism. Instead, the reference is left unresolved, and the load module is marked as executable.

Reserves Storage

The linkage editor processes common control sections generated by the FORTRAN and assembler language translators. The static external storage areas generated by the PL/I compiler are processed in the same way. The common areas are collected by the linkage editor, and a reserved main storage area is provided within the output module.

Processes Pseudo Registers

Pseudo registers, like the external dummy sections of Assembler F, aid in generating re-enterable code. The linkage editor processes pseudo registers by accumulating the total length of storage required for all pseudo registers and recording the displacement of each. During execution, the program dynamically acquires the necessary storage.

Creates Overlay Programs

To minimize main storage requirements, the programmer can organize his program into an overlay structure by dividing it into segments according to the functional relationships of the control sections. Two or more segments that need not be in main storage at the same time can be assigned the same relative storage addresses, and can be loaded at different times.

The programmer uses control statements to specify the relationship of segments within the overlay structure. The segments of the load module are placed in a library so that the control program can load them separately when the load module is executed.

Creates Multiple Load Modules

The linkage editor can also process its input to form more than one load module within a single job step. Each load module is placed in the library under a unique member name, as specified by a control statement.

Provides Special Processing and Diagnostic Output Options

The programmer can specify special processing options that negate automatic library call or the effect of minor errors. In addition, the linkage editor can produce a module map or cross-reference table that shows the arrangement of control sections in the output module and indicates how they communicate with one another. A list of the control statements processed can also be produced.

Throughout processing, errors and possible error conditions are logged. Serious errors cause the linkage editor to mark the output module not executable. Additional diagnostic data is automatically logged by the linkage editor. The data indicates the disposition of the load module in the output module library.

Assigns Load Module Attributes

When the linkage editor generates a load module, it places an entry for the module in the directory of the library. This entry contains attributes that describe the structure, content, and logical format of the load module. The control program uses these attributes to determine how a module is to be loaded, what it contains, if it is executable, whether it is executable more than once without reloading, and if it can be executed by concurrent tasks. Some module attributes can be specified by the programmer; others are specified by the linkage editor as a result of information gathered during processing.

Assigns Storage Hierarchies

When main storage hierarchy support is included in a system, the linkage editor provides addressing distinction between processor storage and IBM 2361 Core Storage. In order for the linkage editor to determine into which area of main storage a control section is to be loaded, the programmer specifies the hierarchy to which the control section belongs. The assignment of control sections to a specific hierarchy is accomplished with a control statement.

If main storage hierarchy support is not included in a system, and some control sections within a module are assigned to each hierarchy, an MVT system establishes a two-part region within processor storage. The two parts are not necessarily contiguous. In an MFT system, the module is loaded in one area within processor storage.

Allocates User-Specified Main Storage Areas

The programmer can specify the total amount of main storage to be made available to the linkage editor, the amount to be used for the load module buffer, and the buffer for the output load module. These options should be specified only when the level F linkage editor is used.

Stores System Status Index Information

The following information is intended for systems personnel responsible for maintaining IBM-supplied load modules. It is not generally applicable to non-IBM load modules.

Four bytes in the library directory entry for IBM-supplied load modules are used to store system status index information. This information, which is used for maintenance of the modules, is placed in the directory with a control statement. For details on the use of this statement, refer to the publication IBM System/360 Operating System: Maintenance.

Traces Processing History

Tracing the processing history of a program is simplified by the CSECT Identification (IDR) records created and maintained by the linkage editor. A CSECT Identification record can contain data that describes:

- The language translator, its level, and the translation date for each control section.
- The most recent processing by the linkage editor.
- Any modification made to the executable code of any control section.

Optionally, user-supplied data associated with the executable code of a control section can also be recorded.

RELATIONSHIP TO THE OPERATING SYSTEM

The linkage editor has the same relationship to the operating system as any other processing program. It can be executed either as a job step, a subprogram, or a subtask. Control is passed to the linkage editor in one of three ways:

- As a job step, when the linkage editor is specified on an EXEC job control statement in the input stream.
- As a subprogram, with the execution of a CALL macro instruction (after the execution of a LOAD macro instruction), a LINK macro instruction, or an XCTL macro instruction.
- As a subtask, in multitasking systems, with the execution of the ATTACH macro instruction.

Execution of the linkage editor and the data sets used by the linkage editor are described to the system with job control language statements. These statements describe all jobs to be performed by the system.

Note: Job control statements are not to be confused with linkage editor control statements. Job control statements are processed before the linkage editor is executed; linkage editor control statements are processed during linkage editor execution.

Depending on the operating system configuration used, certain restrictions are placed on the size of a load module. Under MFT, a load module can contain up to 524,288 bytes. If a load module is larger than this, it should be divided into several load modules that are dynamically loaded by assembler language macro instructions. Under MVT, modules larger than 524,288 bytes are allowed.

Time Sharing Option (TSO)

When the linkage editor is used under TSO, it is invoked by the linkage editor prompter, a program that acts as an interface between the user and the operating system and linkage editor. Under TSO, execution of the linkage editor and definition of data sets used by the linkage editor are described to the system through use of the LINK command that causes the prompter to be executed. Operands of the LINK command can also be used to specify the linkage editor options a job requires.

Complete procedures for use of the LINK command are given in the Terminal User's Guide.

LANGUAGE DEPENDENCIES

This section defines control section, entry name, external reference, common area, and pseudo register (external dummy section) in terms of the source language statements that generally create them. The languages described are assembler, COBOL, FORTRAN, and PL/I.

Note: Unless the language translator supports CSECT Identification (IDR) Records, identification data is not produced.

Assembler Language

In the assembler language, a control section is defined by a CSECT statement or a START statement. Either statement may specify a control section name. The control section delimiter is an END statement, or another CSECT or START statement.

An entry name is defined with an ENTRY statement.

An external reference to a data area is specified with an EXTRN statement and an A-type address constant; an external reference to a control section or an entry name is specified with a V-type address constant.

A common area is specified with a COM statement.

An external dummy section (Assembler F and Assembler H only) is defined with a DXD instruction or a DSECT and a Q-type address constant; a CXD instruction defines a 4-byte field that the linkage editor uses to accumulate the length of all external dummy sections in a load module.

COBOL

In COBOL, a control section is produced for each compilation. COBOL control sections are always named, because a name must be specified in the PROGRAM-ID paragraph of the IDENTIFICATION DIVISION.

An entry name is defined with an ENTRY statement.

An external reference is created by the compiler when a CALL statement is used.

COBOL does not use common areas or pseudo registers.

FORTRAN

In FORTRAN, a control section is defined with a SUBROUTINE, FUNCTION, or BLOCK DATA statement that specifies the control section name. If the first statement in a FORTRAN routine is not one of these, it is assumed to begin the main routine of the program. Automatically, the statement

defines a control section named MAIN, the name always assigned to the main routine of a FORTRAN program unless the programmer has used the NAME option to assign a name to his main routine. A control section delimiter is an END statement.

An entry name is defined with an ENTRY statement.

An external reference is created for an EXTERNAL statement or a reference to a subroutine subprogram, a function subprogram, or a BLOCK DATA subprogram.

A common area is specified with a COMMON statement. A name may be specified, if desired.

FORTRAN does not use pseudo registers.

PL/I

In PL/I, a control section is defined by an external PROCEDURE statement and named by the first statement label. When the MAIN option is specified, the control section IHEMAIN, which contains the address of the principal entry point, is created. In both cases, the control section IHENTRY is generated to provide appropriate linkage to the library storage management modules. Control sections are also created for each STATIC EXTERNAL or EXTERNAL declaration with initial text and for each EXTERNAL file constant.

Note: If the labels or variable names used for control section names exceed seven characters, PL/I generates a seven-character control section name by concatenating the first four and the last three characters in the label or variable name.

A control section is also created for STATIC INTERNAL storage; it contains the items declared with their storage class attributes as well as work areas and control blocks added by the compiler. This control section takes its name from the name of the external procedure control section, followed by the letter A and padded to the left with asterisks to a length of eight characters.

An entry name is defined with an ENTRY statement.

An external reference is created for an ENTRY declaration, either explicitly or implicity declared with the EXTERNAL attribute. Unresolved function references or procedure calls imply EXTERNAL scope and also cause an external reference to be generated.

A named common area is specified with a STATIC EXTERNAL or EXTERNAL declaration when the defined area does not contain initial text. (When the area is initialized, a control section is generated.) The name is the name of the variable. PL/I does not use blank common areas.

A pseudo register is created for each CONTROLLED variable, for each file declared, and for each PROCEDURE or PROCEDURE BEGIN block or ON unit in the program. The name of the pseudo register created for a CONTROLLED EXTERNAL variable is the name of the variable. In all other cases, the name of the pseudo register is generated from the external procedure control section name followed by a letter (B, C, etc.) and padded to the left with asterisks to a length of eight characters. The asterisks can be replaced if necessary to provide sufficient unique names.

The linkage editor accepts input from two major sources: the primary input data set and additional data sets. The primary input data set is made available through job control language specifications. Additional data sets are made available either through the automatic library call mechanism, or through user-specified control statements. They must, however, also be defined with job control language specifications.

Primary and additional input data sets may contain the following types of data:

- One or more object modules.
- One or more load modules.
- Control statements.
- Combinations of the above (restrictions on certain combinations are noted where they apply).

Object modules and control statements may be contained in either sequential or partitioned data sets. Load modules must be contained in partitioned data sets.

Execution of the linkage editor with no input results in no error messages. The listing header is printed and the requested options are listed. The linkage editor then terminates.

This chapter describes the "linking" functions of the linkage editor only; the "editing" functions are described in the chapter "Module Editing."

PRIMARY INPUT DATA SET

The primary input data set is required for every linkage editor job step. It must be defined by a DD statement with the ddname SYSLIN. The primary input can be:

- A sequential data set.
- A member of a partitioned data set.
- A concatenation of sequential data sets and/or members of partitioned data sets.

The primary input data set must contain object modules and/or control statements. The modules and control statements are processed sequentially and their order determines the basic order of linkage editor processing during a given execution. However, the order of the control sections after processing does not necessarily reflect the order in which they appeared in the input.

In the examples that follow, only the statements necessary to define the input to the linkage editor are shown; complete examples are shown in Appendix A.

OBJECT MODULES

The primary input to the linkage editor may consist solely of one or more object modules. The rest of this section discusses object module input from cards, as a member of a partitioned data set, passed from a previous job step, and created in a separate job.

From Cards

Object module input to the linkage editor may be on cards. The card deck itself is treated as a sequential data set; the cards are placed in the input stream, after a DD * statement, as follows:

```
//SYSLIN   DD   *
┌-------------------------------------------------------------------┐
|Object Deck A                                                      |
├-------------------------------------------------------------------┤
|Object Deck B                                                      |
└-------------------------------------------------------------------┘
/*
```

The card input is followed by a /* statement.

If card decks are used in addition to other input, the DD * statement must be last, as follows:

```
//SYSLIN   DD   DSNAME=INPUT,...
//         DD   *
┌-------------------------------------------------------------------┐
|Object Deck A                                                      |
├-------------------------------------------------------------------┤
|Object Deck B                                                      |
└-------------------------------------------------------------------┘
/*
```

By omitting the ddname on the second DD statement, the card input is concatenated to the data set described on the SYSLIN DD statement.

As a Member of a Partitioned Data Set

An object module in a partitioned data set can be used as primary input to the linkage editor by specifying its data set name and member name on the SYSLIN DD statement. In the following example, the member named TAXCOMP in the object module library LIBROUT is to be the primary input; LIBROUT is a cataloged data set:

```
//SYSLIN   DD   DSNAME=LIBROUT(TAXCOMP),DISP=(OLD,KEEP)
```

The library member is processed as if it were a sequential data set.

Members of partitioned data sets can be concatenated with other input data sets, as follows:

```
//SYSLIN    DD   DSNAME=OBJLIB,DISP=(OLD,KEEP),...
//          DD   DSNAME=LIBROUT(TAXCOMP),DISP=(OLD,KEEP)
```

Library member TAXCOMP is concatenated to data set OBJLIB; both must contain object modules since they are the primary input.

Passed from a Previous Job Step

An object module to be used as input can be passed from a previous job step to a linkage editor job step in the same job, as in a compile-link edit job. That is, the output from the compiler is direct input to the linkage editor. In the following example, an object module that was created in a previous job step (Step A) is passed to the linkage editor job step (Step B):

```
Step A:  //SYSGO    DD   DSNAME=&&OBJECT,DISP=(NEW,PASS),...
                      .
                      .
                      .
Step B:  //SYSLIN   DD   DSNAME=&&OBJECT,DISP=(OLD,DELETE)
```

The data set name &&OBJECT, used in both job steps, identifies the object module as the output of the language processor on the SYSGO DD statement, and as the primary input to the linkage editor on the SYSLIN DD statement.

Note: The double ampersand (&&) in the data set name defines a temporary data set. These data sets exist for the duration of the job and are automatically deleted at the end of the job. If the data set is to be preserved for longer than the duration of a single job, the double ampersand is not used (DSNAME=OBJECT).

The method used in the preceding example can also be used to retrieve object modules created in previous steps. If the same data set name is used for the output of each language processor, one SYSLIN DD statement can be used to retrieve all the object modules, as follows:

```
Step A:  //SYSGO    DD   DSNAME=&&OBJMOD,DISP=(NEW,PASS),...
                      .
                      .
                      .
Step B:  //SYSPNCH  DD   DSNAME=&&OBJMOD,DISP=(MOD,PASS)
                      .
                      .
                      .
Step C:  //SYSLIN   DD   DSNAME=&&OBJMOD,DISP=(OLD,DELETE)
```

The two object modules from Steps A and B are placed in the same sequential data set, &&OBJMOD. The SYSLIN DD statement in Step C causes both object modules to be used as the primary input to the linkage editor.

Another method can be used to accomplish this purpose: concatenation of data sets. This method could be used if the object modules were created in previous job steps with different member names, as follows:

```
Step A:  //SYSGO    DD   DSNAME=&&OBJLIB(MODA),DISP=(NEW,PASS),...
                      .
                      .
                      .
Step B:  //SYSPNCH  DD   DSNAME=&&OBJLIB(MODB),DISP=(MOD,PASS),...
                      .
                      .
                      .
Step C:  //SYSLIN   DD   DSNAME=&&OBJLIB(MODA),DISP=(OLD,DELETE)
         //         DD   DSNAME=&&OBJLIB(MODB),DISP=(OLD,DELETE)
```

The object modules created in Steps A and B were placed in a partitioned data set with different member names. The two members are concatenated in Step C as primary input. Each member is considered to be a sequential data set.

Created in a Separate Job

If the only input to the linkage editor is an object module from a previous job, the SYSLIN DD statement contains all the information necessary to locate the object module, as follows:

```
//SYSLIN   DD   DSNAME=OBJECT,DISP=(OLD,DELETE),UNIT=2311,
//              VOLUME=SER=LIB613
```

An object module created in a separate job may also be on cards, in which case it is handled as described earlier.

CONTROL STATEMENTS

The primary input data set may also consist solely of control statements. When the primary input is control statements, input modules are specified on INCLUDE control statements (see "Included Data Sets"). The control statements may be either placed in the input stream or stored in a permanent data set.

In the following example, the primary input consists of control statements in the input stream:

```
//SYSLIN   DD   *
┌-------------------------------------------------------------------┐
|Linkage Editor Control Statements                                  |
└-------------------------------------------------------------------┘
/*
```

In the next example, the primary input consists of control statements stored in the member INCLUDES in the partitioned data set CTLSTMTS:

```
//SYSLIN    DD    DSNAME=CTLSTMTS(INCLUDES),DISP=(OLD,KEEP),...
```

In either case, the control statements can be any of those described in "Linkage Editor Control Statement Summary," as long as the rules given there are followed.

OBJECT MODULES AND CONTROL STATEMENTS

The primary input to the linkage editor may contain both object modules and control statements. The object modules and control statements may be in either the same data set or different data sets. If the modules and statements are in the same data set, this data set is described on the SYSLIN DD statement as any data set is described.

If the modules and statements are in different data sets, the data sets are concatenated. The control statements may be defined either in the input stream or as a separate data set.

Control Statements in the Input Stream

Control statements can be placed in the input stream and concatenated to an object module data set, as follows:

```
//SYSLIN    DD    DSNAME=&&OBJECT,...
//          DD    *
┌-------------------------------------------------------------------┐
|Linkage Editor Control Statements                                  |
└-------------------------------------------------------------------┘
/*
```

Another method of handling control statements in the input stream is to use the DDNAME parameter, as follows:

```
//SYSLIN    DD    DSNAME=&&OBJECT,...
//          DD    DDNAME=SYSIN
            .
            .
            .
//SYSIN     DD    *
┌-------------------------------------------------------------------┐
|  Linkage Editor Control Statements                                |
└-------------------------------------------------------------------┘
/*
```

Note: The linkage editor cataloged procedures use DDNAME=SYSIN for the SYSLIN DD statement to allow the programmer to specify the primary input data set required.

Control Statements in a Separate Data Set

A separate data set that contains control statements may be concatenated to a data set that contains an object module. The control statements for a frequently used procedure (for example, a complex overlay structure or a series of INCLUDE statements) can be stored permanently. In the following example, the members of data set CTLSTMTS contain linkage editor control statements. One of the members is concatenated to data set &&OBJECT.

```
//SYSLIN    DD    DSNAME=&&OBJECT,DISP=(OLD,DELETE),...
//          DD    DSNAME=CTLSTMTS(OVLY),DISP=(OLD,KEEP),...
```

The control statements in the member named OVLY of the partitioned data set CTLSTMTS are used to structure the object module.

AUTOMATIC CALL LIBRARY

The automatic library call mechanism is used to resolve external references that were not resolved during primary input processing. Unresolved external references found in modules from additional data sources are also processed by this mechanism.

Note: The following discussion of automatic library call does not apply to unresolved weak external references; they are left unresolved.

The automatic library call mechanism involves a search of the directory of the automatic call library for an entry that matches the unresolved external reference. When a match is found, the entire member is processed as input to the linkage editor.

Automatic library call can resolve an external reference when the following conditions exist; the external reference must be (1) a member name or an alias of a module in the call library, and (2) defined as an external name in the external symbol dictionary of the module with that name. If the unresolved external reference is a member name or an alias in the library, but is not an external name in that member, the member is processed but the external reference remains unresolved unless subsequently defined.

The automatic library call mechanism searches the call library defined on the SYSLIB DD statement. The call library can contain either (1) object modules and control statements or (2) load modules; it must not contain both.

Modules from libraries other than the SYSLIB call library can be searched by the automatic library call mechanism as directed by the LIBRARY control statement. The library specified in the control statement is searched for member names that match specific external references that are unresolved at the end of input processing. If any unresolved references are found in the modules located by automatic library call, they are resolved by another search of the library. Any external references not specified on a LIBRARY control statement are resolved from the library defined on the SYSLIB DD statement.

In addition, two means exist to negate the automatic library call mechanism. The LIBRARY statement can be used to negate the automatic library call for selected external references unresolved after input processing; the NCAL option on the EXEC statement can be used to negate the automatic library call for all external references unresolved after input processing. Use of the LIBRARY control statement and the NCAL option are discussed after the SYSLIB DD statement that follows.

SYSLIB DD STATEMENT

If the automatic library call mechanism is to be used, the call library must be a partitioned data set described by a DD statement with a ddname of SYSLIB. The call library may be either a system call library or a private call library; call libraries may be concatenated.

System Call Library

Most of the system processing programs have their own automatic call library (Table 1). This library must be defined when an object module produced by that processor is to be link edited.

The call library may contain input/output, data conversion, and/or other special routines that are needed to complete the module. The processor creates an external reference for these special routines and the linkage editor resolves the references from the appropriate call library.

In the following example, a FORTRAN object module created in Step A is to be link edited in Step B, and the FORTRAN automatic call library is used to resolve external references:

```
Step A:  //SYSOBJ  DD   DSNAME=&&OBJMOD,DISP=(NEW,PASS),...
                    .
                    .
                    .
Step B:  //SYSLIN  DD   DSNAME=&&OBJMOD,DISP=(OLD,DELETE)
         //SYSLIB  DD   DSNAME=SYS1.FORTLIB,DISP=SHR
```

The disposition of SHR on the SYSLIB DD statement means that other tasks which may be executing concurrently with Step B may also use SYS1.FORTLIB.

Table 1. System Automatic Call Libraries

Processing Program	Library Name
ALGOL	SYS1.ALGLIB
COBOL	SYS1.COBLIB
FORTRAN	SYS1.FORTLIB
PL/I	SYS1.PL1LIB
Sort/Merge	SYS1.SORTLIB

Private Call Libraries

The SYSLIB DD statement can also describe a private, user-written library. In this case, the automatic library call mechanism searches the private library for unresolved external references. In the following example, unresolved external references are to be resolved from a private library named PVTPROG:

```
//SYSLIB    DD    DSNAME=PVTPROG,DISP=SHR,UNIT=2311,VOLUME=SER=PVT002
```

Concatenation of Call Libraries

System call libraries and private call libraries may be concatenated either to themselves, and/or to each other. When libraries are concatenated, they must all be either object module libraries or load module libraries; they may not be mixed.

If object modules from different system processors are to be link edited to form one load module, the call library for each must be defined. This is accomplished by concatenating the additional call libraries to the library defined on the SYSLIB DD statement. In the following example, a FORTRAN object module and a COBOL object module are to be link edited; the two system call libraries are concatenated as follows:

```
//SYSLIB   DD   DSNAME=SYS1.FORTLIB,DISP=SHR
//         DD   DSNAME=SYS1.COBLIB,DISP=SHR
```

System libraries are cataloged; no unit or volume information is needed.

A system call library and a private call library can also be concatenated in this way. For example, by adding the following statement to the two in the preceding example, the private call library PVTPROG, which is not cataloged, is concatenated to the two system call libraries:

```
//         DD   DSNAME=PVTPROG,DISP=SHR,UNIT=2311,VOLUME=SER=PVT002
```

Any external references not resolved from the two system libraries are resolved from the private library.

LIBRARY CONTROL STATEMENT

The LIBRARY control statement can be used to direct the automatic library call mechanism to a library other than that specified in the SYSLIB DD statement. Only external references listed on the LIBRARY statement are resolved in this way. All other unresolved external references are resolved from the library in the SYSLIB DD statement.

The LIBRARY statement can also be used to specify external references that are not to be resolved by the automatic library call mechanism. The LIBRARY statement specifies the duration of the nonresolution: either during the current linkage editor job step, called restricted no-call; or during this or any subsequent linkage editor job step, called never-call.

Examples of each use of the LIBRARY statement follow; a description of the format is given in "Linkage Editor Control Statement Summary."

Additional Call Libraries

If additional libraries are to be used to resolve specific references, the LIBRARY statement contains the ddname of a DD statement that describes the library. The LIBRARY statement also contains, in parentheses, the external references to be resolved from the library; i.e., the names of the members to be used from the library. If the unresolved external reference is not a member name in the specified library, the reference remains unresolved unless subsequently defined.

For example, two modules (DATE and TIME) from a system call library have been rewritten. The new modules are to be tested with the calling modules before they replace the old modules. Because the automatic library call mechanism would otherwise search the system call library (which is needed for other modules), a LIBRARY statement is used, as follows:

```
//SYSLIB   DD   DSNAME=SYS1.COBLIB,DISP=SHR
//TESTLIB  DD   DSNAME=TEST,DISP=(OLD,KEEP),...
//SYSLIN   DD   DSNAME=ACCTROUT,...
//         DD   *
  LIBRARY    TESTLIB(DATE,TIME)
/*
```

Two external references, DATE and TIME, are resolved from the library described on the TESTLIB DD statement. All other unresolved external references are resolved from the library described on the SYSLIB DD statement.

Restricted No-Call Function

The programmer can use the LIBRARY statement to specify those external references in the output module for which there is to be no library search during the current linkage editor job step. This is done by specifying the external reference(s) in parentheses without specifying a ddname. However, the reference remains unresolved and the linkage editor marks the module nonexecutable unless LET is specified on the EXEC statement.

For example, a program contains references to two large modules that are called from the automatic call library. One of the modules has been tested and corrected, the other is to be tested in this job step. Rather than execute the tested module again, the restricted no-call function is used to prevent automatic library call from processing the module as follows:

```
//         EXEC PGM=IEWL,PARM=LET
//SYSLIB   DD   DSNAME=PVTPROG,DISP=SHR,UNIT=2311,VOLUME=SER=PVT002
           .
           .
           .
//SYSLIN   DD   DSNAME=&&PAYROL,...
//         DD   *
  LIBRARY    (OVERTIME)
/*
```

As a result, the external reference to OVERTIME is not resolved by automatic library call.

Never-Call Function

The never-call function specifies those external references that are not to be resolved by automatic library call during this or any subsequent linkage editor job step. This is done by specifying an asterisk followed by the external reference(s) in parentheses. However, the reference remains unresolved and the linkage editor marks the module nonexecutable unless LET is specified on the EXEC statement.

For example, a certain part of a program is never executed, but it contains an external reference to a large module (CITYTAX) which is no longer used by this program. However, the module is in a call library needed to resolve other references. Rather than take up storage for a module that is never used, the never-call function is specified, as follows:

```
//          EXEC   PGM=IEWL,PARM=LET
//SYSLIB      DD   DSNAME=PVTPROG,DISP=SHR,UNIT=2311,VOLUME=SER=PVT002
              .
              .
              .
//SYSLIN    DD     DSNAME=TAXROUT,DISP=OLD,...
//          DD      *
  LIBRARY   *(CITYTAX)
/*
```

As a result, whenever program TAXROUT is executed, the external reference to CITYTAX is not resolved by automatic library call.

NCAL OPTION

When the NCAL option is specified, no automatic library call occurs to resolve external references that are unresolved after input processing. The NCAL option is similar to the restricted no-call function on the LIBRARY statement, except that the NCAL option negates automatic library call for all unresolved external references and restricted no-call negates automatic library call for selected unresolved external references. However, with NCAL, the output module is marked executable; with restricted no-call, the module is marked nonexecutable unless LET is specified.

The NCAL option is a special processing parameter that is specified on the EXEC statement as described in "No Automatic Library Call Option."

INCLUDED DATA SETS

The INCLUDE control statement requests the linkage editor to use additional data sets as input. These can be sequential data sets containing object modules and/or control statements, or members of partitioned data sets containing object modules and/or control statements, or load modules.

The INCLUDE statement specifies the ddname of a DD statement that describes the data set to be used as additional input. If the DD statement describes a partitioned data set, the INCLUDE statement also contains the name of each member to be used. See "Linkage Editor Control Statement Summary" for a detailed description of the format of the INCLUDE statement.

When an INCLUDE control statement is encountered, the linkage editor processes the module or modules indicated. Figure 10 shows the processing of an INCLUDE statement. In the illustration, the primary input data set is a sequential data set named OBJMOD which contains an INCLUDE statement. After processing the included data set, the linkage editor processes the next primary input item. The arrows indicate the flow of processing.

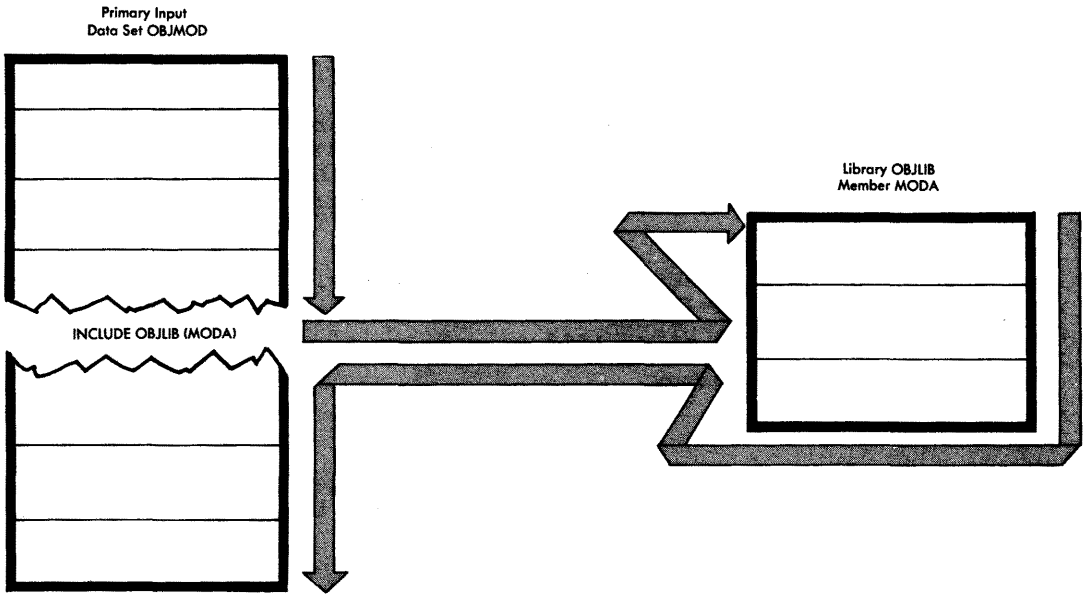


Figure 10. Processing of One INCLUDE Control Statement

If an included data set also contains an INCLUDE statement, this specified module is also processed. However, any data following the INCLUDE statement is not processed.

If the OBJMOD data set shown in Figure 10 is itself included, the data following the INCLUDE statement for OBJLIB is not processed. Figure 11 shows the flow of processing for this example.

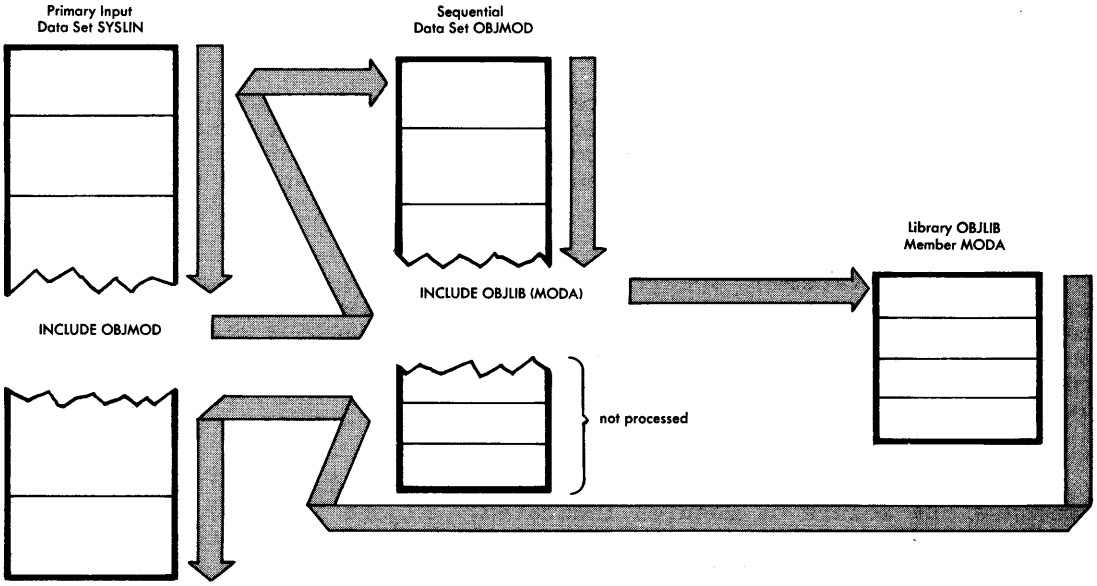


Figure 11. Processing of More than One INCLUDE Control Statement

Including Sequential Data Sets

Sequential data sets containing object modules and/or control statements can be specified by an INCLUDE control statement. In the following example, an INCLUDE statement specifies the ddnames of two sequential data sets to be used as additional input:

```
//ACCOUNTS  DD   DSNAME=ACCTROUT,DISP=(OLD,KEEP),...
//INVENTRY  DD   DSNAME=INVENTRY,DISP=(OLD,KEEP),...
//SYSLIN    DD   DSNAME=QTREND,...
//          DD   *
  INCLUDE ACCOUNTS,INVENTRY
/*
```

Each ddname could also have been specified on a separate INCLUDE statement; with either method, a DD statement must be specified for each ddname.

Another method of doing the preceding example is given in "Including Concatenated Data Sets."

Including Library Members

One or more members of a partitioned data set can be specified on an INCLUDE control statement. The member name must be specified on the INCLUDE statement; no member name should appear on the DD statement itself.

In the following example, one member name is specified on the INCLUDE statement:

```
//PAYROLL  DD   DSNAME=PAYROUTS,DISP=(OLD,KEEP),...
//SYSLIN   DD   DSNAME=&&CHECKS,DISP=(OLD,DELETE)
//         DD   *
  INCLUDE  PAYROLL(FICA)
/*
```

If more than one member of a partitioned data set is to be included, the INCLUDE statement specifies all the members to be used from each library. The member names are not repeated on the DD statement.

In the following example, an INCLUDE statement specifies two members from each of two libraries to be used as additional input:

```
//PAYROLL  DD   DSNAME=PAYROUTS,DISP=(OLD,KEEP),...
//ATTEND   DD   DSNAME=ATTROUTS,DISP=(OLD,KEEP),...
//SYSLIN   DD   *
  INCLUDE  PAYROLL(FICA,TAX),ATTEND(ABSENCE,OVERTIME)
/*
```

Each library could have been specified on a separate INCLUDE statement; with either method, a DD statement must be specified for each ddname.

Another method of doing this example is given in "Including Concatenated Data Sets."

Including Concatenated Data Sets

Several data sets can be designated as input with one INCLUDE statement that specifies one ddname; additional data sets are then concatenated to the data set described on the specified DD statement. When data sets are concatenated, all of the records must have the same characteristics (i.e., format, record length, block size, etc.).

Sequential Data Sets: In the following example, two sequential data sets are concatenated and then specified as input with one INCLUDE statement:

```
//CONCAT   DD   DSNAME=ACCTROUT,DISP=(OLD,KEEP),...
//         DD   DSNAME=INVENTRY,DISP=(OLD,KEEP),...
//SYSLIN   DD   DSNAME=SALES,DISP=OLD,...
//         DD   *
  INCLUDE   CONCAT
/*
```

When the INCLUDE statement is recognized, the contents of the sequential data sets ACCTROUT and INVENTRY are processed.

Library Members: Members from more than one library can be designated as input with one ddname on an INCLUDE statement. In this case, all the members are listed on the INCLUDE statement; the partitioned data sets are concatenated using the ddname from the INCLUDE statement:

```
//CONCAT    DD   DSNAME=PAYROUTS,DISP=(OLD,KEEP),...
//          DD   DSNAME=ATTROUTS,DISP=(OLD,KEEP),...
//SYSLIN    DD   DSNAME=REPORT,DISP=OLD,...
//          DD   *
  INCLUDE   CONCAT(FICA,TAX,ABSENCE,OVERTIME)
/*
```

When the INCLUDE statement is recognized, the two libraries PAYROUTS and ATTROUTS are searched for the four members; the members are then processed as input.

The linkage editor produces two types of output: a load module and diagnostic information. The principal output of the linkage editor is the output load module. The linkage editor always places this load module in a partitioned data set. In addition, the linkage editor issues diagnostic information. Error and/or warning messages, module disposition data, and optional diagnostic output are stored in the diagnostic output data set.

OUTPUT LOAD MODULE

The linkage editor produces one or more load modules from the input processed. When more than one load module is produced, the process is called multiple load module processing.

Whether or not the linkage editor produces one or more load modules, the following apply:

- The load module is stored in a partitioned data set called the output module library.
- The load module must have an entry point; if the programmer has not assigned one, the linkage editor does.
- During processing, the linkage editor reserves and collects common areas, as specified in the source language program.
- During processing, the linkage editor accumulates total length and individual displacements for each pseudo register (external dummy section).
- During processing, the linkage editor collects and records identification data in the CSECT Identification (IDR) records.

OUTPUT MODULE LIBRARY

The linkage editor stores every load module it produces in the output module library. This library is a partitioned data set that must be described by a DD statement with the name SYSLMOD. The data set name of the library is also specified on this DD statement. The data set can be either temporary (defined with a double ampersand), or permanent (defined without a double ampersand). If the data set name is either SYS1.LINKLIB or SYS1.SVCLIB, it would be advisable to re-IPL the system after linkage editor processing is complete. This ensures that the corresponding Data Extent Block (DEB) is updated to reflect additional extents if secondary allocation of direct access space was required.

Whether the data set is permanent or temporary, each module must be assigned a unique name, called the member name, to distinguish one load module from another. The output module can be assigned aliases if the programmer wants the module either identified by more than one name or entered for execution at several different points. Each member name and alias in a load module library must be unique. The library member name

and aliases for each load module appear as separate entries in the library directory, along with the module attributes. (Some module attributes can be assigned on the EXEC statement for each linkage editor job step; see "Module Attributes" in "Job Control Language Summary.")

Member Name

The member name of the output load module must be unique in the library. The member name must be specified either on the SYSLMOD DD statement or in a NAME control statement. Either method can also be used to replace an identically named member in the library. If the name is omitted, the linkage editor assigns a temporary member name (TEMPNAME) that may not be unique.

Assigned on SYSLMOD DD Statement: If the member name is assigned on the SYSLMOD DD statement, the name is written in parentheses following the data set name of the library. For example:

```
//SYSLMOD  DD   DSNAME=MATHLIB(SQDEV),DISP=(NEW,KEEP),UNIT=2311,
//              SPACE=(TRK,(100,10,1)),VOLUME=SER=LIB002
```

The member name SQDEV is assigned to the load module, which is placed in the new library named MATHLIB.

Assigned on NAME Control Statement: If the member name is not specified on the SYSLMOD DD statement, it must be assigned in a NAME control statement. For example:

```
//SYSLMOD  DD   DSNAME=MATHLIB,DISP=(NEW,KEEP),...
//SYSLIN   DD   DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//         DD   *
  NAME   SQDEV
/*
```

The member name SQDEV is assigned to the load module, which is placed in the library named MATHLIB.

Assigned on Both: If both the SYSLMOD DD statement and the NAME control statement specify a member name, the names should be identical. If the names are different, the name on the NAME control statement is used as the member name. If a temporary data set name was used on the SYSLMOD statement and the NAME statement specifies a different name, the member cannot be located for execution. For example:

```
//LKED     EXEC  PGM=IEWL
              .
              .
              .
//SYSLMOD  DD    DSNAME=&&LOADST(GO),DISP=(NEW,PASS),...
//SYSLIN   DD    DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//         DD    *
  NAME    READ
/*
//GO       EXEC  PGM=*.LKED.SYSLMOD
              .
              .
              .
```

The EXEC statement of the GO step specifies that the module to be executed is described in the LKED step in the SYSLMOD statement. The system tries to locate a member named GO; however, the output module was assigned the name READ.

Replacing an Identically Named Library Member: An output module can replace an identically named member in the library in either of two ways. The disposition field of the SYSLMOD statement contains OLD, as follows:

```
//SYSLMOD  DD   DSNAME=MATHLIB(SQDEV),DISP=(OLD,KEEP),...
```

Or, the NAME control statement specifies the replace function, as follows:

```
NAME       SQDEV(R)
```

In either case, the member named SQDEV is replaced with a new module of the same name.

Alias Names

An output module can be assigned a maximum of 16 aliases, specified with the ALIAS control statement. The aliases exist in addition to the member name of the output module. When a module is referred to by an alias, execution begins at the external name specified by the alias. If the name specified by the ALIAS statement is not an external symbol within the module, the main entry point is used.

For example, an output module is to be assigned two additional entry points, CODE1 and CODE2. In addition, due to a misunderstanding, calling modules have been written and tested using both ROUTONE and ROUT1 to refer to the output module. Rather than correct the calling modules, an alternate library member name (alias) is also assigned.

```
//SYSLMOD  DD   DSNAME=PVTLIB,DISP=OLD,UNIT=2314,
//              VOLUME=SER=LIB001
//SYSLIN   DD   DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//         DD   *
  ALIAS    CODE1,CODE2,ROUTONE
  NAME     ROUT1
/*
```

The names CODE1, CODE2, and ROUTONE appear in the library directory along with ROUT1, the member name. Because CODE1 and CODE2 are defined as external symbols within the output module, when these names are used, execution begins at these points. Control may be passed to the main entry point by using either the member name ROUT1 or the alias ROUTONE.

ENTRY POINT

Every load module must have a main entry point. The programmer may specify the entry point in one of two ways:

- On a linkage editor ENTRY control statement.
- On an assembler language END statement, which is the last statement in the source program. The assembler produces an object module and an END statement for the module. The assembler-produced END statement contains an entry point only if the source language END statement contained one.

From its input, the linkage editor selects the entry point for the load module as follows:

1. From the first ENTRY control statement in the input.
2. If there is no ENTRY control statement in the input, from the first assembler-produced END statement that specifies an entry point.
3. If no ENTRY control statement or no assembler-produced END statement specifies an entry point, the first byte of the first control section of the load module is used as the entry point.

In general, the entry point should be explicitly specified because it is not always possible to predict which control section will be first in the output module.

When a load module is reprocessed by the linkage editor, it has no END statement. Therefore, if the first byte of the first control section of the load module is not a suitable entry point, the entry point must be specified in one of two ways:

- Through an ENTRY control statement.
- Through the assembler-produced END statement of another input module, which is being processed for the first time. This object module must be the first such module to be processed by the linkage editor.

Entry points other than the main entry point may be specified with an ALIAS control statement. The symbol specified on the ALIAS statement must be defined as an external symbol in the load module. Any reference to that symbol causes execution of the module to begin at that point instead of the main entry point.

In the following example, assume that CDCHECK, CODE1, and CODE2 are defined as external symbols in the output module:

```
//SYSLIN    DD   DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//          DD   *
  ENTRY CDCHECK
  ALIAS CODE1,CODE2,ROUTONE
  NAME ROUT1
/*
```

As a result of the preceding control statements, CDCHECK is the main entry point; CODE1 and CODE2 are additional entry points. Any reference to ROUTONE or ROUT1 causes execution to begin at CDCHECK; any reference to CODE1 and CODE2 causes execution to begin at these points.

RESERVING STORAGE IN THE OUTPUT LOAD MODULE

In FORTRAN, assembler language, and PL/I, the programmer can create control sections that reserve main storage areas that contain no data or instructions. These control sections are called "common" or "static external" areas, and are produced in the object modules by the language translators. These common areas are used, for example, as communication regions for different parts of a program or to reserve main storage areas for data supplied at execution time. These common areas are either named or unnamed (blank).

Collection of Common Areas: During processing, the linkage editor collects common areas. That is, if two or more blank common areas are found in the input, the largest blank common area is used in the output module; all references to a blank common area refer to the one retained. If two or more named common areas have the same name, the largest of the identically named common areas is used in the output module; all references to the named common areas refer to the one area retained.

Identically Named Common Areas and Control Sections: If a control section (as is generated from a BLOCK DATA subprogram in FORTRAN, for example) and a named common area have the same name, the length of the control section must be greater than or equal to the length of the named common area. If the control section is smaller in length than the named common area, a diagnostic message is issued. The control section is regarded as the largest of the common areas processed with that name. All subsequent control sections and/or common areas with the same name are ignored.

PROCESSING PSEUDO REGISTERS

In PL/I, programmers can use pseudo registers to define storage that will not be reserved in the load module but can be allocated dynamically during execution. The external dummy sections generated by Assembler F or Assembler H correspond to the pseudo registers of PL/I.

The linkage editor accumulates the total length of all pseudo registers in the input and records the displacement of each. If two or more pseudo registers have the same name, the one with the longest length and the most restrictive alignment will be retained. All other pseudo registers with the same name will be ignored; all references to the identically named pseudo registers will refer to the one retained.

MULTIPLE LOAD MODULE PROCESSING

The linkage editor can produce more than one load module in a single job step. A NAME control statement in the input stream is used as a delimiter for input to a load module. If additional input modules follow the NAME statement in the input stream, they are used in the formation of the next load module.

Each load module that is formed has a unique name and is placed in the same library as a separate member. When processing multiple load modules in a single job step, the options and attributes specified in the EXEC statement for that job step apply to all load modules created. If the linkage editor terminates abnormally during processing of any of the output modules, neither that module nor any of the modules yet to be processed in the job step is processed or placed in the library. Load modules processed before abnormal termination have already been placed in the library.

The SYSLMOD DD statement should not specify a member name when a NAME control statement is used to specify the name of the first load module. However, if the SYSLMOD statement does specify a member name, the name must be identical to that specified in either the first NAME statement or an ALIAS statement for the first module. In either case, the NAME statement is regarded as the last item to be processed for the preceding load module.

In the following example, two load modules are produced in one linkage editor job step:

```
//LKED     EXEC  PGM=IEWL,PARM='MAP,LIST'
//SYSLMOD  DD    DSNAME=PAYROLL(OVERTIME),DISP=OLD,UNIT=2314,
//              VOLUME=SER=LIB002
//MODTWO   DD    DSNAME=&&OBJECT(B),DISP=(OLD,DELETE)
//SYSLIN   DD    DSNAME=&&OBJECT(A),DISP=(OLD,DELETE)
//         DD    *
  ENTRY    INIT
  NAME     OVERTIME
  INCLUDE  MODTWO
  ENTRY    HSKEEP
  NAME     VACATION
/*
```

The first load module is produced from the object module in the data set defined on the SYSLIN DD statement. The main entry point is INIT and the member name is OVERTIME.

The second load module is produced from the object module specified by the INCLUDE statement. The main entry point is HSKEEP and the member name is VACATION.

Both load modules are placed in the library PAYROLL, defined on the SYSLMOD statement. Note that the member name specified on the SYSLMOD statement is identical to the name given the first load module.

The parameters on the EXEC card specify that a module map and a control statement listing is produced for each load module. The map and listing are discussed in detail in the next section.

DIAGNOSTIC OUTPUT

Diagnostic information is stored in the diagnostic output data set, which must be defined by a DD statement with the name SYSPRINT. This output is a collection of messages generated by the linkage editor, as well as any optional output requested by the programmer.

DIAGNOSTIC MESSAGES

The linkage editor generates two types of messages: module disposition messages and error/warning messages.

Module Disposition Messages

Module disposition messages of several types are printed for each load module produced. The first message indicates the options and attributes specified for each module. Invalid options or attributes are replaced by INVALID in the output. Messages are also generated to inform the programmer that incompatible attributes have been specified.

Disposition messages also describe the handling of the load module. These messages are preceded by several asterisks, and are:

- member name NOW ADDED TO DATA SET.
- member name NOW REPLACED IN DATA SET.
- member name DOES NOT EXIST BUT HAS BEEN ADDED TO THE DATA SET.

  (The replacement function was specified, but the member did not exist in the data set; the module is added to the data set using the member name given.)

- alias name IS AN ALIAS FOR THIS MEMBER.
- MODULE HAS BEEN MARKED NOT EXECUTABLE.

In addition, module disposition messages are used when the re-enterable (RENT), reusable (REUS), and/or refreshable (REFR) linkage editor options have been specified for the module. When one or more of these module attributes has been indicated, a message informs the user what attribute(s) have been assigned to the module. This message indicates whether the load module has been marked re-enterable or not re-enterable, reusable or not reusable, refreshable or not refreshable, depending on the option or options used. (See "Reusablity Attributes" and "Refreshable Attribute" in the job control language summary section for more information on these options.)

The message consists of several asterisks and MODULE HAS BEEN MARKED, followed by the attribute(s) assigned as a result of the linkage editor options specified. The programmer, of course, is responsible for verifying that the module actually is re-enterable, reusable, and/or refreshable. The following messages are examples of some possible combinations:

- MODULE HAS BEEN MARKED REFRESHABLE.
- MODULE HAS BEEN MARKED NOT REFRESHABLE.
- MODULE HAS BEEN MARKED REUSABLE AND NOT REFRESHABLE.
- MODULE HAS BEEN MARKED REUSABLE AND REFRESHABLE.

When an error causes the linkage editor to mark a module not executable, only the MODULE HAS BEEN MARKED NOT EXECUTABLE message appears; no attribute messages are generated.

Error/Warning Messages

Certain conditions that are present when a module is being processed can cause an error or warning message to be printed. These messages contain a message code and message text. If an error is encountered during processing, the message code for that error is printed with the applicable symbol or record in error. After processing is completed, the diagnostic message associated with that code is printed. The error warning messages have the following format:

IEW0mms message text

where:

IEW0 indicates a linkage editor message
mm is the message number
s is the severity code, and may be one of the following values:

1 -- Indicates a condition that may cause an error during execution of the output module. A module map or cross-reference table is produced if specified by the programmer. The output module is marked executable.

2 -- Indicates an error that could make execution of the output module impossible. Processing continues. When possible, a module map or cross-reference table is produced if specified by the programmer. The output module is marked not executable unless the LET option is specified on the EXEC statement.

3 -- Indicates an error that will make execution of the output module impossible. Processing continues. When possible, a module map or cross-reference table is produced if specified by the programmer. The output module is marked not executable.

4 -- Indicates an error condition from which no recovery is possible. Processing terminates. The only output is diagnostic messages.

Note: A special severity code of zero is generated for each control statement printed as a result of the LIST option. Severity zero does not indicate an error or warning condition.

The highest severity code encountered during processing is multiplied by 4 to create a return code that is placed in register 15 at the end of processing. This return code can be tested to determine whether or not processing is to continue (see "Job Control Language Summary").

message text contains combinations of the following:

- The message classification (either error or warning).
- Cause of error.
- Identification of the symbol, segment number (when in overlay), or input item to which the message applies.
- Instructions to the programmer.
- Action taken by the linkage editor.

Optionally, error/warning messages can be sent to a separate output data set, which is defined by specifying TERM in the PARM field of the EXEC statement and including a SYSTERM DD statement. This separate SYSTERM data set consists of only numbered error/warning messages. It supplements the SYSPRINT output data set, which can also include module disposition messages and optional diagnostic output. When SYSTERM is used, the numbered error/warning messages appear in both data sets.

Appendix D contains a complete list of error/warning messages.

Sample Diagnostic Output

Figure 12 and Figure 13 show the format of the diagnostic output for the level E and level F linkage editor, respectively. No optional output was requested other than the list of control statements.

The letters indicate the disposition and error/warning messages as follows:

(A) Is a module disposition message that lists the options and attributes specified. For the level F linkage editor, additional information is printed indicating the variable and default options used.

(B) Is a list of control statements used (IEW0000) and the message codes (IEW0201 and IEW0461) for error/warning conditions discovered during processing. For error/warning message codes, the symbol in error, if necessary, is also listed (CCCCCCCC and BASEDUMP).

(C) Is a module disposition message (****) that indicates that the output module (BBBBBBBB) has been added to the output module data set.

(D) Is the diagnostic message directory that contains the text of the error codes listed in item (A).

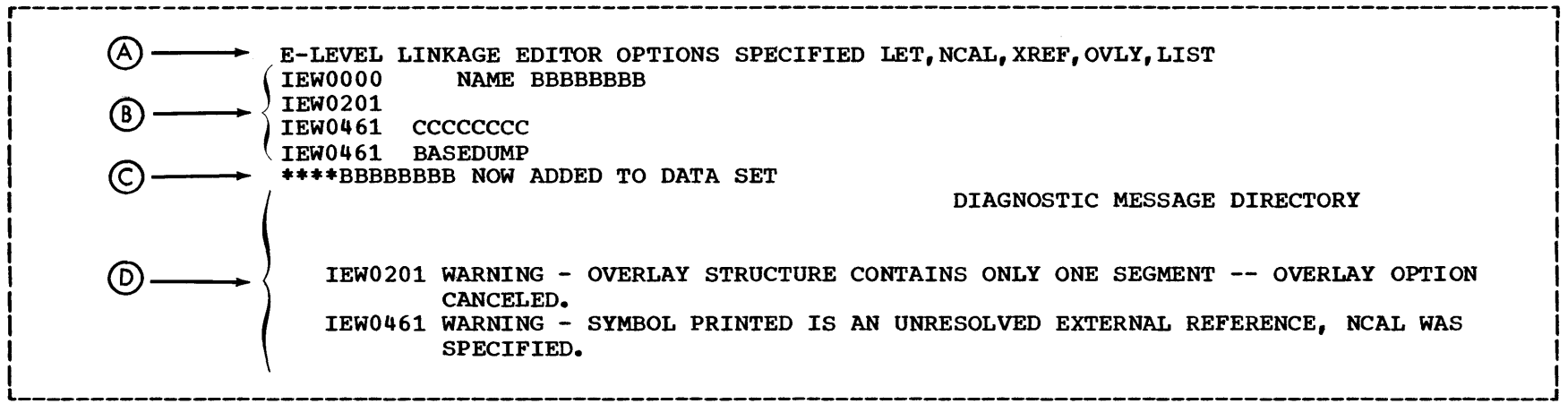


Figure 12. Diagnostic Messages for the Level E Linkage Editor

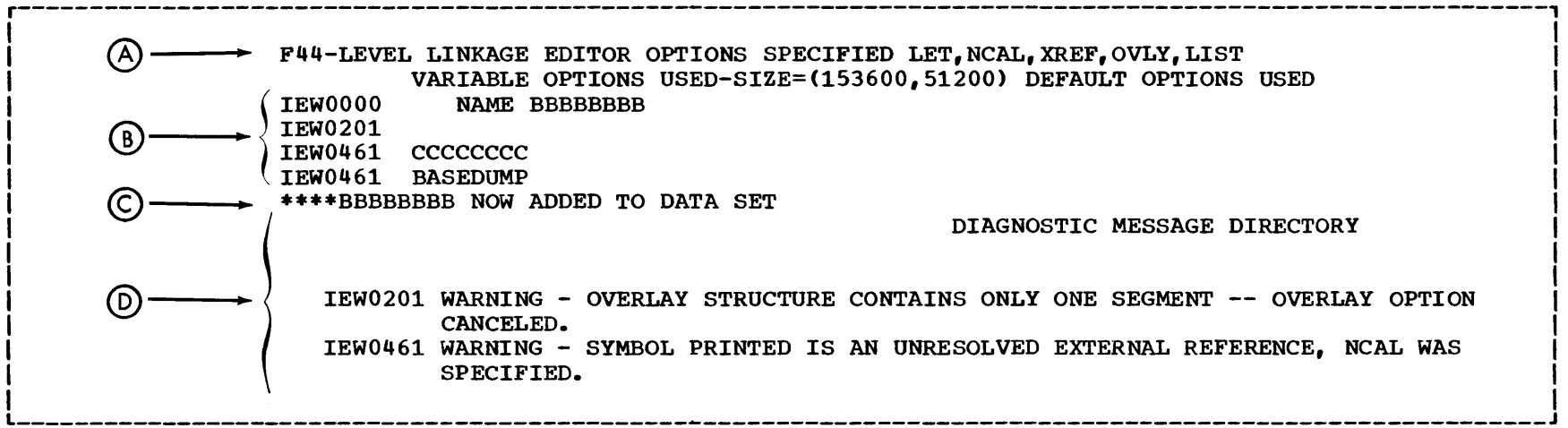


Figure 13. Diagnostic Messages for the Level F Linkage Editor

OPTIONAL OUTPUT

In addition to error/warning and disposition messages, the linkage editor can produce diagnostic output as requested by the programmer. This optional output includes a control statement listing, a module map, and a cross-reference table.

Control Statement Listing

If the LIST option is specified on the EXEC statement, a listing of all linkage editor control statements is produced. For each control statement, the listing contains a special message code, IEW0000, followed by the control statement. Item B in Figures 12 and 13 contains an example of a control statement listing.

Module Map

If the MAP option is specified on the EXEC statement, a module map of the output load module is produced. The module map shows all control sections in the output module and all entry names in each control section. Named common areas are listed as control sections.

For each control section, the module map indicates its origin (relative to zero) and length in bytes (in hexadecimal notation). For each entry name in each control section, the module map indicates the location at which the name is defined. These locations are also relative to zero.

If the module is not in an overlay structure, the control sections are arranged in ascending order according to their origins. An entry name is listed with the control section in which it is defined.

If the module is an overlay structure, the control sections are arranged by segment. The segments are listed as they appear in the overlay structure, top to bottom, left to right, and region by region. Within each segment, the control sections and their corresponding entry names are listed in ascending order according to their assigned origins. The number of the segment in which they appear is also listed.

In any module map, the following are identified by a dollar sign:

- Blank common area.
- Private code (unnamed control section).
- For overlay programs, the segment table and each entry table.

Each control section that is obtained from a call library during automatic library call is identified by an asterisk after the control section name.

At the end of the module map is the entry address, that is, the relative address of the main entry point. The entry address is followed by the total length of the module in bytes; in the case of an overlay module, the length is that of the longest path. Pseudo registers, if used, also appear at the end of the module map; the name, length, and displacement of each pseudo register is given.

Figure 14 contains a module map with five control sections. There are two named control sections (COBSUB and MAINMOD), one unnamed control section (designated by $PRIVATE), and two control sections obtained from a call library (ILBODSP0 and ILBOSTP0). In addition, two entry names are defined, SUB1 in the unnamed control section and ILBOSTP1 in control section ILBOSTP0.

Note: The IMBMDMAP program described in the OS Service Aids publication can also be used to obtain a module map.

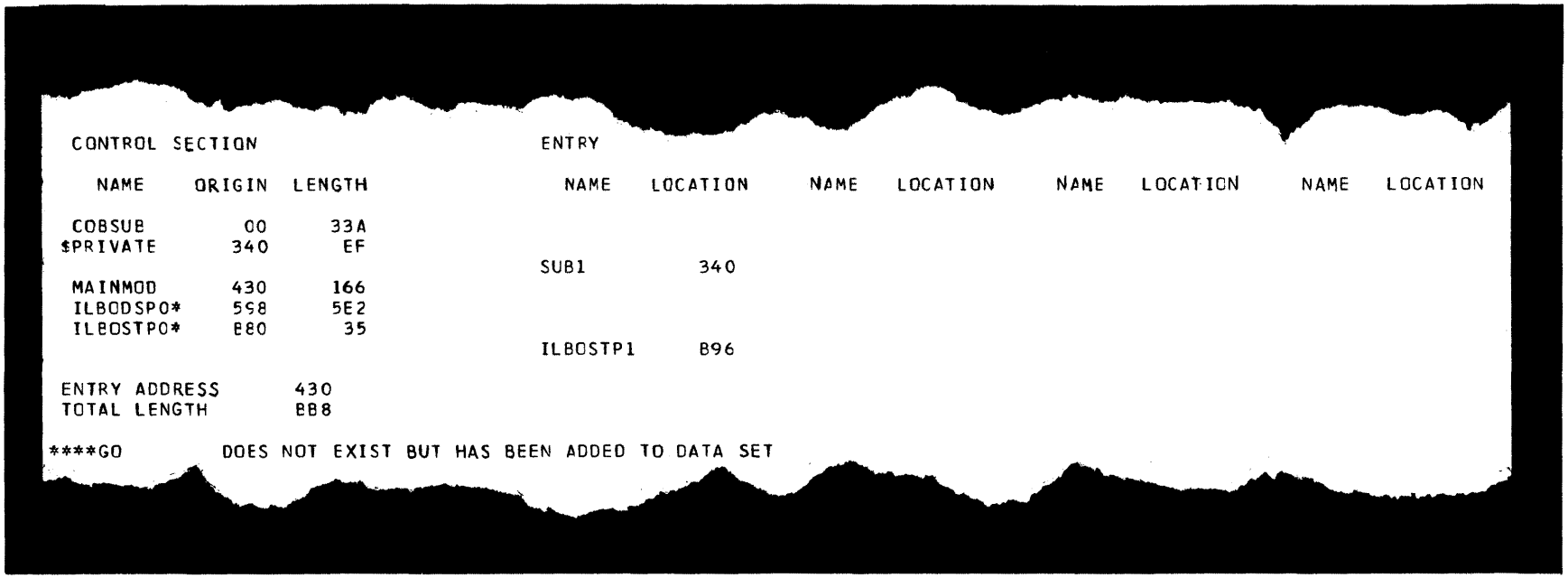
Cross-Reference Table

If the XREF option is specified on the EXEC statement, a cross-reference table is produced. The cross-reference table consists of a module map and a list of cross-references for each control section. Each address constant that refers to a symbol defined in another control section is listed with its assigned location, the symbol referred to, and the name of the control section in which the symbol is defined.

For overlay programs, this information is provided for each segment; in addition, the number of the segment in which the symbol is defined is provided.

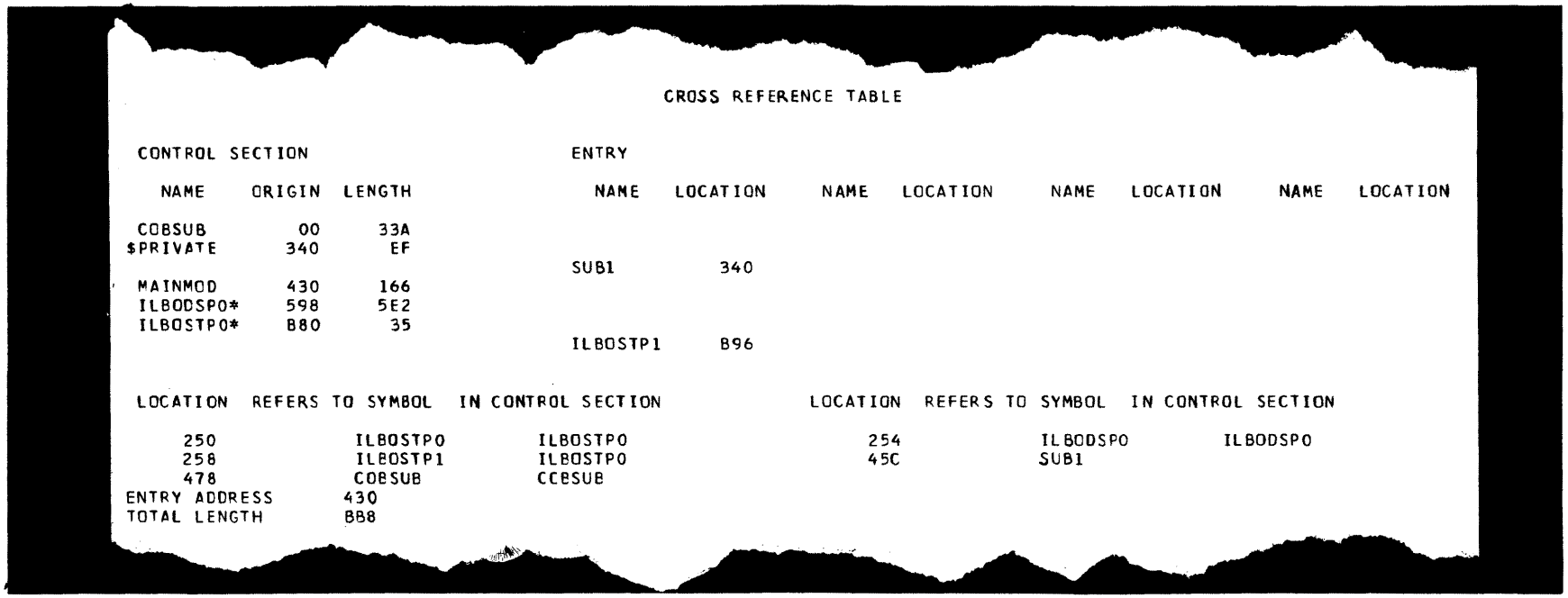
If a symbol is unresolved after processing by the linkage editor, it is identified by $UNRESOLVED in the list. However, if an unresolved symbol is marked by the never-call function (as specified on a LIBRARY control statement), it is identified by $NEVER-CALL. If an unresolved symbol is a weak external reference, it is identified by $UNRESOLVED(W).

Figure 15 contains a cross-reference table for the same program whose module map is shown in Figure 14. All of the information from the module map is present, plus a list of cross-references for each control section.



```
CONTROL SECTION                                ENTRY
  NAME     ORIGIN  LENGTH                      NAME    LOCATION     NAME    LOCATION     NAME    LOCATION     NAME    LOCATION
 COBSUB        00     33A
$PRIVATE      340      EF
                                               SUB1         340
 MAINMOD      430     166
 ILBODSP0*    598     5E2
 ILBOSTP0*    B80      35
                                               ILBOSTP1     B96
ENTRY ADDRESS      430
TOTAL LENGTH       BB8

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

Figure 14. Module Map



```
                                CROSS REFERENCE TABLE

CONTROL SECTION                                ENTRY
  NAME     ORIGIN  LENGTH                      NAME    LOCATION     NAME    LOCATION     NAME    LOCATION     NAME    LOCATION
 COBSUB        00     33A
$PRIVATE      340      EF
                                               SUB1         340
 MAINMOD      430     166
 ILBODSP0*    598     5E2
 ILBOSTP0*    B80      35
                                               ILBOSTP1     B96

 LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION          LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION
      250          ILBOSTP0       ILBOSTP0                  254          ILBODSP0       ILBODSP0
      258          ILBOSTP1       ILBOSTP0                  45C          SUB1
      478          COBSUB         CCBSUB
ENTRY ADDRESS      430
TOTAL LENGTH       BB8
```

Figure 15. Cross-Reference Table

The linkage editor performs editing functions either automatically or as directed by control statements. These editing functions provide for program modification on a control section basis. That is, they make it possible to modify a control section within an object or load module, without recompiling the entire source program.

The editing functions can modify either an entire control section or external symbols within a control section. Control sections can be deleted or replaced; external symbols can be deleted or changed. (External symbols are control section names, entry names, external references, named common areas, or pseudo registers.)

Whatever function is used, it is requested in reference to an input module. The resulting output load module reflects the request. That is, no actual change, deletion, or replacement is made to an input module. The requested alterations are used to control linkage editor processing (Figure 16).

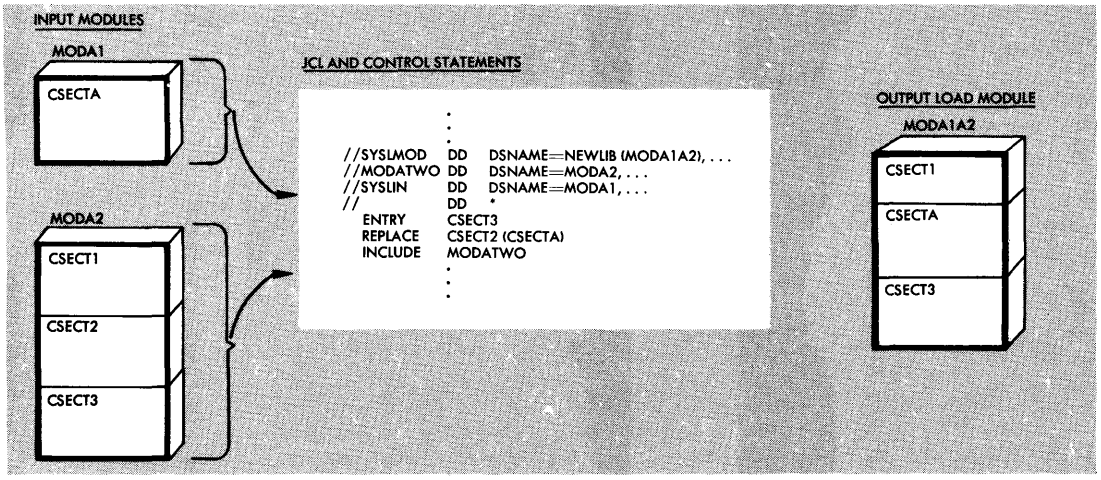


Figure 16. Editing a Module

Editing Conventions

In requesting editing functions, certain conventions should be followed to ensure that the specified modification is processed correctly. These conventions concern the following items:

- Entry points for the new module.
- Placement of control statements.
- Identical old and new symbols.

Entry Points: Each time the linkage editor reprocesses a load module, the entry point for the output module should be specified in one of two ways:

- Through an ENTRY control statement.
- Through the assembler-produced END statement of an input object module, if one is present. If the entry point specified in the assembler-produced END statement is not defined in the object module, the entry name must be defined as an external reference.

The entry point assigned must be defined as an external name within the resulting load module.

Placement of Control Statements: The control statement (CHANGE or REPLACE) used to specify an editing function must precede either the module to be modified, or the INCLUDE statement that specifies the module. If an INCLUDE statement specifies several modules, the CHANGE or REPLACE statement applies only to the first module included.

Identical Old and New Symbols: The same symbol should not appear as both an old external symbol and a new external symbol in one linkage editor run. If a control section is to be replaced by another control section with the same name, the linkage editor handles this automatically (see "Automatic Replacement").

CHANGING EXTERNAL SYMBOLS

The linkage editor can be directed to change an external symbol to a new symbol while processing an input module. External references and address constants within the module automatically refer to the new symbol. External references from other modules to a changed external symbol must be changed with separate control statements.

Both the old and the new symbols are specified on either a CHANGE control statement or a REPLACE control statement. The use of the old symbol within the module determines whether the new symbol becomes a control section name, an entry name, or an external reference. The old symbol appears first, followed by the new symbol in parentheses.

The CHANGE control statement changes a control section name, an entry name, or an external reference. The REPLACE statement changes or deletes an entry name; if the symbols on a REPLACE statement are control section names, the entire control section is replaced or deleted (see "Replacing Control Sections").

In the following example, assume that SUBONE is defined as an external reference in the input load module. A CHANGE statement is used to change the external reference to NEWMOD (Figure 17).

```
//SYSLMOD  DD   DSNAME=PVTLIB,DISP=OLD,UNIT=2311,VOLUME=SER=PVT002
//SYSLIN   DD   *
  ENTRY    BEGIN
  CHANGE   SUBONE(NEWMOD)
  INCLUDE  SYSLMOD(MAINROUT)
  NAME     MAINROUT(R)
/*
```

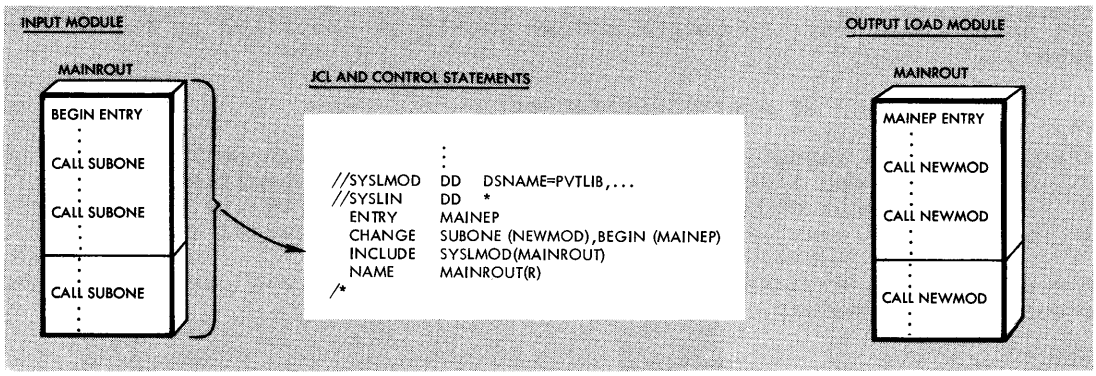


Figure 17. Changing an External Reference and an Entry Point

In the load module MAINROUT, every reference to SUBONE is changed to NEWMOD. Note also that the INCLUDE statement specifies a ddname of SYSLMOD. This allows a library to be used both as input and as the output module library.

More than one change can be specified on the same control statement. If, in the same example, the entry point is also to be changed, the two changes can be specified at once (Figure 17).

```
//SYSLMOD  DD   DSNAME=PVTLIB,DISP=OLD,UNIT=2311,VOLUME=SER=PVT002
//SYSLIN   DD   *
  ENTRY    MAINEP
  CHANGE   SUBONE(NEWMOD),BEGIN(MAINEP)
  INCLUDE  SYSLMOD(MAINROUT)
  NAME     MAINROUT(R)
/*
```

The main entry point is now MAINEP instead of BEGIN. The ENTRY control statement specifies the new entry point because this is the entry point that is entered in the library directory entry for the load module.

Both changes could also have been specified on the same REPLACE control statement.

REPLACING CONTROL SECTIONS

An entire control section can be replaced with a new control section. Control sections can be replaced either automatically or with a REPLACE control statement. Automatic replacement acts upon all input modules; the REPLACE statement acts only upon the module that follows it.

Note 1: Any CSECT Identification (IDR) records associated with a particular control section are also replaced.

Note 2: (For assembler language programmers only.) When some but not all control sections of a separately assembled module are to be replaced, A-type address constants that refer to a deleted symbol will be incorrectly resolved unless the entry name is at the same displacement from the origin in both the old and the new control section. If all control sections of a separately assembled module are replaced, no restrictions apply.

AUTOMATIC REPLACEMENT

Control sections are automatically replaced if both the old and the new control section have the same name. The first of the identically named control sections processed by the linkage editor is made a part of the output module. All subsequent identically named control sections are ignored; external references to identically named control sections are resolved with respect to the first one processed. Therefore, to cause automatic replacement, the new control section must have the same name as the control section to be replaced, and must be processed before the old control section.

Caution: Automatic replacement applies to duplicate control section names only; if duplicate entry points exist in control sections with different names, a REPLACE control statement must be used to specify the entry point name.

Note on overlay programs: When identically named control sections appear in modules being placed in an overlay structure, the second and any subsequent control sections with that name are ignored. This occurs whether the modules are in segments in the same path or in exclusive segments. Resolution of external references may therefore cause invalid exclusive references. Invalid exclusive references cause the linkage editor to mark the output module not executable unless the XCAL option is specified on the EXEC statement.

Example 1

An object module deck contains two control sections, READ and WRITE; member INOUT of library PVTLIB also contains a control section WRITE.

```
//SYSLMOD  DD   DSNAME=PVTLIB,DISP=OLD,UNIT=2311,VOLUME=SER=PVT002
//SYSLIN   DD   *
┌──────────────────────────────────────────────────────────────────┐
│ Object Deck for READ                                             │
├──────────────────────────────────────────────────────────────────┤
│ Object Deck for WRITE                                            │
└──────────────────────────────────────────────────────────────────┘
  ENTRY    READIN
  INCLUDE  SYSLMOD(INOUT)
  NAME     INOUT(R)
/*
```

The output load module contains the new READ control section, the new WRITE control section (replacing the old WRITE control section in member INOUT), and all remaining control sections from INOUT.

Example 2

A large load module named PAYROLL, originally written in COBOL, contains many control sections. Two control sections, FICA and STATETAX, were recompiled and passed to the linkage editor job step in the &&OBJECT data set. Then, by including the load module PAYROLL, a member of the partitioned data set LIB001, as well as the output of the language translator, the modified control sections automatically replace the identically named control sections (Figure 18).

```
//SYSLMOD   DD    DSNAME=LIB002(PAYROLL),DISP=OLD,UNIT=2314,
//                VOLUME=SER=LIB002
//SYSLIB    DD    DSNAME=SYS1.COBLIB,DISP=SHR
//OLDLOAD   DD    DSNAME=LIB001,DISP=(OLD,DELETE),UNIT=2314,
//                VOLUME=SER=LIB001
//SYSLIN    DD    DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//          DD    *
  INCLUDE   OLDLOAD(PAYROLL)
  ENTRY     INIT1
/*
```

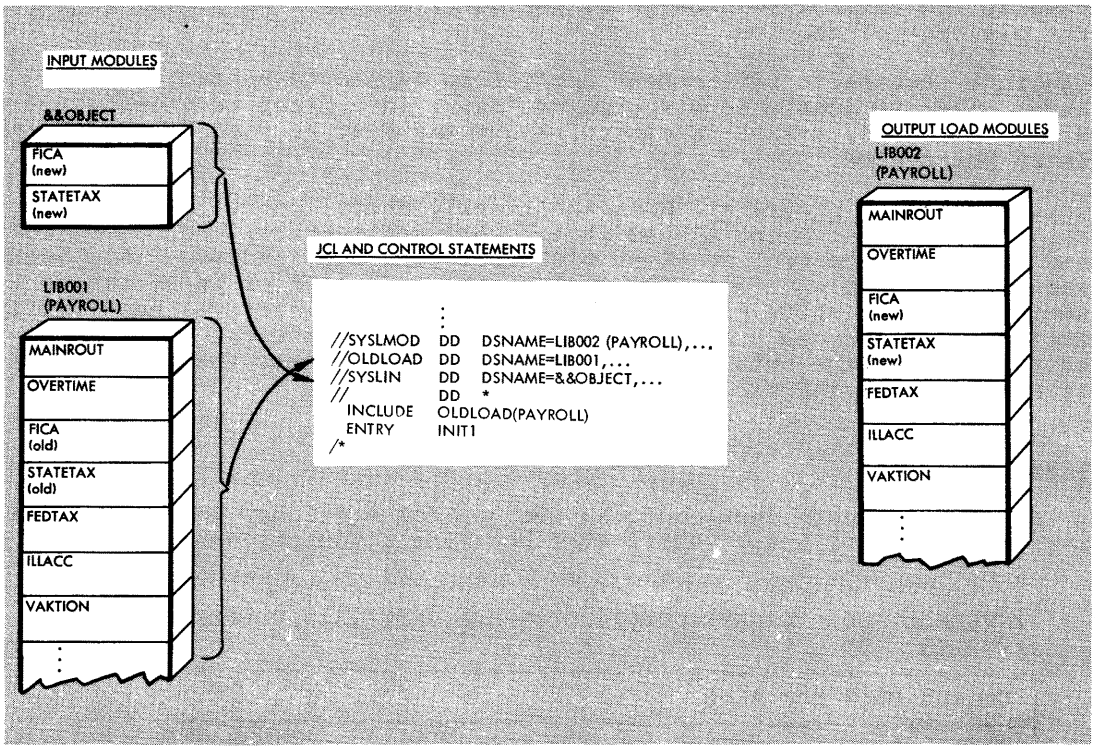


Figure 18. Automatic Replacement of Control Sections

The output module contains the modified FICA and STATETAX control sections and the rest of the control sections from the old PAYROLL module. The main entry point is INIT1, and the output module is placed in a library named LIB002. The COBOL automatic call library is used to resolve any external references that may be unresolved after the SYSLIN data sets are processed.

REPLACE STATEMENT

The REPLACE statement is used to replace control sections when the old and the new control sections have different names. The name of the old control section appears first, followed by the name of the new control section in parentheses. The REPLACE statement must immediately precede either the input module that contains the control section to be replaced, or the INCLUDE statement that specifies the input module.

An external reference to the old control section from within the same input module is resolved to the new control section. An external reference to the old control section from any other module becomes an unresolved external reference unless one of the following occurs:

- The external reference to the old control section is changed to the new control section with a separate CHANGE control statement.
- The same entry name appears in the new control section or in some other control section in the linkage editor input.

In the following example, the REPLACE statement is used to replace one control section with another of a different name. Assume that the old control section SEARCH is in library member TBLESRCH, and that the new control section BINSRCH is in the data set &&OBJECT, which was passed from a previous step (Figure 19).

```
//SYSLMOD  DD   DSNAME=SRCHRTN,DISP=OLD,UNIT=2311,
//              VOLUME=SER=SRCHLIB
//SYSLIN   DD   DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//         DD   *
  ENTRY    READIN
  REPLACE  SEARCH(BINSRCH)
  INCLUDE  SYSLMOD(TBLESRCH)
  NAME     TBLESRCH(R)
/*
```

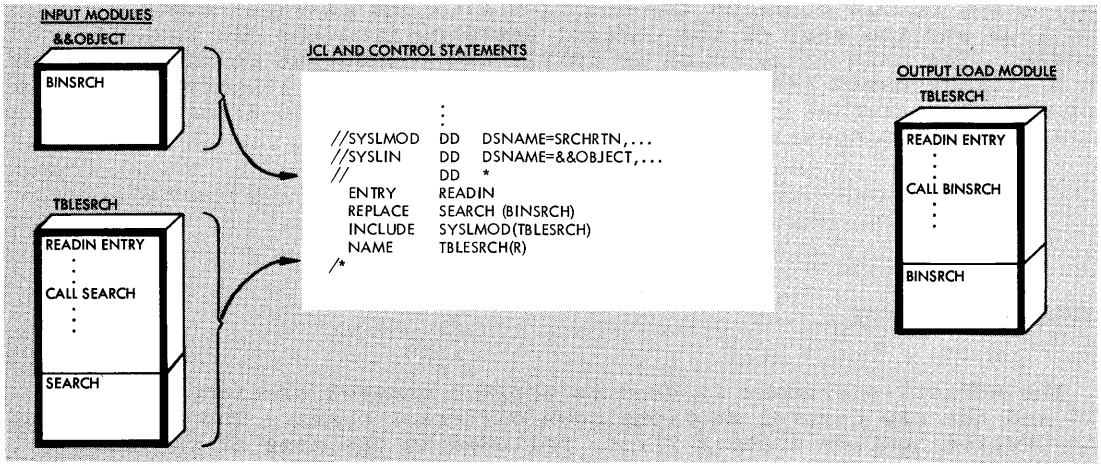


Figure 19. Replacing a Control Section with the REPLACE Control Statement

The output module contains BINSRCH instead of SEARCH; any references to SEARCH within the module refer to BINSRCH. Any external references to SEARCH from other modules will not be resolved to BINSRCH.

DELETING A CONTROL SECTION OR ENTRY NAME

The REPLACE statement can be used to delete a control section or an entry name. The REPLACE statement must immediately precede either the module that contains the control section or entry name to be deleted or the INCLUDE statement that specifies the module. Only one symbol appears on the REPLACE statement; the appropriate deletion is made depending on how the symbol is defined in the module.

If the symbol is a control section name, the entire control section is deleted. The control section name is deleted from the external symbol dictionary only if no address constants refer to the name from within the same input module. If an address constant does refer to it, the control section name is changed to an external reference.

The preceding is also true of an entry name to be deleted. Any references to it from within the input module cause the entry name to be changed to an external reference.

These editor-supplied external references, unless resolved with other input modules, cause the automatic library call mechanism to attempt to resolve them. Also, the deletion of a control section or an entry name may cause external references from other input modules to be unresolved. Either condition can cause the output load module to be marked not executable.

If a deleted control section contains an unresolved external reference, the reference remains.

Note: When a control section is deleted, any CSECT Identification data associated with that control section is also deleted.

In the following example, control section CODER is to be deleted (Figure 20).

```
//SYSLMOD  DD   DSNAME=PVTLIB,DISP=OLD,UNIT=2311,VOLUME=SER=PVT002
//SYSLIN   DD   *
  ENTRY    START1
  REPLACE  CODER
  INCLUDE  SYSLMOD(CODEROUT)
  NAME     CODEROUT(R)
/*
```

The control section CODER is deleted. If no address constants refer to CODER from other control sections in the module, the control section name is also deleted. If address constants refer to CODER, the name is retained as an external reference.

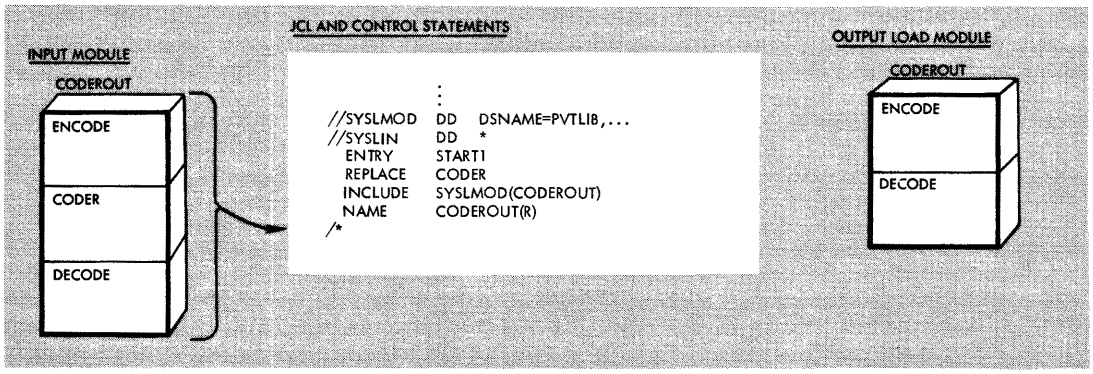


Figure 20. Deleting a Control Section

Ordinarily, when a load module produced by the linkage editor is executed, all of the control sections of the module remain in main storage throughout execution. The length of the load module is, therefore, the sum of the lengths of all of the control sections. When main storage space is not at a premium, this is the most efficient way to execute a program. However, if a program approaches the limits of the main storage available, the programmer should consider using the overlay facilities of the linkage editor.

In most cases, all that is needed to convert an ordinary program to an overlay program is the addition of control statements to structure the module. The programmer chooses the overlayable portions of the program, and the system arranges to load the required portions when needed during execution of the program.

When the linkage editor overlay facility is requested, the load module is structured so that, at execution time, certain control sections are loaded only when referenced. When a reference is made from an executing control section to another, the system determines whether or not the code required is already in main storage. If it is not, the code is loaded dynamically and may overlay an unneeded part of the module already in storage.

The rest of this chapter is divided into three sections that describe the design, specification, and special considerations for overlay programs.

DESIGN OF AN OVERLAY PROGRAM

The way in which an overlay module is structured depends on the relationships among the control sections within the module. Two control sections that do not have to be in storage at the same time can overlay each other. Such control sections are independent; that is, they do not reference each other either directly or indirectly. Independent control sections can be assigned the same load addresses and are loaded only when referenced. For example, control sections that handle error conditions or unusual data may be used infrequently, and need not be occupying storage unless in use.

Control sections are grouped into segments. A segment is the smallest functional unit (one or more control sections) that can be loaded as one logical entity during execution. The control sections required all of the time are grouped into a special segment called the root segment. This segment remains in storage throughout execution of an overlay program.

When a particular segment is to be executed, any segments between it and the root segment must also be in storage. This is a path. A reference from one segment to another segment lower in a path is a downward reference. That is, the segment contains a reference to another segment farther from the root segment. Conversely, a reference from one segment to another segment higher in a path (closer to the root segment) is an upward reference.

Therefore, a downward reference may cause overlay because the necessary segment may not yet be in main storage. An upward reference will not cause overlay because all segments between a segment and the root segment must be present in storage.

Sometimes several paths need the same control sections. This problem may be solved by placing the control sections in another region. In an overlay structure, a region is a contiguous area of main storage within which segments can be loaded independently of paths in other regions. An overlay program can be designed in single or multiple regions.

SINGLE REGION OVERLAY PROGRAM

To design an overlay structure, the programmer should select those control sections that will receive control at the beginning of execution, plus those that should always remain in main storage; these control sections form the root segment. The rest of the structure is developed by determining the dependencies of the remaining control sections and how they can use the same main storage locations at different times during execution.

Besides control section dependency, other topics discussed in this section are segment dependency, the length of the overlay program, segment origin, communication between segments, and overlay processing.

Control Section Dependency

Control section dependency is determined by the requirements of a control section for a given routine in another control section. A control section is dependent upon any control section from which it receives control, or which processes its data. For example, if control section C receives control from control section B, then C is dependent upon B. That is, both control sections must be in main storage before execution can continue beyond a given point in the program.

A program contains seven control sections, CSA through CSG, and exceeds the amount of storage available for its execution. Before the program is rewritten, it is examined to see whether or not it could be placed into an overlay structure. Figure 21 shows the groups of dependent control sections in the program (the arrows indicate dependencies).

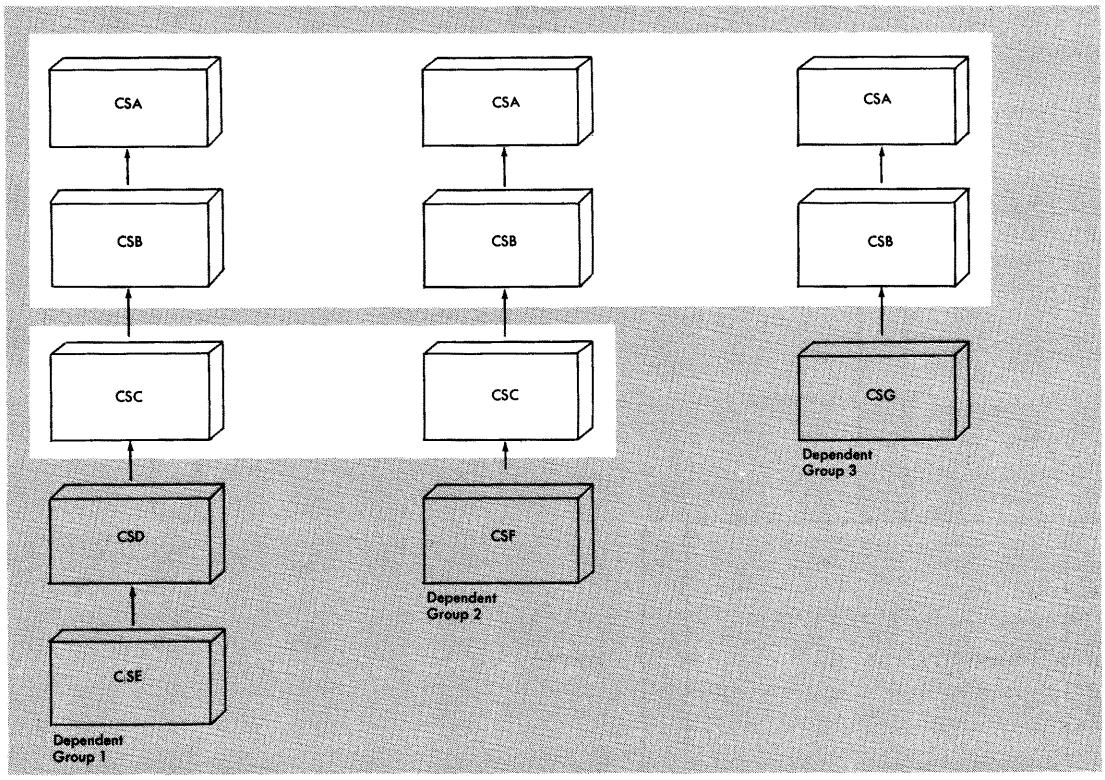


Figure 21. Control Section Dependencies

Each dependent group is also a path. That is, if control section CSG is to be executed, CSB and CSA must also be in storage. Because CSA and CSB are in each path, they must be in the root segment. Control section CSC is in two groups, and therefore is a common segment in two different paths.

A better way to show the relationship between segments is with a tree structure. A tree is the graphic representation that shows how segments can use main storage at different times. It does not imply the order of execution, although the root segment is the first to receive control. Figure 22 shows the tree structure for the dependent groups shown in Figure 21. The structure is contained in one region, and has five segments.

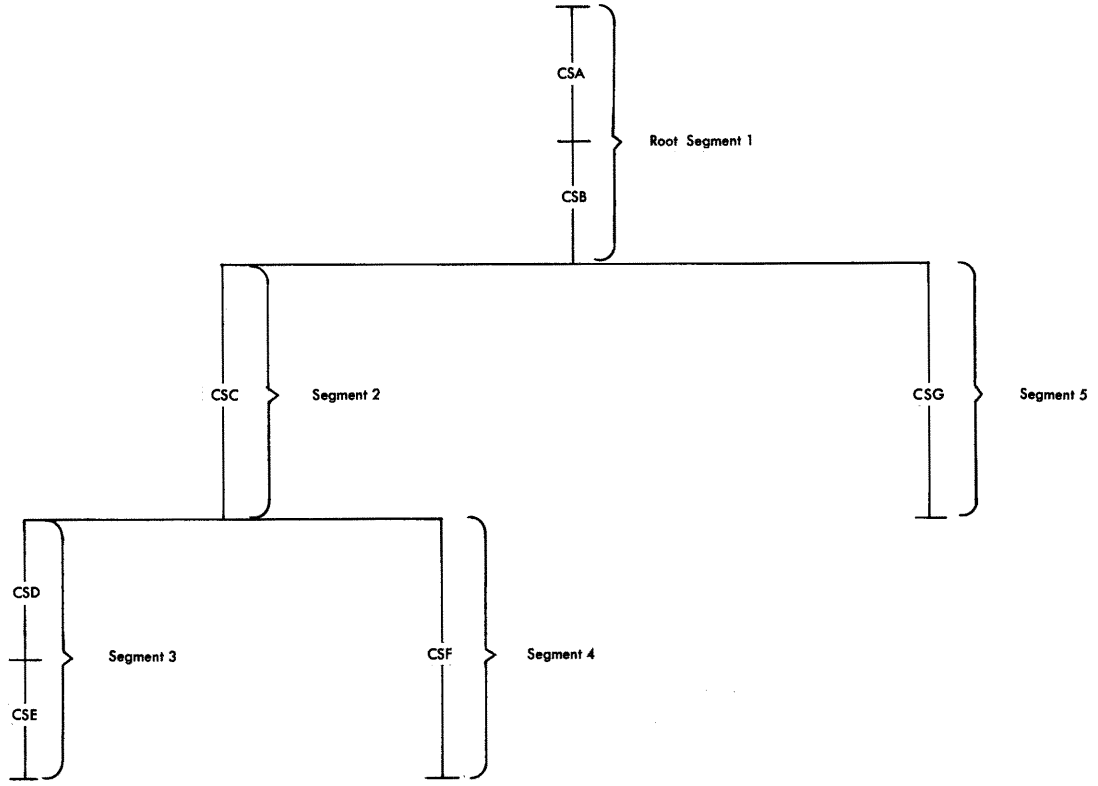


Figure 22. Single-Region Overlay Tree Structure

Segment Dependency

When a segment is in main storage, all segments in its path are also in main storage. Each time a segment is loaded, all segments in its path are loaded if they are not already in main storage. In Figure 22, when segment 3 is in main storage, segments 1 and 2 are also in main storage. However, if segment 2 is in storage, this does not imply that segment 3 or 4 is in main storage since neither segment is in the path of segment 2.

The position of the segments in an overlay tree structure does not imply the sequence in which the segments are executed. A segment can be loaded and overlaid as many times as required by the logic of the program. However, a segment will not be overlaid by itself. If a segment is modified during execution, that modification remains only until the segment is overlaid.

Length of an Overlay Program

For purposes of illustration, assume that the control sections in the sample program have the following lengths:

Control Section	Length (in bytes)
CSA	3,000
CSB	2,000
CSC	6,000
CSD	4,000
CSE	3,000
CSF	6,000
CSG	8,000

If the program were not in overlay, it would require 32,000 bytes of main storage. In overlay, however, the program requires the amount of storage needed for the longest path. In this structure, the longest path is formed by segments 1, 2, and 3, since, when they are all in storage, they require 18,000 bytes as shown in Figure 23.

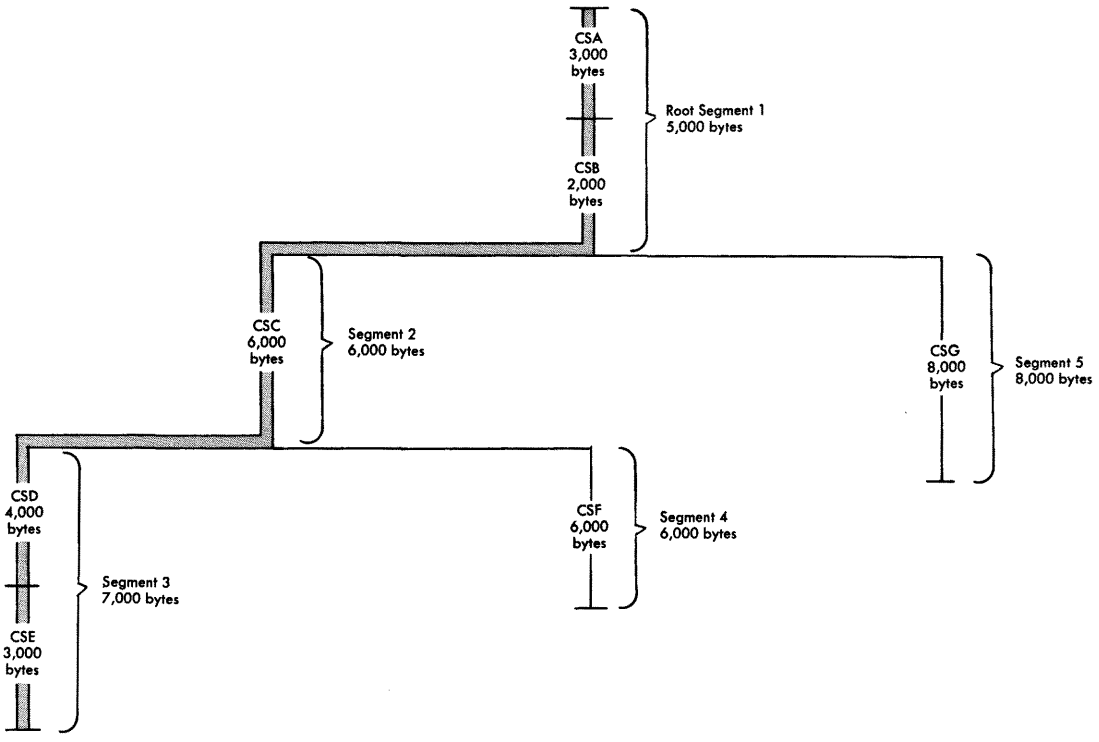


Figure 23. Length of an Overlay Module

Note, however, that the length of the longest path is not the minimum requirement for an overlay program; when a program is in overlay, certain tables are used, and their storage requirements must also be considered. The storage required by these tables is given in the section "Special Considerations."

Segment Origin

The linkage editor assigns the relocatable origin of the root segment (the origin of the program) at 0. The relative origin of each segment is determined by 0 plus the length of all segments in the path. For example, the origin of segments 3 and 4 is equal to 0 plus 6,000 (the length of segment 2) plus 5,000 (the length of the root segment), or 11,000. The origins of all the segments are as follows:

Segment	Origin
1	0
2	5,000
3	11,000
4	11,000
5	5,000

The segment origin is also called the load point, because it is the relative location at which the segment is loaded.

Figure 24 shows the segment origin for each segment and the way storage is used by the sample program. In the illustration, the vertical bars indicate segment origin; any two segments with the same origin may use the same storage area. Figure 24 also shows that the longest path is that of segments 1, 2, and 3.

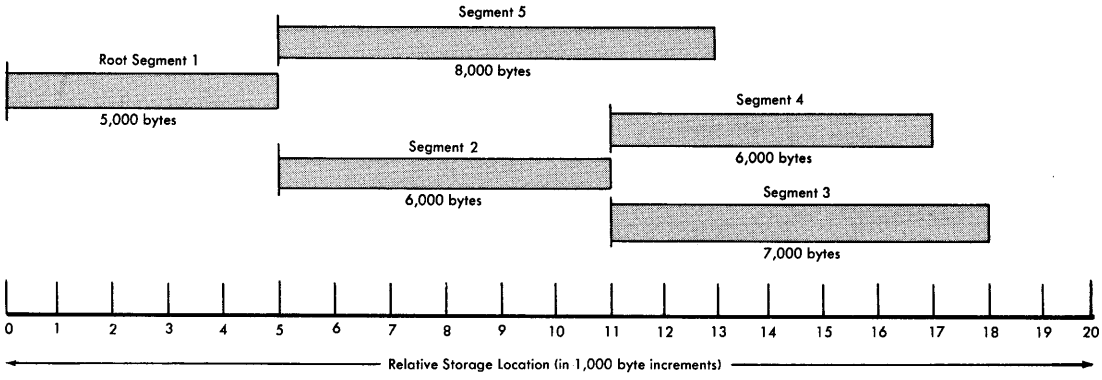


Figure 24. Segment Origin and Use of Storage

Communication Between Segments

Segments that can be in main storage simultaneously are considered to be inclusive. Segments in the same region but not in the same path are considered to be exclusive; they cannot be in main storage simultaneously. Figure 25 shows the inclusive and exclusive segments in the sample program.

Segments upon which two or more exclusive segments are dependent are called common segments. A segment common to two other segments is part of the path of each segment. In Figure 25 segment 2 is common to segments 3 and 4, but not to segment 5.

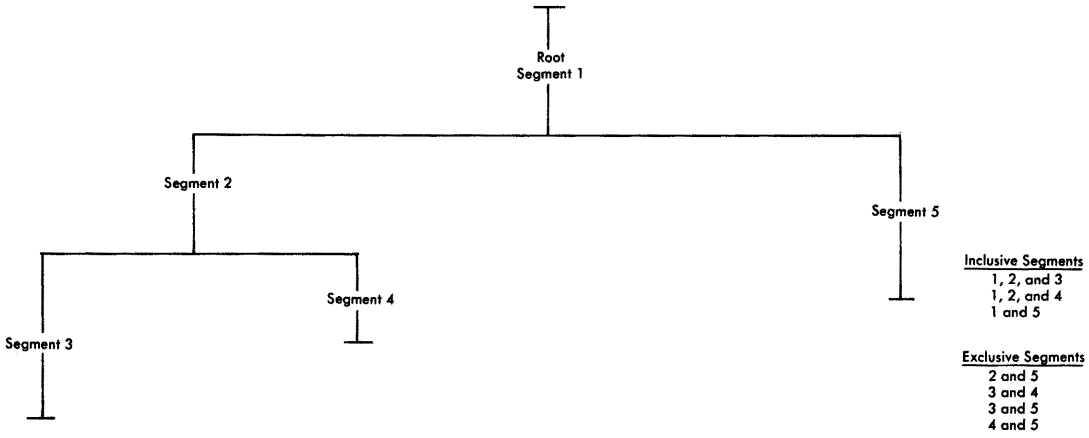


Figure 25. Inclusive and Exclusive Segments

An inclusive reference is a reference between inclusive segments; that is, a reference from a segment in storage to an external symbol in a segment that will not cause overlay of the calling segment. An exclusive reference is a reference between exclusive segments; that is, a reference from a segment in storage to an external symbol in a segment that will cause overlay of the calling segment.

Figure 26 shows the difference between an inclusive reference and an exclusive reference; the arrows indicate references between segments.

Inclusive References: Wherever possible, inclusive references should be used instead of exclusive references. Inclusive references between segments are always valid and do not require special options. When inclusive references are used, there is also less chance for error in structuring the overlay program correctly.

Exclusive References: An exclusive reference is made when the external reference in the requesting segment is to a symbol defined in a segment not in the path of the requesting segment. Exclusive references are either valid or invalid.

An exclusive reference is valid only if there is also a reference to the requested control section in a segment common to both the segment to be loaded and the segment to be overlaid. The same symbol must be used in both the common segment and the exclusive reference. In Figure 26, a reference from segment B to segment A is valid, because there is an inclusive reference from the common segment to segment A. (An entry table in the common segment contains the address of segment A; the overlay does not destroy this table.)

In the same illustration, a reference from segment A to segment B is invalid because there is no reference from the common segment to segment B. A reference from segment A to segment B can be made valid by including, in the common segment, an external reference to the symbol used in the exclusive reference to segment B.

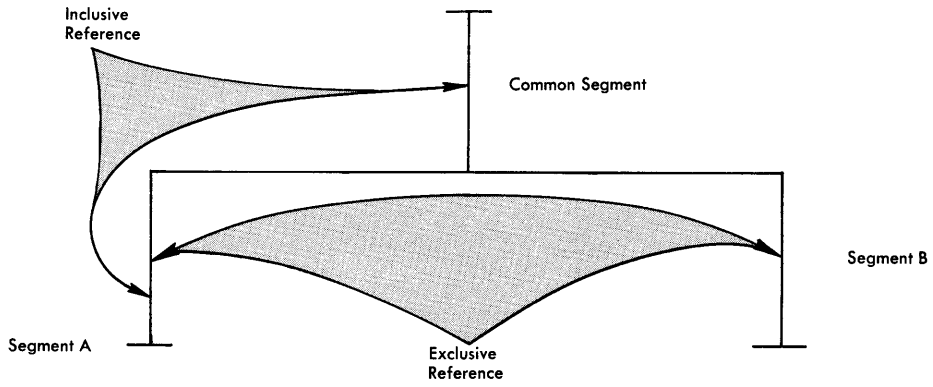


Figure 26. Inclusive and Exclusive References

Another way to eliminate exclusive references is to arrange the program so that the references that will cause overlay are made in a higher segment. For example, the programmer could eliminate the exclusive reference shown in Figure 26 by writing a new module to be placed in the common segment; the new module's only function would be to reference segment B. He would then change the code in segment A to refer to the new module instead of to segment B. Control then would pass from segment A to the common segment, where the overlay of segment A by segment B would be initiated.

If either valid or invalid exclusive references appear in the program, the linkage editor considers them errors unless one of the special options is used. These options are described later in this section.

Notes:

- During the execution of a program written in a higher level language such as FORTRAN, COBOL, or PL/I, an exclusive call results in abnormal termination of the program if the requested segment attempts to return control directly to the invoking segment that has been overlaid.
- If a program written in COBOL includes a segment that contains a reference to a COBOL class test or TRANSFORM table, the segment containing the table must be either (1) the root segment or (2) a segment that is higher in the same path than the segment containing the reference to the table.

Overlay Process

The overlay process is initiated during execution of a program only if a control section in main storage references a control section not in storage. The control program determines the segment that the referenced control section is in and, if necessary, loads the segment. When a segment is loaded, it overlays any segment in storage with the same relative origin. Any segments in storage that are lower in the path of the overlaid segment are also overlaid. An exclusive reference can also cause segments higher in the path to be overlaid. If a control section in storage references a control section in another segment already in storage, no overlay occurs.

The portion of the control program that determines when overlay is to occur is the overlay supervisor, which uses special tables to determine when overlay is necessary. These tables are generated by the linkage editor, and are part of the output load module. The special tables are the segment table and the entry table(s). Figure 27 shows the location of the segment and entry tables in the sample program.

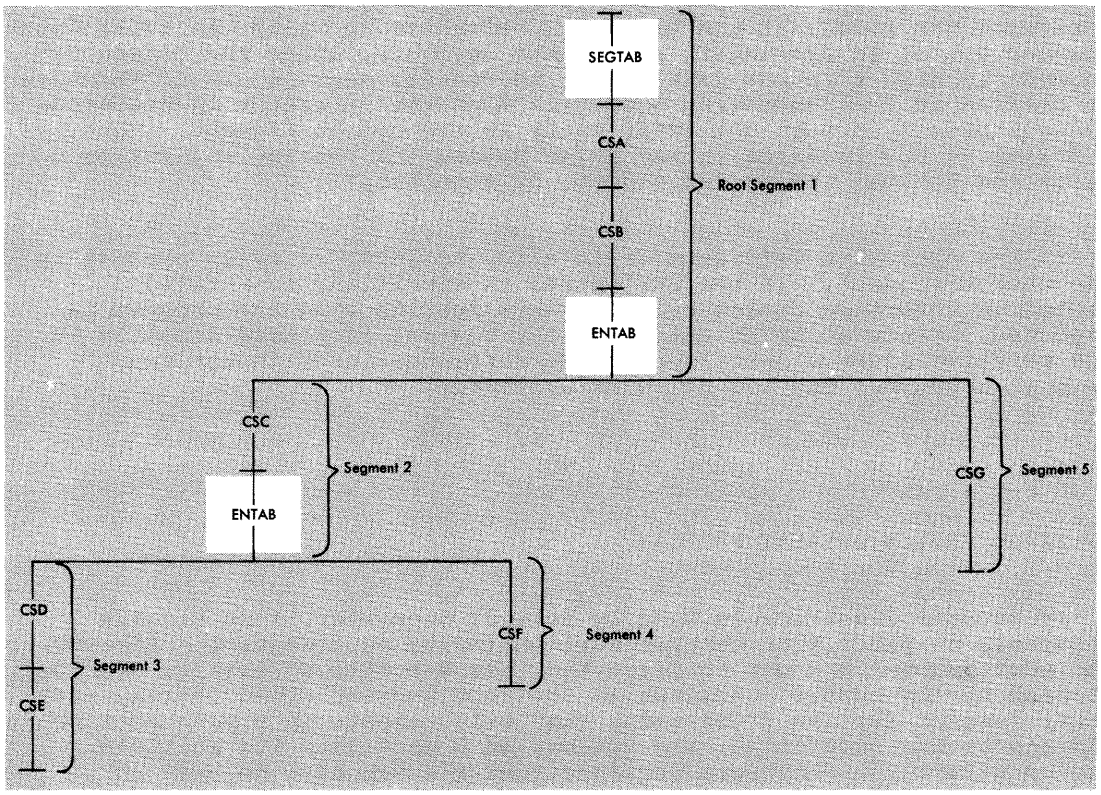


Figure 27. Location of Segment and Entry Tables in an Overlay Module

Because the tables are present in every overlay module, their size must be considered when planning the use of main storage. The storage requirements for the tables are given in "Special Considerations." A more detailed discussion of the segment and entry tables follows.

Segment Table: Each overlay program contains one segment table (SEGTAB); this table is the first control section in the root segment. The segment table contains information about the relationship of the segments and regions in the program. During execution, the table also indicates which segments are either in storage or being loaded, and other control information.

Entry Table: Each segment that is not the last segment in a path may contain one entry table (ENTAB); this table, when present, is the last control section in a segment.

When overlay will be required, an entry in the table is created for a symbol to which control is to be passed, provided (1) the symbol is used as an external reference in the requesting segment, and (2) the symbol is defined in another segment either lower in the path of the requesting segment, or in another region. An ENTAB entry is not created for any

symbol already present in an entry table closer to the root segment (higher in the path), or for a symbol defined higher in the path. (A reference to a symbol higher in the path does not have to go through the control program because no overlay is required.)

If an external reference and the symbol to which it refers are in segments not in the same path but in the same region, an exclusive reference was made. If the exclusive reference is valid, an ENTAB entry for the symbol is present in the common segment. Since the common segment is higher in the path of the requesting segment, no ENTAB entry is created in the requesting segment. When the reference is executed, control passes through the ENTAB entry in the common segment. That is, a branch to the location in the ENTAB causes the overlay supervisor to be called to load the needed segment or segments.

If the exclusive reference is invalid, no ENTAB entry is present in the common segment. If the LET option is specified, an invalid exclusive reference causes unpredictable results when the program is executed. Since no ENTAB entry exists, control is passed directly to the relative address specified in the reference, even though the requested segment may not be in main storage.

MULTIPLE REGION OVERLAY PROGRAM

If a control section is used by several segments, it is usually desirable to place that control section in the root segment. However, the root segment can get so large that the benefits of overlay are lost. If some of the control sections in the root segment could overlay each other (except for the requirement that all segments in a path must be in storage at the same time), the job may be a candidate for multiple region structure. Multiple region structures can also be used to increase segment loading efficiency: processing can continue in one region while the next path to be executed is being loaded into another region.

With multiple regions, a segment has access to segments that are not in its path. Within each region, the rules for single region overlay programs apply, but the regions are independent of each other. A maximum of four regions can be used.

Figure 28 shows the relationship between the control sections in the sample program and two new control sections, CSH and CSI. The two new control sections are each used by two other control sections in different paths. Placing CSH and CSI in the root segment makes the segment larger than necessary because CSH and CSI can overlay each other. The two control sections should not be duplicated in two paths because the linkage editor automatically deletes the second pair and an invalid exclusive reference may then result.

If however, the two control sections are placed in another region, they can be in storage when needed, regardless of the path being executed in the first region. Figure 29 shows all of the control sections in a two-region structure. Either path in region 2 can be in main storage regardless of the path being executed in region 1; segments in region 2 can cause segments in region 1 to be loaded without being overlaid themselves.

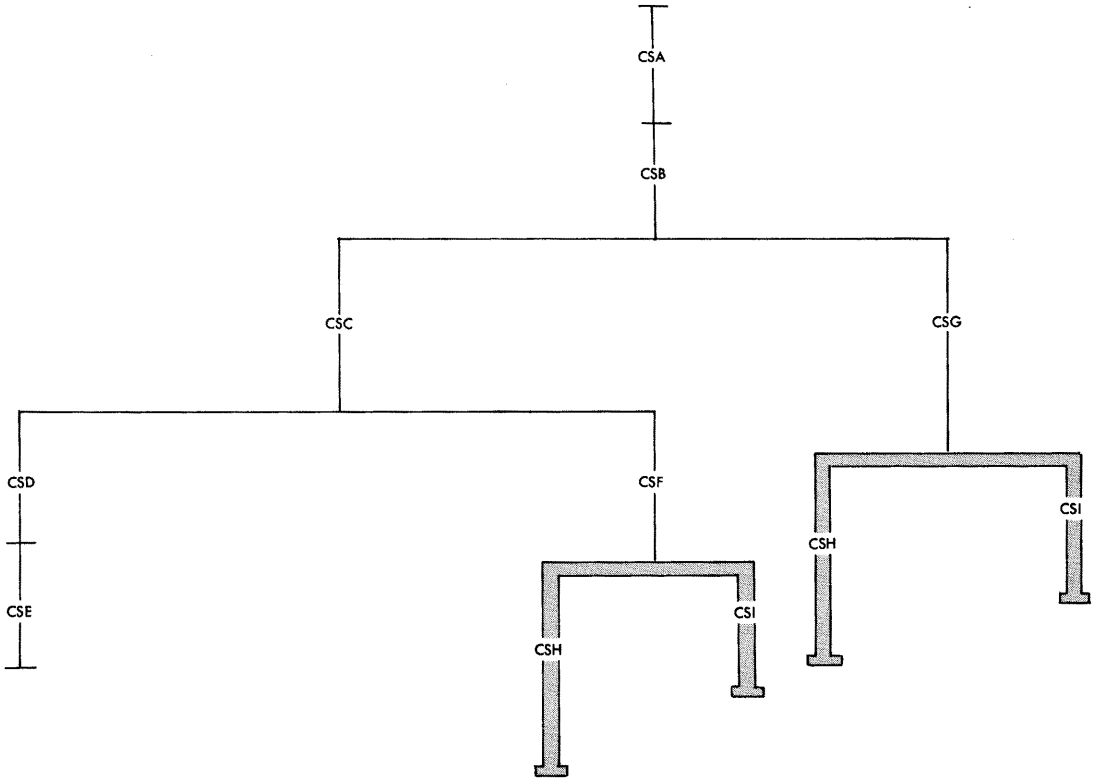


Figure 28. Control Sections Used by Several Paths

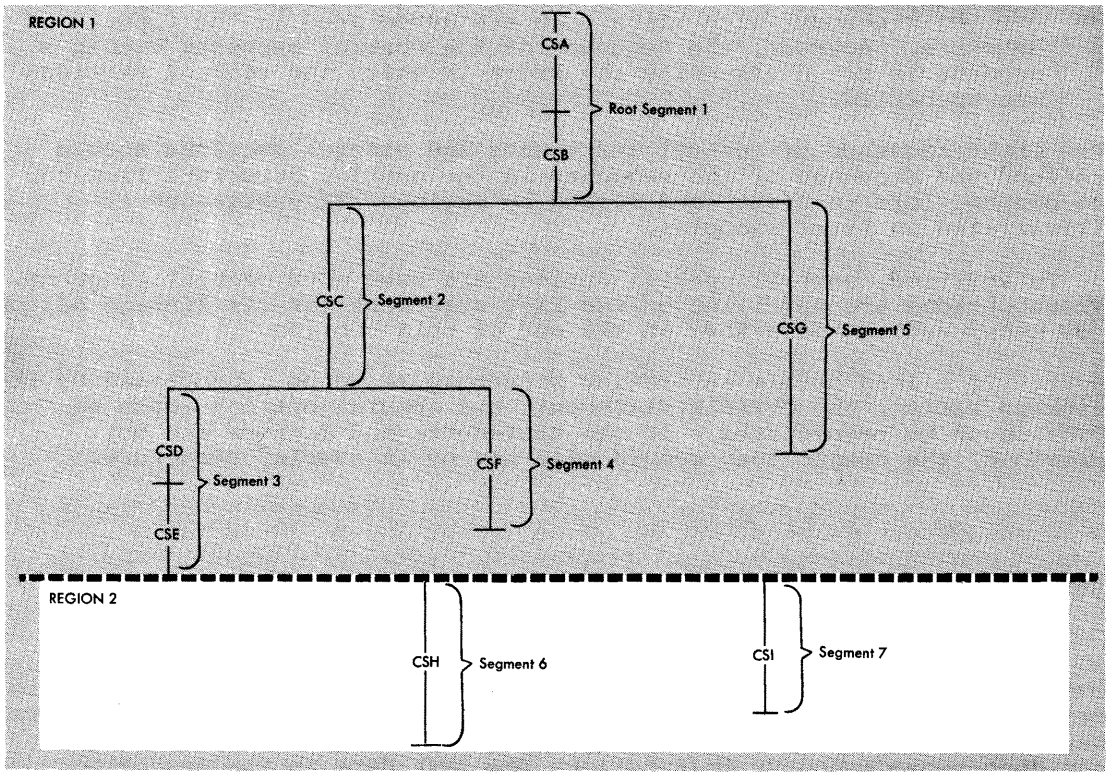


Figure 29. Overlay Tree for Multiple-Region Program

The relative origin of a second region is determined by the length of the longest path in the first region (18,000 bytes). Region 2, therefore, begins at 0 plus 18,000 bytes. The relative origin of a third region would be determined by the length of the longest path in the first region plus the longest path in the second region.

The main storage required for the program is determined by adding the lengths of the longest path in each region. In Figure 29, if CSH is 4,000 bytes and CSI is 3,000 bytes, the storage required is 22,000 bytes, plus the storage required by the special overlay tables.

SPECIFICATION OF AN OVERLAY PROGRAM

Once the programmer has designed an overlay structure, he must place the module in that structure by indicating to the linkage editor the relative positions of the segments and regions, and the control sections in each segment. Positioning is accomplished as follows:

- Segments are positioned by OVERLAY statements. Since segments are not named, the programmer identifies a segment by giving its origin (or load point) a symbolic name and then uses that name in an OVERLAY statement to specify a symbolic origin. Each OVERLAY statement begins a new segment.

- Regions are also positioned by OVERLAY statements. The programmer specifies the origin of the first segment of the region, followed by the word REGION in parentheses.

- Control sections are positioned in the segment specified by the OVERLAY statement with which they are associated in the input sequence. However, the sequence of the control sections within a segment is not necessarily the order in which the control sections are specified.

The input sequence of control statements and control sections should reflect the sequence of the segments in the overlay structure from top to bottom, left to right, and region by region. This sequence is illustrated in later examples.

In addition, several special options are used with overlay programs. These options are specified on the EXEC statement for the linkage editor job step, and are described at the end of this section.

Note: If a load module in overlay structure is to be reprocessed by the linkage editor, the OVERLAY statements and special options (such as OVLY) must be respecified. If the statements and options are not provided, the output load module will not be in overlay structure.

SEGMENT ORIGIN

The symbolic origin of every segment, other than the root segment, must be specified with an OVERLAY statement. The first time a symbolic origin is specified, a load point is created at the end of the previous segment. That load point is logically assigned a relative address at the doubleword boundary that follows the last byte in the preceding segment. Subsequent use of the same symbolic origin indicates that the next segment is to have its origin at the same load point.

In the sample single-region program, the symbolic origin names ONE and TWO are assigned to the two necessary load points, as shown in Figure 30. Segments 2 and 5 are at load point ONE, segments 3 and 4 are at load point TWO.

The following sequence of OVERLAY statements will result in the structure in Figure 30 (the control sections in each segment are indicated by name):

```
Control section CSA
Control section CSB
OVERLAY ONE
Control section CSC
OVERLAY TWO
Control section CSD
Control section CSE
OVERLAY TWO
Control section CSF
OVERLAY ONE
Control section CSG
```

Note that the sequence of OVERLAY statements reflects the order of segments in the structure from top to bottom and left to right.

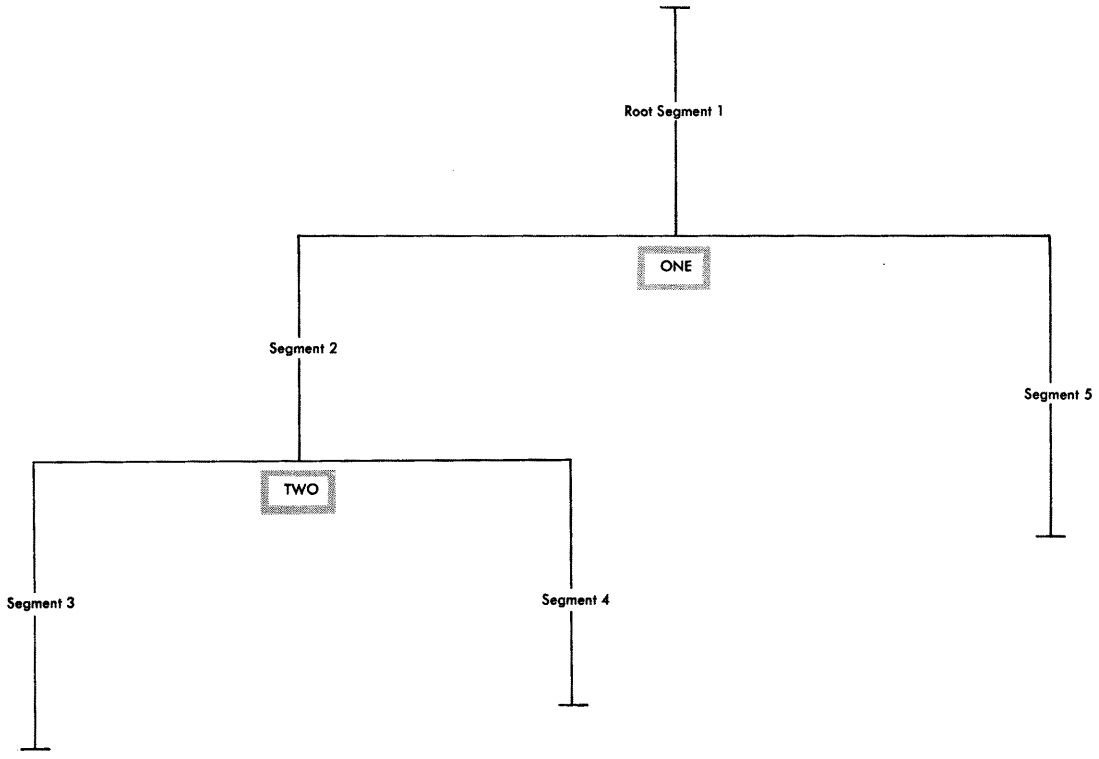


Figure 30. Symbolic Segment Origin in Single-Region Program

REGION ORIGIN

The symbolic origin of every region, other than the first, must be specified with an OVERLAY statement. Once a new region is specified, a segment origin from a previous region should not be specified.

In the sample multiple-region program, the symbolic origin THREE is assigned to region 2, as shown in Figure 31. Segments 6 and 7 are at load point THREE.

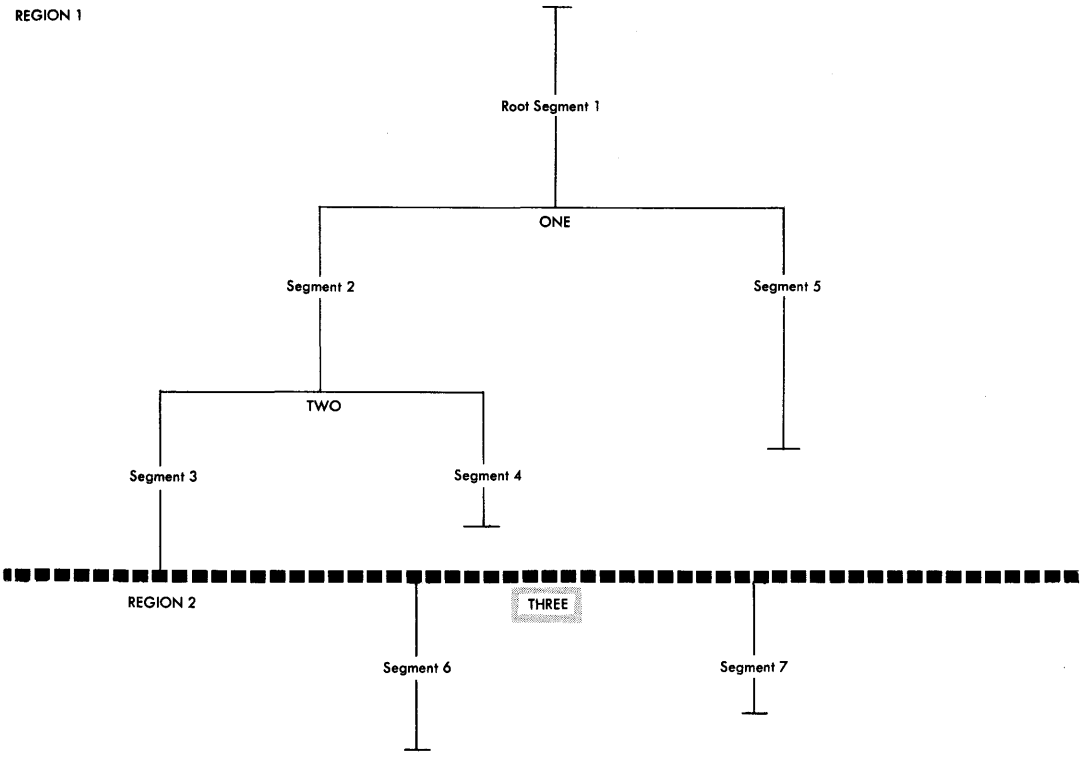


Figure 31. Symbolic Segment and Region Origin in Multiple-Region Program

If the following is added to the sequence for the single-region program, the multiple-region structure will be produced:

```
          .
          .
          .
OVERLAY THREE(REGION)
Control section CSH
OVERLAY THREE
Control section CSI
```

POSITIONING CONTROL SECTIONS

After each OVERLAY statement, the control sections for that segment must be specified. The control sections for a segment can be specified in one of three ways:

- By placing the object decks for each segment after the appropriate OVERLAY statement.
- By using INCLUDE control statements for the modules containing the control sections for the segment.
- By using INSERT control statements to reposition a control section from its position in the input stream to a particular segment.

Any control sections that precede the first OVERLAY statement are placed in the root segment; they can be repositioned with an INSERT statement. Control sections from the automatic call library are also placed in the root segment. The INSERT statement can be used to place these control sections in another specific segment. Common areas in an overlay program are described in "Special Considerations."

An example of each of the three methods of positioning control sections follows. Each example results in the structure for the single-region sample program. An example is also given of repositioning control sections from the automatic call library.

Using Object Decks

The primary input data set for this example contains an ENTRY statement and seven object decks, separated by OVERLAY statements:

```
//LKED     EXEC PGM=IEWL,PARM='OVLY'
            .
            .
            .
//SYSLIN   DD   *
  ENTRY BEGIN
  Object deck for CSA
  Object deck for CSB
  OVERLAY ONE
  Object deck for CSC
  OVERLAY TWO
  Object deck for CSD
  Object deck for CSE
  OVERLAY TWO
  Object deck for CSF
  OVERLAY ONE
  Object deck for CSG
/*
```

The EXEC statement illustrates that the OVLY parameter must be specified for every overlay program to be processed by the linkage editor.

Using INCLUDE Statements

The primary input data set for this example contains a series of control statements. The INCLUDE statements in the primary input data set direct the linkage editor to library members that contain the control sections of the program.

```
//LKED     EXEC  PGM=IEWL,PARM='OVLY'
               .
               .
               .
//MODLIB   DD    DSNAME=OBJLIB,DISP=(OLD,KEEP),...
//SYSLIN   DD    *
  ENTRY BEGIN
  INCLUDE MODLIB(CSA,CSB)
  OVERLAY ONE
  INCLUDE MODLIB(CSC)
  OVERLAY TWO
  INCLUDE MODLIB(CSD,CSE)
  OVERLAY TWO
  INCLUDE MODLIB(CSF)
  OVERLAY ONE
  INCLUDE MODLIB(CSG)
/*
```

This example differs from the previous one in that the control sections of the program are not part of the primary input data set, but are represented in the primary input by the INCLUDE statements. When an INCLUDE statement is processed, the appropriate control section is retrieved from the library and processed.

Using INSERT Statements

When INSERT statements are used, the INSERT and OVERLAY statements may either follow or precede all the input modules. However, the order of the control sections in a segment is not necessarily the same as the order of the INSERT statements for each segment. An example of each is given, as well as an example of repositioning automatically called control sections.

Following All Input: The control statements can follow all the input modules, as shown in the following example:

```
//LKED     EXEC  PGM=IEWL,PARM='OVLY'
               .
               .
               .
//SYSLIN   DD    DSNAME=OBJECT,DISP=(OLD,KEEP),...
//         DD    *
  ENTRY BEGIN
  INSERT CSA,CSB
  OVERLAY ONE
  INSERT CSC
  OVERLAY TWO
  INSERT CSD,CSE
  OVERLAY TWO
  INSERT CSF
  OVERLAY ONE
  INSERT CSG
/*
```

The primary input data set contains the object modules for the control sections, and the input stream is concatenated to it.

Preceding All Input: The control statements can also precede all input modules, as shown in the following example:

```
//LKED     EXEC  PGM=IEWL,PARM='OVLY'
//MODULES  DD    DSNAME=OBJSEQ,DISP=(OLD,KEEP),...
                 .
                 .
                 .
//SYSLIN   DD    *
  ENTRY BEGIN
  INSERT CSA,CSB
  OVERLAY ONE
  INSERT CSC
  OVERLAY TWO
  INSERT CSD,CSE
  OVERLAY TWO
  INSERT CSF
  OVERLAY ONE
  INSERT CSG
  INCLUDE MODULES
/*
```

The primary input data set contains all of the control statements for the overlay structure and an INCLUDE statement. The data set specified by the INCLUDE statement contains all of the object modules for the structure, and is a sequential data set.

Repositioning Automatically Called Control Sections: The INSERT statement can also be used to move automatically called control sections from the root segment to the desired segment. This is helpful when control sections from the automatic call library are used in only one segment. By moving such control sections, the root segment will contain only those control sections used by more than one segment.

When a program is written in a higher level language, special control sections are called from the automatic call library. Assume that the sample program is written in COBOL and that two control sections (ILBOVTR0 and ILBOSCH0) are called automatically from SYS1.COBLIB. Ordinarily, these control sections are placed in the root segment. However, INSERT statements are used in the following example to place these control sections in segments other than the root segment.

```
//LKED     EXEC  PGM=IEWL,PARM='OVLY'
//MODLIB   DD    DSNAME=OBJLIB,DISP=(OLD,KEEP),...
//SYSLIB   DD    DSNAME=SYS1.COBLIB,DISP=SHR
                .
                .
                .
//SYSLIN   DD    *
  ENTRY BEGIN
  INCLUDE MODLIB(CSA,CSB)
  OVERLAY ONE
  INCLUDE MODLIB(CSC)
  OVERLAY TWO
  INCLUDE MODLIB(CSD,CSE)
  INSERT ILBOVTR0
  OVERLAY TWO
  INCLUDE MODLIB(CSF)
  INSERT ILBOSCH0
  OVERLAY ONE
  INCLUDE MODLIB(CSG)
/*
```

As a result, segments 3 and 4 will also contain ILBOVTR0 and ILBOSCH0, respectively.

This example also combines two of the ways of specifying the control sections for a segment.

SPECIAL OPTIONS

The linkage editor provides three special job step options for the overlay programmer. These options are specified on the EXEC statement for the linkage editor job step. They must be specified each time a load module in overlay structure is reprocessed by the linkage editor. The three options are OVLY, LET, and XCAL.

OVLY Option

The OVLY option must be specified for every overlay program. If the option is omitted, all the OVERLAY and INSERT statements are considered invalid. The output module is marked not executable unless the LET option is specified. The output module is not in an overlay structure.

LET Option

With the LET option, the output module is marked executable even though certain error conditions were found during linkage editor processing. When LET is specified, any exclusive reference (valid or invalid) is accepted. At execution time, a valid exclusive reference is executed correctly; an invalid exclusive reference usually causes unpredictable results.

Also with the LET option, unresolved external references do not prevent the module from being marked executable. This could be helpful when part of a large program is ready for testing; the segments to be tested may contain references to segments not yet coded. If LET is

specified, the program can be executed to test those parts that are finished (as long as the references to the absent segments are not executed). If the LET option is not specified, these unresolved references will cause the module to be marked not executable.

XCAL Option

With the XCAL option, a valid exclusive call is not considered an error, and the load module is marked executable. However, other errors could cause the module to be marked not executable, unless the LET option is specified; in this case, the XCAL option is not required.

SPECIAL CONSIDERATIONS

This section discusses several special considerations that affect overlay programs. These considerations include the handling of common areas, special storage requirements, and overlay communication.

COMMON AREAS

When common areas (blank or named) are encountered in an overlay program, the common areas are collected as described previously (i.e., the largest blank or identically named common area is used). The final location of the common area in the output module depends on whether INSERT statements were used to structure the program.

If INSERT statements are used to structure the overlay program, a named common area should either be part of the input stream in the segment to which it belongs, or should be placed there with an INSERT statement.

Because INSERT statements cannot be used for blank common areas, a blank common area should always be part of the input stream in the segment to which it belongs.

If INSERT statements are not used, and the control sections for each segment are placed or included between OVERLAY statements, the linkage editor "promotes" the common area automatically. That is, the common area is placed in the common segment of the paths that contain references to it so that the common area is in main storage when needed. The position of the promoted area in relation to other control sections within the common segment is unpredictable.

If a common area is encountered in a module from the automatic call library, automatic promotion places the common area in the root segment. In the case of a named common area, this may be overridden by use of the INSERT statement.

Assume that the sample program is written in FORTRAN and that common areas are present as shown in Figure 32. Further assume that the overlay program is structured with INCLUDE statements between the OVERLAY statements so that automatic promotion occurs.

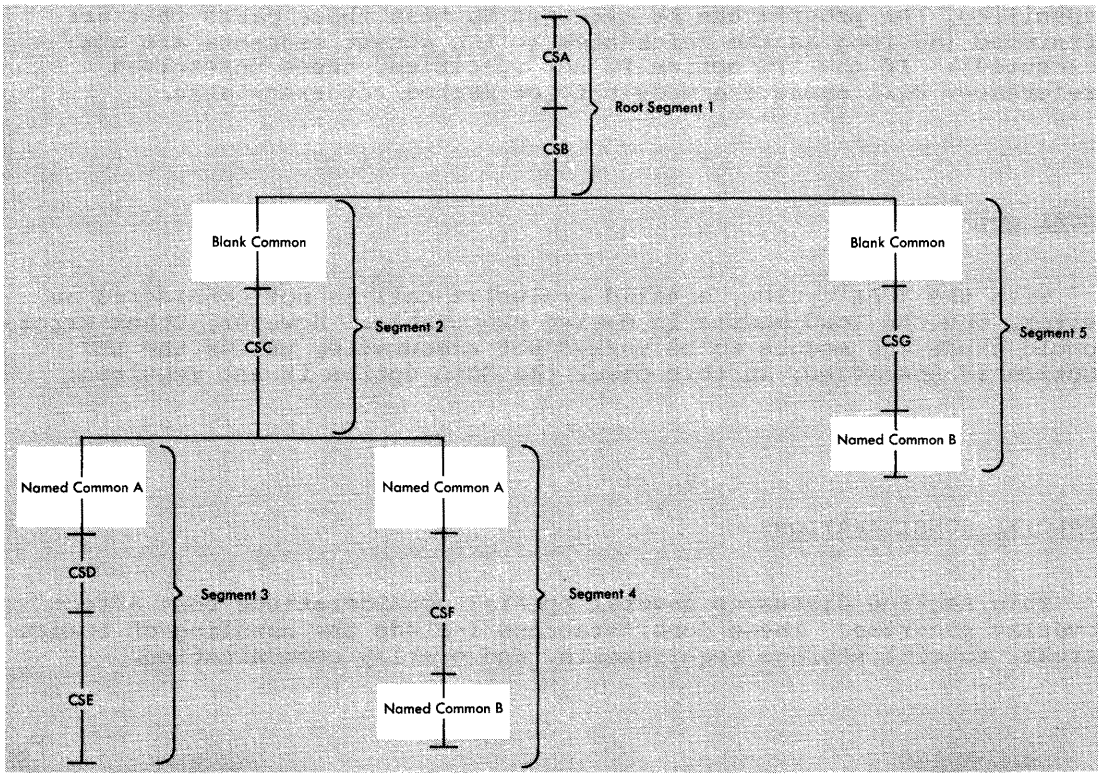


Figure 32. Common Areas Before Processing

Segments 2 and 5 contain blank common areas, segments 3 and 4 contain named common area A, and segments 4 and 5 contain named common area B. During linkage editor processing, the blank common areas are collected and the largest area is promoted to the root segment (the first common segment in the two paths); the common areas named A are collected and the largest area is promoted to segment 2; the common areas named B are collected and promoted to the root segment. Figure 33 shows the location of the common areas after processing by the linkage editor.

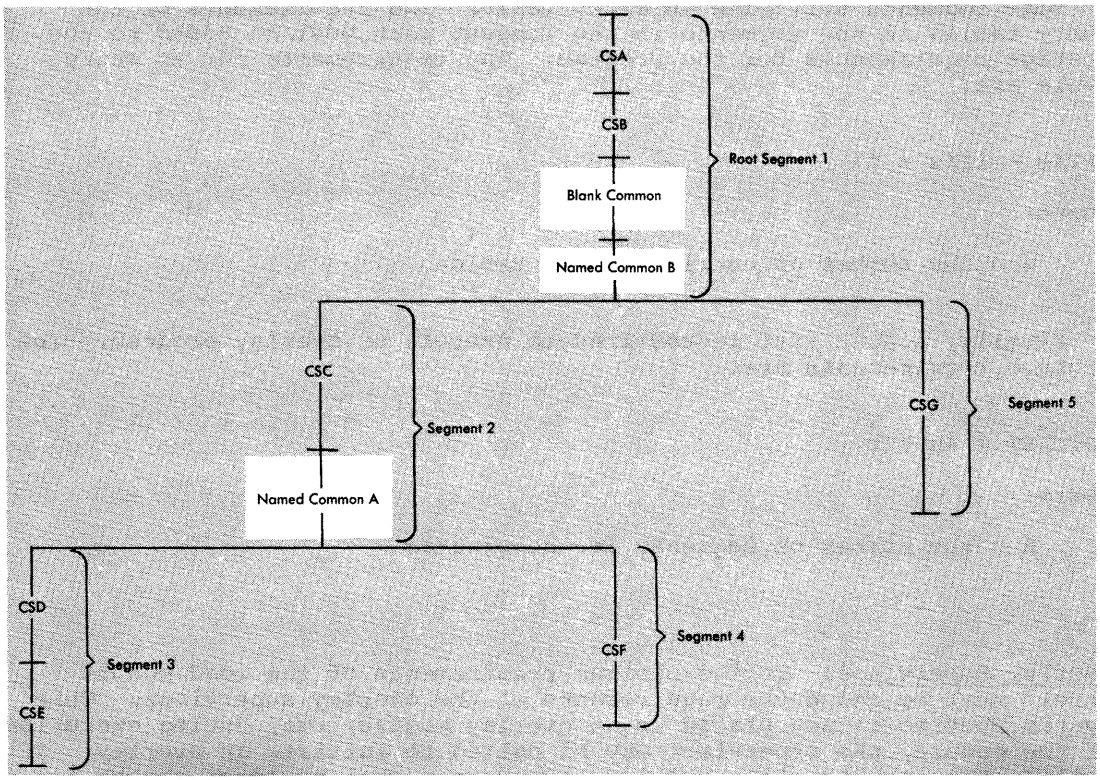


Figure 33. Common Areas After Processing

STORAGE REQUIREMENTS

The storage requirements for an overlay program include the items placed in the module by the linkage editor and the overlay supervisor necessary for execution.

Items in the Load Module: The items that the linkage editor places in an overlay load module are the segment table, entry tables, and other control information. Their size must be included in the minimum requirements for an overlay program, along with the storage required by the longest path and any control sections from the automatic call library.

Every overlay program has one segment table in the root segment. The storage requirements are:

SEGTAB = 4n + 24

where:

n = the number of segments in the program

Some segments will have an entry table. The requirements of the entry tables in the segments in the longest path must be added to the storage requirements for the program. The requirements for an entry table are:

ENTAB = 12(x + 1)

where:

x = the number of entries in the table

Finally, a NOTE list is required to execute an overlay program. The storage requirements are:

NOTELST = 4n + 8

where:

n = the number of segments in the program

Overlay Supervisor: To the minimum requirements of the load module itself must be added the requirements of the overlay supervisor. This system routine is not placed in an overlay module, but, during execution of the module, the supervisor may be called to initiate an overlay. If called, the storage allocated for the program must be large enough for the supervisor also.

Three overlay supervisor modules are furnished with the system: the basic, advanced, and asychronous modules. The basic module does not test whether a request for overlay is valid; the other two do. Neither the basic nor advanced modules permit overlay through the SEGLD macro instruction (see "Overlay Communication"); the asynchronous module does. When the SEGLD macro instruction is used with the basic and advanced modules, it is ignored. The storage requirements for the overlay supervisor modules are:

Module	Storage Requirements (in bytes)
Basic (used with MFT)	436
Advanced (used with MFT)	512
Asynchronous (used with MVT)	992

OVERLAY COMMUNICATION

Several ways of communicating between segments of an overlay program are discussed in this section. A higher level or assembler language program may use a CALL statement or CALL macro instruction, respectively, to cause control to be passed to a symbol defined in another segment. The CALL may cause the segment to be loaded if it is not already present in storage. An assembler language program may also use three additional ways to communicate between segments:

- By a branch instruction, which causes a segment to be loaded and control to be passed to a symbol defined in that segment.

- By a segment load (SEGLD) macro instruction (MVT only), which requests loading of a segment. Processing continues in the requesting segment while the requested segment is being loaded.

- By a segment load and wait (SEGWT) macro instruction, which requests loading of a segment. Processing continues in the requesting segment only after the requested segment is loaded.

Any of the four methods may be used to make inclusive references. Only the CALL and branch may be used to make exclusive references. Neither the SEGLD nor SEGWT macro instruction should be used to make exclusive references; since both imply that processing is to continue in the requesting segment, an exclusive reference leads to erroneous results when the program is executed.

CALL Statement or CALL Macro Instruction

A CALL statement or CALL macro instruction refers to an external name in the segment to which control is to be passed. The external name must be defined as an external reference in the requesting segment. In assembler language, the name must be defined as a four-byte V-type address constant; the high-order byte is reserved for use by the control program, and must not be altered during execution of the program.

When a CALL is used, the requested segment and any segments in its path are loaded if they are not part of the path already in main storage. After the segment is loaded, control is passed to the requested segment at the location specified by the external name.

A CALL between inclusive segments is always valid. A return can be made to the requesting segment by another source language statement, such as RETURN. A CALL between exclusive segments is valid if the conditions for a valid exclusive reference are met; a return from the requested segment can be made only by another exclusive reference, because the requesting segment has been overlaid.

Branch Instruction

Any of the branching conventions shown in Table 2 can be used to request loading and branching to a segment. As a result, the requested segment and any segments in its path are loaded if they are not part of the path already in main storage. Control is then passed to the requested segment at the location specified by the address constant placed in general register 15.

The address constant must be a 4-byte V-type address constant. The high-order byte is reserved for use by the control program, and must not be altered during execution of the program.

Table 2. Branch Sequences for Overlay Programs

Example	Name[1]	Operation	Operand[2] [3]
1		L BALR	R15,=V(name) Rn,R15
2		L BALR . . .	R15,ADCON Rn,R15
	ADCON	DC	V(name)
3		L BAL	R15,=V(name) Rn,0(0,R15)[4]
4		L BAL	R15,=V(name) Rn,0(R15)[5]
5[6]		L BCR	R15,=V(name) 15,R15
6[6]		L BC	R15,=V(name) 15,0(0,R15)[4]
7[6]		L BC	R15,=V(name) 15,0(R15)[5]

[1]When the name field is blank, specification of a name is optional.
[2]R15 is the register into which is loaded a 4-byte address constant that is an entry name or a control section name in the requested segment. The address constant must be loaded into the standard entry point register, register 15.
[3]Rn is any other register and is used to hold the return address. This register is usually register 14.
[4]This may also be written so that the index register is loaded with the address constant; the other fields must be zero.
[5]In this format, the base register must be loaded with the address constant; the displacement must be zero.
[6]This example is an unconditional branch; other conditions are also allowed.

A branch between inclusive segments is always valid; a return may be made by means of the address stored in Rn. A branch between exclusive segments is valid if the conditions for a valid exclusive reference are met; a return can be made only by another exclusive reference.

Segment Load (SEGLD) Macro Instruction

The SEGLD macro instruction is used to provide overlap between segment loading and processing within the requesting segment. As a result of using any of the examples in Table 3, the loading of the requested segment and any segments in its path is initiated when they are not part of the path already in main storage. Processing then resumes at the next sequential instruction in the requesting segment while the segment or segments are being loaded. Control may be passed to the requested segment with either a CALL or a branch, as shown in examples 1 and 2, respectively. A SEGWT instruction can be used to

ensure that the data in the control section specified by the external name is in main storage before processing begins, as shown in Example 3.

The external names specified in the SEGLD macro instruction must be defined with a 4-byte V-type address constant. The high-order byte is reserved for use by the control program and must not be altered during execution of the program.

Note: Some configurations of the control program do not have the capability of processing the SEGLD macro instruction. When used, the macro instruction is treated as a NOP (no operation) and the segment is loaded when a SEGWT macro instruction or a branch is executed. If the rules of overlay are followed, correct execution occurs.

Table 3. Use of the SEGLD Macro Instruction

Example	Name[1]	Operation	Operand[2] [3]
1		SEGLD	external name
		CALL	external name
2		SEGLD	external name
		branch	
3		SEGLD	external name
		SEGWT	external name
		L	Rn,=A(name)

[1]When the name field is blank, specification of a name is optional.
[2]External name is an entry name or a control section name in the requested segment.
[3]Rn is any other register and is used to hold the return address. This register is usually register 14.

Segment Wait (SEGWT) Macro Instruction

The SEGWT macro instruction is used to stop processing in the requesting segment until the requested segment is in main storage.

As a result of using any of the examples in Table 4, no further processing takes place until the requested segment and all segments in its path are loaded when not already in main storage. Processing resumes at the next sequential instruction in the requesting segment after the requested segment has been loaded.

If the SEGWT and SEGLD macro instructions are used together, overlap occurs between processing and segment loading; use of the SEGWT macro instruction serves as a check to see that the necessary information is in storage when it is finally needed (see Example 1 in Table 4). In Example 2 in Table 4, no overlap is provided; the SEGWT macro instruction initiates loading, and processing is stopped in the requesting segment until the requested segment is in main storage.

The external name specified in the SEGWT macro instruction must be defined with a 4-byte V-type address constant. The high-order byte is reserved for use by the control program, and must not be altered during execution of the program.

If the contents of a main storage location in the requested segment are to be processed, the entry name of the location must be referred to by an A-type address constant.

Table 4. Use of the SEGWT Macro Instruction

Example	Name[1]	Operation	Operand[2] [3]
1		SEGLD	external name
		SEGWT	external name
		L	Rn,ADCON
		branch	
	ADCON	DC	A(name)
2		SEGWT	external name
		L	Rn,=A(name)

[1]When the name field is blank, specification of a name is optional.
[2]External name is an entry name or a control section name in the requested segment.
[3]Rn is any other register and is used to hold the return address. This register is usually register 14.

This chapter summarizes those aspects of the job control language that pertain directly to the use of the linkage editor. The major topics covered are the EXEC statement, DD statements, and cataloged procedures for the linkage editor. The reader should be familiar with the job control language as described in the publication IBM System/360 Operating System: Job Control Language Reference.

EXEC STATEMENT -- INTRODUCTION

The EXEC statement is the first statement of every job step. For the linkage editor job step, the following topics are pertinent:

- The program name of the linkage editor.
- Linkage editor options passed to the job step.
- Region requirements for the linkage editor.

For an execution job step following the linkage editor job step, the linkage editor return code is important.

EXEC STATEMENT -- PROGRAM NAME

The EXEC statement contains the symbolic name of the load module to be invoked for execution. The linkage editor can be invoked with one of the following symbolic program names:

- IEWLE150 for the 15K design level E linkage editor.
- IEWLE180 for the 18K design level E linkage editor.
- IEWLF440 for the 44K design level F linkage editor.
- IEWLF880 for the 88K design level F linkage editor.
- IEWLF128 for the 128K design level F linkage editor.

If the alias name IEWL or LINKEDIT is specified, the largest design level of the linkage editor available in the system is invoked.

For example, the following EXEC statement causes the 44K level F linkage editor to be invoked:

```
//LKED     EXEC PGM=IEWLF440,...
```

If PGM=IEWL were specified, the 44K linkage editor would be executed only if it were the largest linkage editor available.

Appendix C contains a description of the five linkage editor design levels.

EXEC STATEMENT -- JOB STEP OPTIONS

The EXEC statement also contains a list of options or parameters to be passed to the linkage editor. These options are of four types:

- Module attributes, which describe the characteristics of the output load module.
- Special processing options, which affect linkage editor processing.
- Space allocation options, which affect the amount of storage used by the linkage editor for processing and output module library buffers.
- Output options, which specify the kind of output the linkage editor is to produce.

The rest of this section describes the options in each category. All of the options for a particular linkage editor execution are listed in the PARM parameter on the EXEC statement. They can be listed in any sequence, as long as the rules for coding parameters are followed.

MODULE ATTRIBUTES

The module attributes describe the characteristics of the output module, or modules. (If more than one load module is produced by the same linkage editor job step, all output modules will have the attributes assigned on the EXEC statement.) The attributes for each load module are stored in the directory of the output module library along with the member name. (The format of the directory entry of a partitioned data set is given in the publication IBM System/360 Operating System: System Control Blocks.)

Module attributes specify whether or not the module:

- Can be reprocessed by the level E linkage editor.
- Is to be processed in hierarchy format.
- Can ever be reprocessed by the linkage editor.
- Can be brought into main storage only by the LOAD macro instruction.
- Is to be in overlay format.
- Can be reused.
- Can be placed in the link pack area; i.e., is re-enterable.
- Can be replaced during execution by recovery management; i.e., is refreshable.
- Is to be processed in scatter format.
- Is to be tested by TESTRAN (assembler language only).

After the descriptions of the module attributes, the default and incompatible attributes are discussed.

Downward Compatible Attribute

A module with the downward compatible attribute can be reprocessed by either the level E or level F linkage editor. The downward compatible attribute must be specified when load modules produced by the level F linkage editor are to be processed again by the level E linkage editor. When this attribute is specified, a maximum record size of 1024 bytes is used for the output module library. If the level E linkage editor is requested to process a load module that does not have this attribute, the request is treated as an error.

To assign the downward compatible attribute, code DC in the PARM field as follows:

```
//LKED     EXEC PGM=IEWL,PARM='DC,...'
```

The level E linkage editor automatically assigns the downward compatible attribute to all load modules it produces.

Hierarchy Format Attribute

Control sections within a module with the hierarchy format attribute are suitable for either block or scatter loading into the hierarchies specified in HIARCHY control statements. Specification of hierarchy format, when main storage hierarchy support is included in the system, allows the programmer to make use of both processor storage (hierarchy 0) and IBM 2361 Core Storage (hierarchy 1). When main storage hierarchy support is not included in the system, programs with the hierarchy format attribute are block or scatter loaded into processor storage (see "Scatter Format").

When storage hierarchies are used, all control sections assigned to a hierarchy are normally block loaded. If the allocated region within the hierarchy is not large enough for block loading of the control sections, and the scatter loading feature is available, the control sections may be scatter loaded into the allocated area within the hierarchy.

The hierarchy format attribute overrides the scatter format attribute; the overlay attribute overrides the hierarchy format attribute and must be omitted if hierarchies are to be assigned.

To assign the hierarchy format attribute, code HIAR in the PARM field, as follows:

```
//LKED     EXEC PGM=IEWL,PARM='HIAR,...'
```

See the description of the HIARCHY control statement for information on assigning control sections to a specific hierarchy.

Note: Because control sections may be scatter loaded when HIAR is specified, the programmer should ensure that the load module does not contain zero-length control sections, private code sections, or common areas. The presence of such sections in a module that is to be scatter loaded can, under certain circumstances, cause Program Fetch to terminate abnormally when the module is loaded into main storage for execution.

Not Editable Attribute

A module with the not editable attribute has no external symbol dictionary, and cannot ever be reprocessed by the linkage editor. Because the external symbol dictionary is not stored with the module, the module requires less storage space in the output module library. If a module map or a cross-reference table is requested, the not editable attribute is negated.

To assign the not editable attribute, code NE in the PARM field, as follows:

```
//LKED      EXEC  PGM=IEWL,PARM='NE,...'
```

Note: The not editable attribute is intended primarily for use by the control program.

Only Loadable Attribute

A module with the only loadable attribute can be brought into main storage only with a LOAD macro instruction. Some subsets of the control program use a smaller control table when the load module is invoked with a LOAD. This reduces the overall main storage requirements of the module.

A module with the only loadable attribute must be entered by means of a branch instruction or a CALL macro instruction. If an attempt is made to enter the module with a LINK, XCTL, or ATTACH macro instruction, the program making the attempt is terminated abnormally by the control program.

To assign the only loadable attribute, code OL in the PARM field as follows:

```
//LKED      EXEC  PGM=IEWL,PARM='OL,...'
```

Note: The only loadable attribute is intended primarily for use by the control program. Use of this attribute by the problem programmer can impair the usability of the module.

Overlay Attribute

A program with the overlay attribute is placed in an overlay structure as directed by the linkage editor OVERLAY control statements. The module is suitable only for block loading; it cannot be refreshable, re-enterable, serially reusable, or assigned to hierarchies.

If the overlay attribute is specified and no OVERLAY control statements are found in the linkage editor input, the attribute is negated. The condition is considered a recoverable error; that is, if the LET option is specified, the module is marked executable.

The overlay attribute must be specified for overlay processing. If this attribute is omitted, the OVERLAY and INSERT statements are

considered invalid, and the module is not an overlay structure. This condition is also recoverable; if the LET option is specified, the module is marked executable.

To assign the overlay attribute, code OVLY in the PARM field as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='OVLY,...'
```

See "Overlay Programs" for information on the design and specification of an overlay structure.

Reusability Attributes

Either one of two attributes may be specified to denote the reusability of a module. Reusability means that the same copy of a load module can be used by more than one task either concurrently or one at a time. The reusability attributes are re-enterable and serially reusable; if neither is specified, the module is not reusable and a fresh copy must be brought into main storage before another task can use the module.

The linkage editor only stores the attribute in the directory entry; it does not check whether the module is really re-enterable or serially reusable. A re-enterable module is automatically assigned the reusable attribute. However, a reusable module is not also defined as re-enterable; it is reusable only. For information on designing a reusable module, see the publication IBM System/360 Operating System: Concepts and Facilities.

Re-enterable: A module with the re-enterable attribute can be executed by more than one task at a time; that is, a task may begin executing a re-enterable module before a previous task has finished executing it. This type of module cannot be modified by itself or by any other module during execution.

If a module is to be re-enterable, all of the control sections within the module must be re-enterable. If the re-enterable attribute is specified, and any load modules that are not re-enterable become a part of the input to the linkage editor, the attribute is negated.

To assign the re-enterable attribute, code RENT in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='RENT,...'
```

Serially Reusable: A module with the serially reusable attribute can be executed by only one task at a time; that is, a task may not begin executing a serially reusable module before a previous task has finished executing it. This type of module must initialize itself and/or restore any instructions or data in the module altered during execution.

If a module is to be serially reusable, all of its control sections must be either serially reusable or re-enterable. If the serially reusable attribute is specified, and any load modules that are neither serially reusable nor re-enterable become a part of the input to the linkage editor, the serially reusable attribute is negated.

To assign the serially reusable attribute, code REUS in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='REUS,...'
```

Refreshable Attribute

A module with the refreshable attribute can be replaced by a new copy during execution by a recovery management routine without changing either the sequence or results of processing. This type of module cannot be modified by itself or by any other module during execution. The linkage editor only stores the attribute in the directory entry; it does not check whether the module is refreshable.

If a module is to be refreshable, all of the control sections within it must be refreshable. If the refreshable attribute is specified, and any load modules that are not refreshable become a part of the input to the linkage editor, the attribute is negated.

To assign the refreshable attribute, code REFR in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='REFR,...'
```

Scatter Format Attribute

A module with the scatter format attribute need not be loaded into a contiguous block of main storage; rather, the programmer can specify the dynamic loading of control sections into noncontiguous, or scattered, areas within his assigned main storage area. Although scatter loading can also be left to the control program, the programmer should specify the loading process himself for most effective use of available storage. If the scatter format attribute is not specified, the linkage editor produces a load module in a format suitable for block loading. That is, the control program can load the module only into one contiguous main storage area large enough to contain the complete module.

When the scatter format attribute is specified, the linkage editor produces a load module in a format suitable for either scatter or block loading. If the scatter load feature is not available in the control program, modules with the scatter format attribute are block loaded.

To assign the scatter format attribute, code SCTR in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='SCTR,...'
```

Note 1: The block format attribute is assigned by the linkage editor if scatter format is not specified. (The programmer cannot specify block format.)

Note 2: SCTR is specified, the programmer should ensure that the load module does not contain zero-length control sections, private code sections, or common areas. The presence of such sections in a module that is to be scatter loaded can, under certain circumstances, cause Program Fetch to terminate abnormally when the module is loaded into main storage for execution.

Test Attribute

A module with the test attribute is to be tested and contains the testing symbol tables for the test translator (TESTRAN) or the TSO TEST command. The linkage editor accepts these tables as input, and places them in the output module. The module is marked as being under test. If the test attribute is not specified, the symbol tables are ignored by the linkage editor and are not placed in the output module. If the test attribute is specified, and no symbol table input is received, the output load module will not contain symbol tables to be used by TESTRAN or the TSO TEST command.

To assign the test attribute, code TEST in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='TEST,...'
```

Note 1: The test attribute applies primarily to assembler language programs using TESTRAN or the TSO TEST command.

Note 2: Modules that use TESTRAN should not be marked with the RENT, REUS, or REFR attribute.

Default Attributes

Unless specific module attributes are indicated by the programmer, the output module is not in an overlay structure, and it is not tested (assembler only). The module is in block format, not refreshable, not re-enterable, not serially reusable, and cannot be reprocessed by the level E linkage editor.

One other attribute is specified by the linkage editor after processing is finished. If, during processing, severity 2 errors were found that would prevent the output module from being executed successfully, the linkage editor assigns the not executable attribute. The control program will not load a module with this attribute.

If the LET option is specified, the output module is marked executable even if severity 2 errors occur. The LET option is discussed later in this section.

Incompatible Attributes

Although there are ten module attributes that the programmer may specify, several are mutally exclusive. When mutually exclusive attributes are specified for a load module, the linkage editor ignores the less significant attributes. For example, if both OVLY and RENT are specified, the module will be in an overlay structure and will not be re-enterable.

Certain attributes are also incompatible with other job step options. For convenience, all job step options are shown in Figure 34 at the end of this chapter along with those options that are incompatible.

SPECIAL PROCESSING OPTIONS

The special processing options affect the executability of the output module and the use of the automatic library call mechanism. These options are the exclusive call option, the let execute option, and the no automatic call option.

Exclusive Call Option

When the exclusive call option is specified, the linkage editor marks the output module as executable when valid exclusive references have been made between segments. However, a warning message is given for each valid exclusive reference.

To specify the exclusive call option, code XCAL in the PARM field as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='XCAL,OVLY,...'
```

The OVLY attribute must also be specified for an overlay program.

Note: Other errors may cause the module to be marked not executable unless the let execute option is specified.

Let Execute Option

When the let execute option is specified, the linkage editor marks the output module as executable even though a severity 2 error condition was found during processing. (A severity 2 error condition could make execution of the output load module impossible.) Some examples of severity 2 errors are:

- Unresolved external references.
- Valid or invalid exclusive calls in an overlay program.
- Error on a linkage editor control statement.
- A library module that cannot be found.
- No available space in the directory of the output module library.

To specify the let execute option, code LET in the PARM field as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='LET,...'
```

Note: If LET is specified, XCAL need not be specified.

No Automatic Library Call Option

When the no automatic library call option is specified, the linkage editor library call mechanism does not call library members to resolve external references. The output module is marked executable even though unresolved external references are present. If this option is specified, the LIBRARY statement cannot be used to negate the automatic library call for selected external references. Also, with this option, a SYSLIB DD statement need not be supplied.

To specify the no automatic library call option, code NCAL in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='NCAL,...'
```

Note: Other errors may cause the module to be marked not executable unless the LET option is also specified.

SPACE ALLOCATION OPTIONS

These options allow the programmer to specify the storage available to the linkage editor, and to specify the block size for the output module. These options can only be used with the level F linkage editor.

SIZE Option

The programmer can specify, through the SIZE parameter, the amount of main storage to be used by the level F linkage editor. Also, he can specify how much of the specified main storage is to be used as the load module/text buffer, which is the main storage used to contain input and output data. If this buffer is large enough, use of the intermediate data set (SYSUT1) may not be required.

If (1) the SIZE option is not specified, (2) a value is incorrectly specified in the SIZE option, or (3) one of the values is not specified, default values chosen during system generation are used. For details on how to establish default values, see the publication IBM System/360 Operating System: System Generation.

The following text describes the format of the SIZE option, how to determine the value for the load module buffer, and the blocking factors used with the linkage editor F.

Format: The format of the SIZE option is:

SIZE=($value_1$,$value_2$)

When coded in the PARM field, the expression is enclosed in single quotes, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='SIZE=(value1,value2),...'
```

where:

$value_1$
: specifies the maximum number of bytes of main storage available to the linkage editor. This value can be specified either in the form n (where n represents the actual number of bytes of main storage, not to exceed 9999999) or nK (where n represents the number of 1K blocks of main storage, not to exceed 9999K; 1K is equal to 1024 bytes). $Value_1$ must not exceed the amount of main storage that can be made available in the system.

The minimum $value_1$ that can be specified is the design size of the level F linkage editor being used. The following are the minimum values for each design size:

44K -- $value_1$ at least 45056 bytes or 44K

88K -- $value_1$ at least 90112 bytes or 88K

128K -- $value_1$ at least 131072 bytes or 128K

To indicate that additional main storage should be made available to the linkage editor, specify a number larger than the design size.

$Value_1$ includes the number of bytes to be used as the load module buffer, which is specified in $value_2$.

$value_2$
specifies the maximum amount of $value_1$ that is to be used as the load module buffer and is expressed as a number from 6144 (or 6K) through 102400 (or 100K).

For example, if SIZE=(59K,18K) is specified when the 44K design size is used, the maximum number of bytes that can be made available to the linkage editor is 60,416, of which 18,432 bytes are to be used as the load module buffer. Other valid examples of the SIZE option are:

SIZE=(512000,100K) and SIZE=(200K,20480).

If $value_1$ exceeds the amount of main storage available in the system at the time of linkage editor execution, $value_1$ is automatically decreased by the linkage editor. This value is never decreased below the design size being used. After a new $value_1$ is established, an attempt is made to satisfy the request for $value_2$. If this request cannot be satisfied, $value_2$ is also decreased. This value is never decreased below 6K.

Determining $Value_2$: The load module buffer is used for three different purposes during linkage editor processing. The buffer is used for input text records, intermediate data records, or output load module records.

Therefore, the size specified in $value_2$ must be large enough to hold the largest load module input record, a record from the intermediate data set (SYSUT1), or a record for the output module library (SYSLMOD). In any case, the device on which the data set resides determines the values to be considered. That is, the maximum record size for the device is used to determine $value_2$. The $value_2$ chosen must meet the requirements for all three types of data sets. Table 5 contains the maximum record sizes for the allowable devices.

Table 5. Device Types and Maximum Record Sizes

Device	Maximum Record Size
IBM 2301 Drum Storage	18K
IBM 2302 Disk Storage	4K
IBM 2303 Drum Storage	4K
IBM 2311 Disk Storage	3K
IBM 2314 Disk Storage	6K
IBM 2319 Disk Storage	6K
IBM 2321 Data Cell	1K
IBM 3330 Disk Storage Facility	12K
IBM 2305 Fixed Head Storage Facility	13K

The load module buffer must be large enough to contain an input load module record. An input load module record could be from the automatic call library (SYSLIB), or a data set specified on an INCLUDE statement. If the linkage editor encounters a record that cannot be contained in the load module buffer, the record is deleted. Therefore, $value_2$ must be at least large enough to hold an input record from the device containing the largest load module records.

For example, a user has a SYSLIB data set on an IBM 2301 Drum Storage Device, which holds 18K records. Since the linkage editor may normally allocate only 6K to the load module buffer, an additional 12K must be provided for this buffer. Therefore, the following SIZE option could be used:

```
SIZE=(56K,18K)
```

These values allow the 44K design size to run in sufficient storage while providing 18K for the load module buffer.

The greater the size of the load module buffer, the less likely it is that the intermediate data set would be required. For example, if SIZE=(200K,100K) is specified, it is less likely that SYSUT1 would be required than if SIZE=(59K,18K) is specified. Consider a user with a SYSLIB data set on an IBM 2311 Disk Storage Device, who would like to allow 102,400 bytes for $value_1$. Because he only needs 3K for the largest load module input record, if $value_2$ is greater than 3K the possibility of not using SYSUT1 is greater. The SIZE option could be coded as follows:

```
SIZE=(100K,24K)
```

In this case, the load module buffer is 24K bytes and it is likely that the intermediate data set will not be used. The additional storage over and above that needed for the linkage editor itself is used for buffer and table allocation.

The previous examples did not consider the interrelationship of the input load module requirements with the output load module library requirements. To achieve the maximum output record size on this library, $value_2$ must be at least twice the record size of the device for the SYSLMOD data set. Note, however, that if the downward compatible attribute is specified for the output load module, the SYSLMOD record size is forced to 1K no matter what device is used.

As stated previously, the load module buffer must be large enough to hold the largest load module input record, or a record from the intermediate data set (SYSUT1). In addition, the buffer must be at least 6K or twice the desired record size for SYSLMOD. Table 6 shows the load module buffer area for each SYSLMOD and SYSUT1 record size. The record size specified for SYSLMOD and the maximum record size for SYSUT1 should be compatible; that is, one should be a multiple of the other. If the sizes specified are not compatible, the linkage editor reduces the larger size until it becomes a multiple of the smaller one or equal to it. For example, if the desired SYSLMOD record size is 6K and the maximum SYSUT1 record size is 4K, the linkage editor reduces the SYSLMOD record size to 4K.

Table 6. Load Module Buffer Area and SYSLMOD and SYSUT1 Record Sizes (Part 1 of 3)

SYSLMOD Record Size		SYSUT1 Record Size		Minimum Load Module Buffer Area ($value_2$)
Device Used	Maximum Record Size Produced	Device Used	Maximum Record Size Produced	
IBM 2321	1K	2321	1K	6K
		2311	3K	
		2302,2303	4K	
		2314,2319	6K	
		3330	12K	14K
		2305	13K	15K
		2301	18K	20K
IBM 2311	3K	2321	1K	6K
		2311	3K	
		2302,2303	3K[2]	
		2314,2319	6K	
		3330	12K	18K
		2305	12K[2]	
		2301	18K	24K

Notes:
[1]The SYSLMOD record size is reduced to less than the maximum to make it compatible with the SYSUT1 record size.
[2]The SYSUT1 record size is reduced to less than the maximum to make it compatible with the SYSLMOD record size.

Table 6. Load Module Buffer Area and SYSLMOD and SYSUT1 Record Sizes (Part 2 of 3)

SYSLMOD Record Size		SYSUT1 Record Size		Minimum Load Module Buffer Area ($value_2$)
Device Used	Maximum Record Size Produced	Device Used	Maximum Record Size Produced	
IBM 2302, IBM 2303	4K	2321	1K	8K
	3K[1]	2311	3K	
	4K	2302,2303	4K	
		2314,2319	4K	
		3330	12K	20K
		2305	12K[2]	
		2301	16K[2]	24K
IBM 2314, IBM 2319	6K	2321	1K	12K
		2311	3K	
	4K[1]	2302,2303	4K	8K
	6K	2314,2319	6K	12K
		3330	12K	
		2305	12K[2]	
		2301	18K	30K
IBM 3330	12K	2321	1K	24K
		2311	3K	
		2302,2303	4K	
		2314,2319	6K	
		3330	12K	
		2305	12K[2]	
		2301	18K	

Notes:
[1]The SYSLMOD record size is reduced to less than the maximum to make it compatible with the SYSUT1 record size.
[2]The SYSUT1 record size is reduced to less than the maximum to make it compatible with the SYSLMOD record size.

Table 6. Load Module Buffer Area and SYSLMOD and SYSUT1 Record Sizes (Part 3 of 3)

SYSLMOD Record Size		SYSUT1 Record Size		Minimum Load Module Buffer Area ($value_2$)
Device Used	Maximum Record Size Produced	Device Used	Maximum Record Size Produced	
IBM 2305	13K	2321	1K	26K
	12K[1]	2311	3K	24K
		2302,2303	4K	
		2314,2319	6K	
		3330	12K	
	13K	2305	13K	26K
		2301	13K[2]	
IBM 2301	18K	2321	1K	36K
		2311	3K	
	16K[1]	2302,2303	4K	32K
	18K	2314,2319	6K	36K
	12K[1]	3330	12K	24K
	13K[1]	2305	13K	26K
	18K	2301	18K	36K

Notes:
[1]The SYSLMOD record size is reduced to less than the maximum to make it compatible with the SYSUT1 record size.
[2]The SYSUT1 record size is reduced to less than the maximum to make it compatible with the SYSLMOD record size.

The maximum size of any SYSLMOD record is 18K, which is the maximum for the IBM 2301 Drum. In this case, the load module buffer must be 36K for maximum efficiency. If records larger than 3K are written on SYSLMOD, $value_1$ for the 44K design size must be increased above 44K. The 44K editor with 74K for $value_1$ and 36K for $value_2$ is capable of writing 18K records. Therefore, only the 88K and 128K design size editors, using that amount of storage respectively, are capable of writing 18K records, and remaining within their respective design points.

Blocking Factors: After the load module buffer is allocated, the linkage editor allocates other input and output buffers. These buffers are for the primary input data set (SYSLIN), additional input object module data sets, and the diagnostic output data set (SYSPRINT). The input blocking factors (i.e., the number of logical records per one physical record) allowed for these buffers are determined by the linkage editor, based on the amount of storage available.

For most efficient processing, one of three blocking factors may be used: 5, 10, or 40. The one selected depends on the design size used, and the amounts selected for $value_1$ and $value_2$ of the SIZE option. (Intermediate blocking factors of 2 through 4, 6 through 9, and 11 through 39 require SIZE option values for blocking factors of 5, 10, and 40, respectively.) Table 7 contains the minimum for $value_1$ and the maximum for $value_2$ for each design size and blocking factor. If $value_2$ is greater than that given in the table, a corresponding increase should be made to $value_1$. If the blocking factor for input or output records is greater than 5 and $value_2$ has been decreased by the linkage editor, no output is produced.

Table 7. Blocking Factors and Their Relationship to the SIZE Option

Design Size	Blocking Factor		
	5 to 1	10 to 1	40 to 1
44K	SIZE=(44K,6K)	SIZE=(52K,6K)	SIZE=(88K,6K)
88K	SIZE=(88K,44K)	SIZE=(88K,36K)	SIZE=(88K,8K)
128K	SIZE=(128K,62K)	SIZE=(128K,56K)	SIZE=(128K,24K)

For example, assume that the load module buffer is to be 12K, and that the input records on SYSLIN are blocked 10 to 1. If the 44K design size is used, the corresponding SIZE option must have the following new values:

SIZE=(58K,12K)

The blocking factor for SYSPRINT and the object module buffers will also be 10 to 1. If, however, only 50K is available and the appropriate reductions are made in $value_1$ and $value_2$, no output is produced.

DCBS Option

The DCBS option allows the programmer to specify the block size for the SYSLMOD data set in the DCB parameter of the DD statement. If the data set is new, the block size specified by the programmer will be used unless it is larger than the maximum record size for the device. In this case, the linkage editor will use the maximum record size. If the data set is old, either the block size specified by the programmer or the existing block size, whichever is larger, will be used. However, if the block size specified by the programmer is larger than the maximum record size for the device, the linkage editor will use the maximum record size.

The following example shows the use of the DCBS option for a 2314 disk:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,DCBS'
                 .
                 .
                 .
//SYSLMOD  DD    DSNAME=LOADMOD(TEST),DISP=(NEW,KEEP),
//               DCB=(BLKSIZE=3072),...
```

As a result, the linkage editor uses a 3K block size for the output module library.

Note: When the DCBS option is used, a block size must be specified in the DCB parameter of the SYSLMOD DD statement.

OUTPUT OPTIONS

These options control the optional diagnostic output produced by the linkage editor. The programmer can request that the linkage editor produce a list of all control statements and a module map or cross-reference table to help in testing a program. The format of each is described in the chapter "Output from the Linkage Editor."

In addition, the programmer can request that the numbered error/warning messages generated by the linkage editor should appear on the SYSTERM data set as well as on the SYSPRINT data set.

Control Statement Listing Option

To request a control statement listing, code LIST in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='LIST,...'
```

When the LIST option is specified, all control statements processed by the linkage editor are listed in card-image format on the diagnostic output data set.

Module Map Option

To request a module map, code MAP in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='MAP,...'
```

When the MAP option is specified, the linkage editor produces a module map of the output module on the diagnostic output data set.

Cross-Reference Table Option

To request a cross-reference table, code XREF in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,...'
```

When the XREF option is specified, the linkage editor produces a cross-reference table of the output module on the diagnostic output data set. The cross-reference table includes a module map; therefore, both XREF and MAP cannot be specified for one linkage editor job step.

Alternate Output (SYSTERM) Option

To request that the numbered linkage editor error/warning messages be generated on the data set defined by a SYSTERM DD statement, code TERM in the PARM field, as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='TERM,...'
```

When the TERM option is specified, a SYSTERM DD statement must be provided. If it is not, the TERM option is negated.

Output specified by the TERM option supplements printed diagnostic information; when TERM is used, linkage editor error/warning messages appear in both output data sets.

INCOMPATIBLE JOB STEP OPTIONS

When mutually exclusive job step options are specified for a linkage editor execution, the linkage editor ignores the less significant options. Figure 34 illustrates the significance of those options that are incompatible. When an X appears at an intersection, the options are incompatible. The option that appears higher in the list is selected.

For example, to check the compatibility of XREF and NE, follow the XREF column down and the NE row across until they intersect. Since an X appears where they intersect, they are incompatible; XREF is selected, NE is negated.

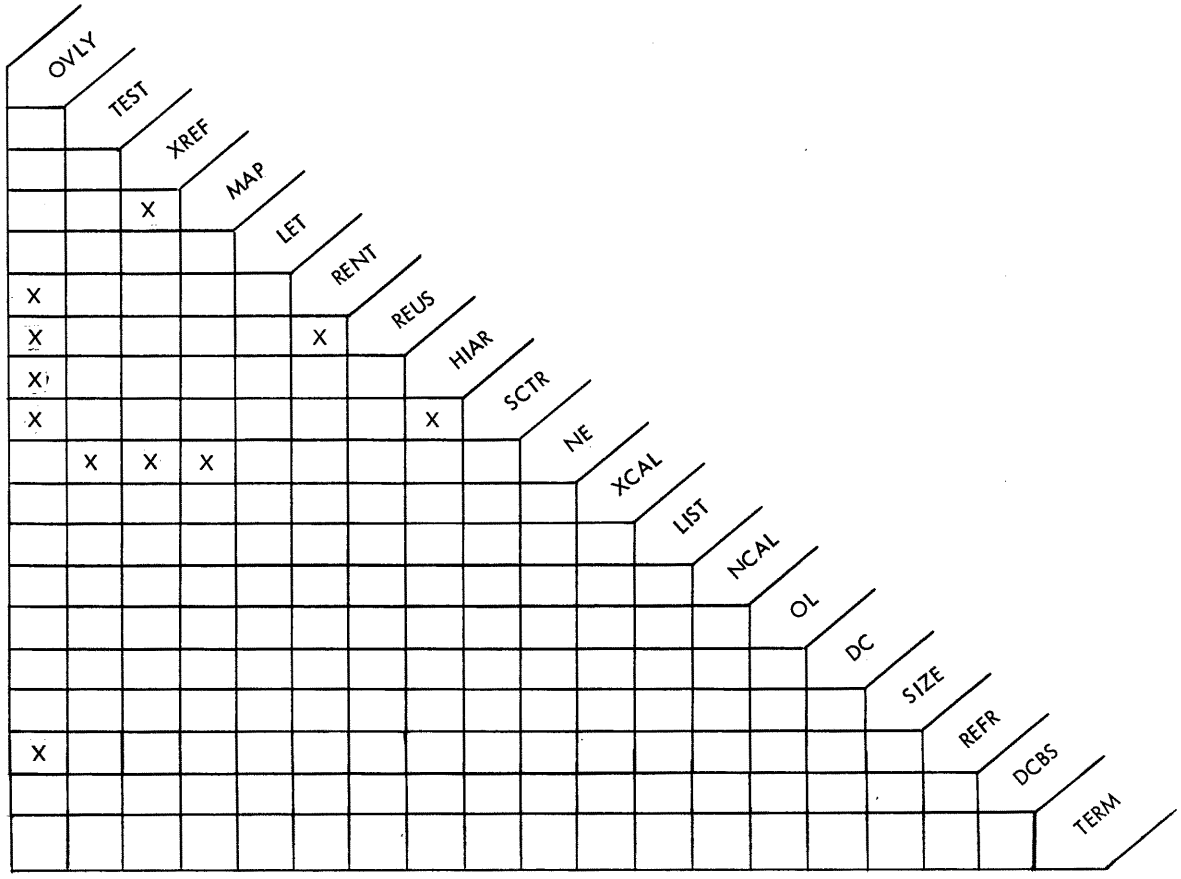


Figure 34. Incompatible Job Step Options for the Linkage Editor

EXEC STATEMENT -- REGION PARAMETER

If the SIZE option is specified with the level F linkage editor, the REGION size, if MVT is used, must be larger than $value_1$. If MFT is used, the partition size must be larger than $value_1$. The increase depends on the design size of the linkage editor used; Table 8 contains the increase for each design size.

For example, if SIZE=(200K,36K) is coded when using the 88K design size, the REGION specified should be at least 208K, that is REGION=208K.

Appendix C contains the minimum storage requirements for the level E linkage editor, and the level F linkage editor without the SIZE option.

Table 8. REGION Increase When the SIZE Option Is Used

Design Size	Increase
44K	10K
88K	8K
128K	8K

EXEC STATEMENT -- RETURN CODE

The linkage editor passes a return code to the control program upon completion of the job step. The return code reflects the highest severity code recorded in any iteration of the linkage editor within that job step. The highest severity code encountered during processing is multiplied by 4 to create the return code; this code is placed into register 15 at the end of linkage editor processing. Table 9 contains the return codes, the corresponding severity code, and a description of each.

The programmer may use this return code to determine whether or not the load module is to be executed by using the condition parameter (COND) on the EXEC statement for the load module. The control program compares the return code with the values specified in the COND parameter, and the results of the comparisons are used to determine subsequent action. The COND parameter may be specified either in the JOB statement or the EXEC statement (see the publication IBM System/360 Operating System: Job Control Language Reference).

Table 9. Linkage Editor Return Codes

Return Code	Severity Code	Description
00	0	Normal conclusion.
04	1	Warning messages have been listed, execution should be successful. For example, if the overlay option is specified and the overlay structure contains only one segment, a return code of 04 is issued.
08	2	Error messages have been listed, execution may fail. The module is marked not executable unless the LET option is specified. For example, if the block size of a specified library data set cannot be handled by the linkage editor, a return code of 08 is issued.
12	3	Severe errors have occurred, execution is impossible. For example, if an invalid entry point has been specified, a return code of 12 is issued.
16	4	Terminal errors have occurred, the processing has terminated. For example, if the level F linkage editor cannot handle the blocking factor requested for SYSPRINT, a return code of 16 is issued.

DD STATEMENTS

Every data set used by the linkage editor must be described with a DD statement. Each DD statement must have a name, unless data sets are concatenated. The DD statements for data sets required by the linkage editor have pre-assigned names; those for additional input data sets have user-assigned names; those for concatenated data sets (after the first) have no names.

In addition to the name, the DD statement provides the control program with information about the input/output device on which the data

set resides, and a description of the data set itself. All of the job control language facilities for device description are available to the users of the linkage editor.

Besides information about the device, the DD statement also contains a data set description, which includes the data set name and its disposition. Information for the data control block (DCB) may also be given.

General information pertinent to the linkage editor on the data set name and DCB information follows; information on disposition is given in the discussion for each data set.

DATA SET NAME: The linkage editor uses either sequential or partitioned data sets. For sequential data sets, only the name of the data set is specified; for partitioned data sets, the member name must also be specified either on the DD statement or with a control statement.

When input data sets are passed from a previous job step, or when the output load module is being tested, a recommended practice is to use temporary data set names (i.e., &&dsname). Use of temporary names ensures that there are no duplicate data sets with out-of-date modules. A data set with a temporary name is automatically deleted at the end of the job. When a module is to be stored permanently, a data set name without ampersands is used.

DCB INFORMATION: Before a data set can be used for input, information describing the data set must be placed in the data control block (DCB). If this information does not exist in the DCB or header label, or if no labels are used (magnetic tape does not require labels), the programmer must specify it in the DCB parameter on the DD statement. (Assembler language programmers may also use the DCB macro instruction.)

Record format (RECFM), logical record size (LRECL), and block size (BLKSIZE) subparameters of the DCB parameter are discussed as they apply to the linkage editor. Specific information on each as it applies to the linkage editor data sets is given in the description of the data set which follows later in this section. Other DCB information (tape recording technique, density, and so forth) is described in the publication IBM System/360 Operating System: Job Control Language Reference.

Record Format: The following record formats are used with the linkage editor:

F -- The records are fixed length.

FB -- The records are fixed length, and blocked.

FBM -- The records are fixed length, blocked, and contain machine code control characters.

FBS -- The records are fixed length, blocked, and written in standard blocks.

FM -- The records are fixed length and contain machine code control characters.

FS -- The records are fixed length and written in standard blocks.

U -- The records are undefined length.

UA -- The records are undefined length and contain USASI control characters.

A record format of FS or FBS must be used with caution. All blocks in the data set must be the same size. This size must be equal to the specified block size. A truncated block can occur only as the last block in the data set.

Logical Record and Block Size: For the level E linkage editor, blocking of input and output data sets is not allowed. That is, LRECL and BLKSIZE must be equal, when both are specified.

For the level F linkage editor, blocking is allowed for input object module data sets and the diagnostic output data set. The blocking factors used to determine buffer allocations are 5, 10, and 40. The BLKSIZE must therefore be a multiple of LRECL. See the description of blocking factors in the discussion of the SIZE option.

Also, with the level F linkage editor, a block size may be specified for the output load module library when the DCBS option is specified (see "SYSLMOD DD Statement" later in this section).

LINKAGE EDITOR DD STATEMENTS

The linkage editor uses six data sets; of these, four are required. The DD statements for these data sets must use the preassigned ddnames given in Table 10. The descriptions that follow give pertinent device and data set information for each linkage editor data set.

Table 10. Linkage Editor ddnames

Data Set	ddname	Required
Primary input data set	SYSLIN	Yes
Automatic call library	SYSLIB	Only if the automatic library call mechanism is used
Intermediate data set	SYSUT1	Yes
Diagnostic output data set	SYSPRINT	Yes
Output module library	SYSLMOD	Yes
Alternate output data set	SYSTERM	Only if the TERM option is specified

SYSLIN DD Statement

The SYSLIN DD statement is always required; it describes the primary input data set which can be assigned to a direct access device, a magnetic tape unit, or the card reader. The data set may be either sequential or partitioned; in the latter case, a member name must be specified.

This data set must contain object modules and/or control statements. Load modules used in the primary input data set are considered a severity 4 error.

The recommended disposition for the primary input data set is SHR or OLD.

The DCB requirements depend on the editor used. These requirements are shown in Table 11.

Table 11. DCB Requirements for Object Module and Control Statement Input

Level Editor Used	DCB Requirements		
	LRECL	BLKSIZE	RECFM
E	80	80	F,FS
F	80	80	F,FS
		400,800,3200*	FB,FBS

*These are the maximum block sizes allowed. Which maximum is applicable depends on the size of the linkage editor and the values given to $value_1$ and $value_2$. See Table 7 for more detail.

SYSLIB DD Statement

The SYSLIB DD statement is required when the automatic library call mechanism is to be used. This DD statement describes the automatic call library, which must be assigned to a direct-access device. The data set must be partitioned, but member names should not be specified.

The recommended disposition for the call library is SHR or OLD.

If concatenated call libraries are used, object and load module libraries must not be mixed. If only object modules are used, the call library may also contain control statements.

The DCB requirements for object module call libraries are given in Table 11. The DCB requirement for load module call libraries is a record format of U; the block size used for storage allocation is equal to the maximum for the device used, not the record read.

SYSUT1 DD Statement

The SYSUT1 DD statement is always required; it describes the intermediate data set, which is a sequential data set assigned to a direct access device. Space must be allocated for this data set but the DCB requirements are supplied by the linkage editor.

SYSPRINT DD Statement

The SYSPRINT DD statement is always required; it describes the diagnostic output data set, which is a sequential data set assigned to a printer or an intermediate storage device. If an intermediate storage device is used, the data records contain a carriage control character as the first byte.

The usual specification for this data set is SYSOUT=A. The system assigns the device and DCB requirements, except for the level F editor. When this editor is used, the programmer may assign a block size if he is running under an MFT or MVT system. The record format assigned by the linkage editor depends on whether blocking is used or not.

Table 12 shows the DCB requirements for SYSPRINT, both level E and level F. The shaded areas represent information supplied by the linkage editor. The only information that can be supplied by the programmer is the block size for the level F linkage editor.

Table 12. DCB Requirements for SYSPRINT

Level Editor Used	DCB Requirements		
	LRECL	BLKSIZE[1]	RECFM
E	121	121	UA
F	121	121	FM
	121	605,1210,4840[2]	FBM

[1]The value specified for BLKSIZE, either on the DCB parameter of the SYSPRINT DD statement or in the DSCB (data set control block) of an existing data set, must be a multiple of 121; if it is not, the linkage editor issues a message to the operator's console and terminates processing.

[2]These are the maximum block sizes allowed. Which maximum is applicable depends on the size of the linkage editor and the values given to $value_1$ and $value_2$. See Table 7 for more detail.

SYSLMOD DD Statement

The SYSLMOD DD statement is always required; it describes the output module library, which must be a partitioned data set assigned to a direct-access device. A member name must be specified, either on the SYSLMOD DD statement or on a NAME control statement.

If the member is to replace an identically named member in an existing library, the disposition should be OLD. If the member is to be added to an existing library, the disposition should be MOD. If no library exists and the member is the first to be added to a new library, the disposition should be NEW. If the member is to be added to an existing library that may be used concurrently in another region or partition (level F editor only), the disposition should be SHR.

For the level E editor, the maximum logical record size and block size is equal to 1K, with a record format of U. These values are assigned by the linkage editor.

For the level F editor, the record format is U. The logical record and block sizes are equal to (1) the maximum track size for the device or (2) one-half of the number specified for $value_2$ of the SIZE option, whichever is smaller. These are the values assigned by the linkage editor unless one of the following conditions exists:

- The DCBS option is specified on the EXEC statement, in which case the programmer must supply a block size in the DCB parameter. The linkage editor then uses either the programmer-specified block size, or the maximum size allowed by the device, whichever is smaller.

- The DC option is specified on the EXEC statement, in which case the logical record and block sizes are forced to 1K to allow reprocessing by the level E editor.

These conditions apply to both old and new data sets. For an old data set, the existing block size in the DSCB (data set control block) will be changed only if the value specified in the DCB parameter is greater than the existing value.

In the following example, the SYSLMOD DD statement specifies a permanent library on an IBM 2314 Disk Storage Device:

```
//SYSLMOD  DD    DSNAME=USERLIB(TAXES),DISP=MOD,UNIT=2314,...
```

The linkage editor assigns a record format of U, and a logical record and block size of 6K, the maximum for a 2314. However, consider the following example:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,DCBS'
                .
                .
                .
//SYSLMOD  DD    DSNAME=USERLIB(TAXES),DISP=MOD,UNIT=2314,
//              DCB=(BLKSIZE=3072),...
```

The linkage editor still assigns a record format of U, but the logical record and block size are now 3K rather than 6K, due to the use of the DCBS option.

SYSTERM DD Statement

The SYSTERM DD statement is optional; it describes a data set that is used only for numbered error/warning messages. Although intended to define the terminal data set when the linkage editor is being used under the Time Sharing Option (TSO) of the operating system, the SYSTERM DD statement can be used in any environment to define a data set consisting of numbered error/warning messages that supplements the SYSPRINT data set.

SYSTERM output is defined by including a SYSTERM DD statement and specifying TERM in the PARM field of the EXEC statement. When SYSTERM output is defined, numbered messages are then written to both the SYSTERM and SYSPRINT data sets.

The following example shows how the SYSTERM DD statement could be used to specify the system output unit:

```
//SYSTERM  DD    SYSOUT=A
```

The DCB requirements for SYSTERM (LRECL=121 and BLKSIZE=121) are supplied by the linkage editor. If necessary, the linkage editor will modify the DSCB (data set control block) of an existing data set to reflect these values.

ADDITIONAL DD STATEMENTS

Each ddname specified on an INCLUDE or LIBRARY control statement must also be described with a DD statement. These DD statements describe sequential or partitioned data sets, assigned to magnetic tape units or direct access devices.

The ddnames are specified by the user along with any other necessary information. The DCB requirements for these data sets are shown in Table 13.

When concatenated data sets are included, each data set must contain records of the same format, record size, and block size. If the data sets reside on magnetic tape, the tape recording technique and density must also be identical.

Table 13. DCB Requirements for Additional Input Data Sets

Level Editor Used	Data Set Contents	DCB Requirements		
		LRECL	BLKSIZE	RECFM
E	Object modules and/or control statements	80	80	F,FS
	Load modules	1K	1K	U
F	Object modules and/or control statements	80	80	F,FS
			400,800,3200*	FB,FBS
	Load modules	maximum for device, or one-half of $value_2$, whichever is smaller	equal to LRECL	U

*These are the maximum block sizes allowed. Which maximum is applicable depends on the size of the linkage editor and the values given to $value_1$ and $value_2$. See Table 7 for more detail.

CATALOGED PROCEDURES

To facilitate the operation of the system, the control program allows the programmer to store EXEC and DD statements under a unique member name in a procedure library. Such a series of job control language statements is called a cataloged procedure. These job control language statements can be recalled at any time to specify the requirements for a job. To request this procedure, the programmer places an EXEC statement in the input stream. The EXEC statement specifies the unique member name of the procedure desired.

The specifications in a cataloged procedure can be temporarily overridden, and DD statements can be added. The information altered by the programmer is in effect only for the duration of the job step; the cataloged procedures themselves are not altered permanently. Any additional DD statements supplied by the programmer must follow those that override the cataloged procedure.

LINKAGE EDITOR CATALOGED PROCEDURES

Two linkage editor cataloged procedures are provided: a single-step procedure that link edits the input and produces a load module (procedure LKED), and a two-step procedure that link edits the input, produces a load module, and executes that module (procedure LKEDG). Many of the cataloged procedures provided for language translators also contain linkage editor steps. The EXEC and DD statement specifications in these steps are similar to the specifications in the cataloged procedures described in the following paragraphs.

Procedure LKED

The cataloged procedure named LKED is a single-step procedure that link edits the input, produces a load module, and passes the load module to another step in the same job. The statements in this procedure are shown in Figure 35: the following is a description of those statements.

Statement Numbers: The 8-digit numbers on the right-hand side of each statement are used to identify each statement and would be used, for example, when permanently modifying the cataloged procedure with the system utility program IEBUPDTE. For a description of this utility program, see the publication IBM System/360 Operating System: Utilities.

EXEC Statement: The PARM field specifies the XREF, LIST, LET, and NCAL options. If the automatic library call mechanism is to be used, the NCAL option must be overridden, and a SYSLIB DD statement must be added. Overriding and adding DD statements is discussed later in this section.

The program name IEWL requests the largest linkage editor available in the system. If the 128K design size of the level F editor is present, a larger REGION must be specified, at least 136K. This is done by overriding the REGION specification of 96K with a specification of REGION=136K.

SYSPRINT Statement: The SYSPRINT DD statement specifies the SYSOUT class A, which is either a printer or an intermediate storage device. If an intermediate storage device is used, a carriage control character precedes the data. The carriage control characters are USASI characters for the level E editor, and machine code for the level F editor.

SYSLIN Statement: The specification of DDNAME=SYSIN allows the programmer to specify any input data set as long as it fulfills the requirements for linkage editor input. The input data set must be defined with a DD statement with the ddname SYSIN. This data set may be either in the input stream or residing on a separate volume.

If the data set is in the input stream, the following SYSIN statement is used:

```
//LKED.SYSIN    DD    *
```

If this SYSIN statement is used, it must be the last DD statement in the job step. The object module decks and/or control statements must follow the SYSIN statement, with a delimiter statement (/*) at the end of the input.

If the data set resides on a separate volume, the following SYSIN statement is used:

```
//LKED.SYSIN    DD    parameters describing an input data set
```

If this SYSIN statement is used, it may be anywhere in the job step DD statements as long as it follows all overriding DD statements. Several data sets may be concatenated as described in the chapter "Input to the Linkage Editor."

SYSLMOD Statement: The SYSLMOD DD statement specifies a temporary data set and a general space allocation. The disposition allows the next job step to execute the load module. If the load module is to reside permanently in a library, these general specifications must be overridden.

SYSUT1 Statement: The SYSUT1 DD statement specifies that the intermediate data set is to reside on a direct-access device, but not the same device as either the SYSLMOD or the SYSLIN data sets. Again, a general space allocation is given.

SYSLIB Statement: Note that there is no SYSLIB DD statement. If the automatic library call mechanism is to be used with a cataloged procedure, a SYSLIB DD statement must be added; also, the NCAL option in the PARM field of the EXEC statement must be negated.

```
//LKED     EXEC PGM=IEWL,PARM='XREF,LIST,LET,NCAL',REGION=96K 00020000
//SYSPRINT DD   SYSOUT=A                                       00040000
//SYSLIN   DD   DDNAME=SYSIN                                   00060000
//SYSLMOD  DD   DSNAME=&&GOSET(GO),SPACE=(1024,(50,20,1)),    C00080000
//             UNIT=SYSDA,DISP=(MOD,PASS)                      00100000
//SYSUT1   DD   UNIT=(SYSDA,SEP=(SYSLMOD,SYSLIN)),            C00120000
//             SPACE=(1024,(200,20))                           00140000
```

Figure 35. Statements in the LKED Cataloged Procedure

Invoking the LKED Procedure: To invoke the LKED procedure, code the following EXEC statement:

```
//stepname EXEC  LKED
```

where stepname is optional and is the name of the job step.

The following example shows the use of the SYSIN DD * statement:

```
Step A:   //LESTEP      EXEC   LKED
          ┌-------------------------------------------------------┐
          |Overriding and additional DD statements for the        |
          |LKED step, each beginning //LKED.ddname...             |
          └-------------------------------------------------------┘
           //LKED.SYSIN  DD     *
          ┌-------------------------------------------------------┐
          |Object module decks and/or control statements          |
          └-------------------------------------------------------┘
           /*
Step B:   //EXSTEP      EXEC   PGM=*.LESTEP.LKED.SYSLMOD
          ┌-------------------------------------------------------┐
          |DD statements and data for load module execution       |
          └-------------------------------------------------------┘
```

If data is supplied for the execution step, the data must be followed by a /* delimiter statement.

Step A invokes the LKED procedure and Step B executes the load module produced in Step A. The job control language statements for these two steps are combined in LKEDG cataloged procedure.

Procedure LKEDG

The cataloged procedure named LKEDG is a two-step procedure that link edits the input, produces a load module, and executes that load module. The statements in this procedure are shown in Figure 36. The two steps are named LKED and GO. The specifications in the statements in the LKED step are identical to the specifications in the LKED procedure.

GO Step: The EXEC statement specifies that the program to be executed is the load module produced in the LKED step of this job. This module was stored in the data set described on the SYSLMOD DD statement in that step. (If a NAME statement was used to specify a member name other than that used on the SYSLMOD statement, use the LKED procedure.)

The condition parameter specifies that the execution step is bypassed if the return code issued by the LKED step is greater than 4. If the LET option is to be effective, the condition parameter must be overridden. The new condition parameter must specify that the execution step is bypassed if 8 is less than the return code issued. That is, COND=(8,LT,LKED) must be specified.

```
//LKED     EXEC PGM=IEWL,PARM='XREF,LIST,LET,NCAL',REGION=96K 00020000
//SYSPRINT DD   SYSOUT=A                                       00040000
//SYSLIN   DD   DDNAME=SYSIN                                   00060000
//SYSLMOD  DD   DSNAME=&&GOSET(GO),SPACE=(1024,(50,20,1)),    C00080000
//             UNIT=SYSDA,DISP=(MOD,PASS)                      00100000
//SYSUT1   DD   UNIT=(SYSDA,SEP=(SYSLMOD,SYSLIN)),            C00120000
//             SPACE=(1024,(200,20))                           00140000
//GO       EXEC PGM=*.LKED.SYSLMOD,COND=(4,LT,LKED)            00160000
```

Figure 36. Statements in the LKEDG Cataloged Procedure

Invoking the LKEDG Procedure: To invoke the LKEDG procedure, code the following EXEC statement:

```
//stepname EXEC  LKEDG
```

where stepname is optional and is the name of the job step.

The following example shows the use of the SYSIN DD * statement with the LKED procedure:

```
//TWOSTEP  EXEC  LKEDG
+-----------------------------------------------------------------+
|Overriding and additional DD statements for the LKED step, each  |
|beginning //LKED.ddname ...                                      |
+-----------------------------------------------------------------+
//LKED.SYSIN  DD     *
+-----------------------------------------------------------------+
|Object module decks and/or control statements                    |
+-----------------------------------------------------------------+
/*
+-----------------------------------------------------------------+
|DD statements for the GO step, each beginning //GO.ddname ...    |
+-----------------------------------------------------------------+
//GO.SYSIN    DD     *
+-----------------------------------------------------------------+
|Data for the GO step                                             |
+-----------------------------------------------------------------+
/*
```

OVERRIDING CATALOGED PROCEDURES

The programmer may override any of the EXEC or DD statement specifications in a cataloged procedure. These new specifications remain in effect only for the duration of the job step. For a detailed description of overriding cataloged procedures, see the publication IBM System/360 Operating System: Job Control Language Reference.

Overriding the EXEC Statement

The EXEC statement in a cataloged procedure is overridden by specifying the changes and additions on the EXEC statement that invokes

the cataloged procedure. The stepname should be specified when overriding the EXEC statement parameters.

For example, the REGION parameter can be increased for the 128K design size of the level F editor as follows:

```
//LESTEP   EXEC  LKED,REGION.LKED=136K
```

The rest of the specifications on the EXEC statement of procedure LKED remain in effect.

If the PARM field is to be overridden, all of the options specified in the cataloged procedure are negated. That is, if XREF, LIST, LET, or NCAL is desired when overriding the PARM field, they must be respecified. In the following example, the OVLY option is added and the NCAL option is negated:

```
//LESTEP   EXEC  LKED,PARM.LKED='OVLY,XREF,LIST,LET'
```

As a result, the XREF, LIST, and LET options are retained, but the NCAL option is negated; when NCAL is negated, a SYSLIB DD statement must be added.

If procedure LKEDG is used, and the LET option is to be effective, the condition parameter of the GO step must be overridden, as follows:

```
//LEEX     EXEC  LKEDG,COND.GO=(8,LT,LKED)
```

Overriding DD Statements

Any of the DD statements in the cataloged procedures can be overridden as long as the overriding DD statements are in the same order as they appear in the procedure. If any DD statements are not overridden, or overriding DD statements are included but are not in sequence, the specifications in the cataloged procedure are used.

Only those parameters specified on the overriding DD statement are affected; the rest of the parameters remain as specified in the procedure. In the following example, the output load module is to be placed in a permanent library:

```
//LIBUPDTE       EXEC  LKED
//LKED.SYSLMOD   DD    DSNAME=LOADLIB(PAYROLL),DISP=OLD
//LKED.SYSIN     DD    DSNAME=OBJMOD,DISP=(OLD,DELETE)
```

Unit and volume information should be given if these data sets are not cataloged.

As a result of the statements in the example, the LKED procedure is used to process the object module in the OBJMOD data set. The output load module is stored in the data set LOADLIB with the name PAYROLL. The SPACE parameter on the SYSLMOD DD statement and the other specifications in the procedure remain in effect.

ADDING DD STATEMENTS

The DD statements for additional data sets can be supplied when using cataloged procedures. These additional DD statements must follow any overriding DD statements, and must precede a DD * statement.

In the following example, the automatic library call mechanism is to be used along with the LKEDG procedure:

```
//CPSTEP          EXEC  LKEDG,PARM.LKED='XREF,LIST'
//LKED.SYSLMOD    DD    DSNAME=LOADLIB(TESTER),DISP=OLD,...
//LKED.SYSLIB     DD    DSNAME=SYS1.PL1LIB,DISP=SHR
//LKED.SYSIN      DD    *
┌-------------------------------------------------------------------┐
|Object module decks and/or control statements                      |
└-------------------------------------------------------------------┘
/*
//GO.SYSIN        DD    *
┌-------------------------------------------------------------------┐
|Data for execution step                                            |
└-------------------------------------------------------------------┘
/*
```

The NCAL option is negated, and a SYSLIB DD statement is added between the overriding SYSLMOD DD statement and the SYSIN DD statement.

LINKAGE EDITOR CONTROL STATEMENT SUMMARY

This chapter summarizes the linkage editor control statements. The description of each statement includes:

- What the statement does
- The format of the statement
- Placement of the statement in the input
- Notes on use, if any
- One or more examples that include job control language statements, when necessary.

The control statements are described in alphabetical order. Before using this chapter, the user should be familiar with the following information on general format, format conventions, and placement.

General Format

Each linkage editor control statement specifies an operation and one or more operands. Nothing must be written preceding the operation, which must begin in or after column 2. The operation must be separated from the operand by one or more blanks.

A control statement can be continued on as many cards as necessary by terminating the operand at a comma, and by placing a nonblank character in column 72 of the card. Continuation must begin in column 16 of the next card. A symbol cannot be split; that is, it cannot begin on one card and be continued on the next.

Format Conventions

The following conventions are used in the formats to describe the coding of the linkage editor control statements:

- Upper-case letters and words must be coded exactly as shown.
- Lower-case letters and words represent variables for which specified information is substituted.
- Parentheses, commas, and asterisks, when shown, are required.
- Items within braces, { }, are required and must be specified.

- Items within brackets, [ ], are optional and may be omitted.
- Stacked items, enclosed in either braces or brackets, represent alternative items; only one item should be specified.
- The ellipsis (...) indicates that the preceding unit may occur once, or any number of times in succession.

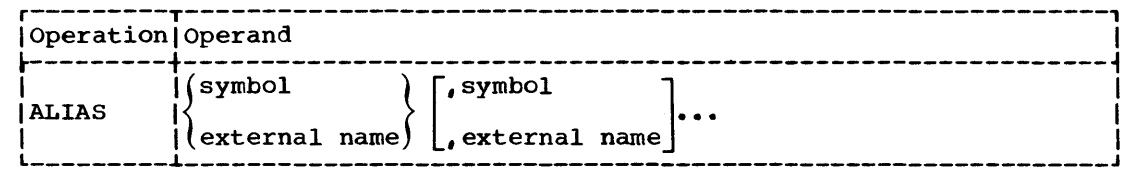
Placement Information

Linkage editor control statements are placed before, between, or after modules. They can be grouped, but they cannot be placed within a module. However, specific placement restrictions may be imposed by the nature of the functions being requested by the control statement. Any placement restrictions are noted.

ALIAS Statement

The ALIAS statement specifies additional names for the output library member, and can also specify names of alternative entry points. Up to 16 names can be specified on one ALIAS statement, or separate ALIAS statements for one library member. The names are entered in the directory of the partitioned data set in addition to the member name.

Format: The format of the ALIAS statement is:



symbol
: specifies an alternate name for the load module. When the module is executed, the main entry point is used as the starting point for execution.

external name
: specifies a name that is defined as a control section name or entry name in the output module. When the module is called for execution, execution begins at the external name referred to.

Placement: An ALIAS statement can be placed before, between, or after object modules or other control statements. It must precede a NAME statement used to specify the member name, if one is present.

Notes:

- In an overlay program, an external name specified by the ALIAS statement must be in the root segment.
- No more than 16 alias names can be assigned to one output module.
- Each alias specified for a load module is retained in the directory entry for the module; the linkage editor does not delete an old alias. Therefore, each alias that is specified must be unique; assigning the same alias to more than one load module can cause incorrect module reference.

Example: An output module, ROUT1, is to be assigned two alternate entry points, CODE1 and CODE2. In addition, calling modules have been written using both ROUT1 and ROUTONE to refer to the output module. Rather than correct the calling modules, an alternative library member name is also assigned.

```
ALIAS       CODE1,CODE2,ROUTONE
NAME        ROUT1
```

Since CODE1 and CODE2 are entry names in the output module, when these names are used to call the module, execution begins at the point referred to. The modules that call the output module with the name ROUTONE now correctly refer to ROUT1 at its main entry point. The names CODE1, CODE2, and ROUTONE appear in the library directory along with ROUT1.

CHANGE Statement

The CHANGE statement causes an external symbol to be replaced by the symbol in parentheses following the external symbol. The external symbol to be changed can be a control section name, an entry name, or an external reference. More than one such substitution may be specified in one CHANGE statement.

Format: The format of the CHANGE statement is:

Operation	Operand
CHANGE	externalsymbol(newsymbol)[,externalsymbol(newsymbol)]...

externalsymbol
is the control section name, entry name, or external reference that is to be changed.

newsymbol
is the name to which the external symbol is to be changed.

Placement: The CHANGE control statement must be placed immediately before either the module containing the external symbol to be changed, or the INCLUDE control statement specifying the module.

Notes:

- External references from other modules to a changed control section name or entry name remain unresolved unless further action is taken.
- If the symbol specified on the CHANGE statement is inadvertently misspelled, the symbol will not be changed. Linkage editor output, such as the cross-reference listing or module map, can be used to verify each change.

Example 1: Two control sections in different modules have the name TAXROUT. Since both modules are to be link edited together, one of the control section names must be changed. The module to be changed is defined with a DD statement named OBJMOD. The control section name could be changed as follows:

```
//OBJMOD   DD    DSNAME=TAXES,DISP=(OLD,KEEP),...
//SYSLIN   DD    *
  CHANGE TAXROUT(STATETAX)
  INCLUDE OBJMOD
/*
```

As a result, the name of control section TAXROUT in module TAXES is changed to STATETAX. Any references to TAXROUT from other modules are not affected.

Example 2: A load module contains references to TAXROUT that must now be changed to STATETAX. This module is defined with a DD statement named LOADMOD. The external references could be changed at the same time the control section name is changed, as follows:

```
//OBJMOD   DD    DSNAME=TAXES,DISP=(OLD,DELETE),...
//LOADMOD  DD    DSNAME=LOADLIB,DISP=OLD,...
//SYSLIN   DD    *
  CHANGE TAXROUT(STATETAX)
  INCLUDE OBJMOD
  CHANGE TAXROUT(STATETAX)
  INCLUDE LOADMOD(INVENTRY)
/*
```

As a result, control section name TAXROUT in module TAXES and external reference TAXROUT in module INVENTRY are both changed to STATETAX. Any references to TAXROUT from other modules are not affected.

ENTRY Statement

The ENTRY statement specifies the symbolic name of the first instruction to be executed when the program is called by its module name for execution. An ENTRY statement should be used whenever a module is reprocessed by the linkage editor. If more than one ENTRY statement is encountered, the first statement specifies the main entry point; all other ENTRY statements are ignored.

Format: The format of the ENTRY statement is:

Operation	Operand
ENTRY	externalname

externalname
is defined as either a control section name or an entry name in a linkage editor input module.

Placement: An ENTRY statement can be placed before, between, or after object modules or other control statements. It must precede the NAME statement for the module, if one is present.

Notes:

- In an overlay program, the first instruction to be executed must be in the root segment.
- The external name specified must be the name of an instruction, not a data name.

Example: In the following example, the main entry point is INIT1:

```
//LOADLIB  DD    DSNAME=LOADLIB,DISP=OLD,...
//SYSLIN   DD    *
  ENTRY INIT1
  INCLUDE LOADLIB(READ,WRITE)
     .
     .
     .
  ENTRY READIN
/*
```

INIT1 must be either a control section name or an entry name in the linkage editor input. The entry point specification of READIN is ignored.

HIARCHY Statement

The HIARCHY statement assigns one or more control sections to a specific storage hierarchy. This provides addressing distinction between processor storage (hierarchy 0) and IBM 2361 Core Storage (hierarchy 1). Only one storage hierarchy may be specified on each HIARCHY statement. All control sections not named in a HIARCHY statement are marked for loading into processor storage. If a control section is named on more than one HIARCHY statement, the last statement processed with the control section name is used to assign a hierarchy.

Format: The format of the HIARCHY statement is:

Operation	Operand
HIARCHY	number,csectname[,csectname]...

number
specifies a storage hierarchy and may be either of the following values:

0 for processor storage
1 for IBM 2361 Core Storage

csectname
is the name of the control section to be assigned to the storage hierarchy.

Placement: A HIARCHY statement can be placed before, between, or after object modules or other control statements.

Notes:

- The HIAR attribute must be specified on the EXEC statement when HIARCHY statements are used.
- If a HIARCHY statement is encountered during the processing of an overlay program, the HIARCHY statement is ignored.
- Any hierarchy assignment for one or more control sections that is specified on a LINK, LOAD, XCTL, or ATTACH macro instruction overrides any assignment made on a HIARCHY statement.

Example: A program contains three control sections (MAINMOD, COMPROUT, and SUBROUT); two control sections (COMPROUT and SUBROUT) are to be assigned to IBM 2361 Core Storage. This could be accomplished as follows:

```
//LKED     EXEC  PGM=IEWL,PARM='HIAR,XREF,LET'
               .
               .
               .
//SYSLIN   DD    *
  HIARCHY 1,COMPROUT,SUBROUT
/*
```

Control section MAINMOD, which does not have a hierarchy specified for it, is assigned to processor storage (hierarchy 0).

IDENTIFY Statement

The IDENTIFY statement specifies any data supplied by the user to be entered into the CSECT Identification (IDR) records for a particular control section. The statement can be used either to supply descriptive data for a control section or to provide a means of associating system-supplied data with executable code.

Format: The format of the IDENTIFY statement is:

Operation	Operand
IDENTIFY	csectname('data')[,csectname('data')]...

csectname
: is the symbolic name of the control section to be identified.

data
: specifies up to 40 EBCDIC characters of identifying information. The user may supply any information desired for identification purposes.

Placement: An IDENTIFY statement can be placed before, between, or after other control statements or object modules. The IDENTIFY statement must follow the module containing the control section to be identified or the INCLUDE statement specifying the module.

Example: In the following example, IDENTIFY statements are used to identify the source level of a control section, a PTF application to a control section, and the functions of several control sections.

```
//LKED      EXEC   PGM=IEWL
//SYSPRINT  DD     SYSOUT=A
//SYSUT1    DD     UNIT=SYSDA,SPACE=(TRK,(10,5))
//SYSLMOD   DD     DSNAME=LOADSET,DISP=OLD
//OLDMOD    DD     DSNAME=OLD.LOADSET,DISP=OLD
//PTFMOD    DD     DSNAME=PTF.OBJECT,DISP=OLD
//SYSLIN    DD     *

  (input object deck for a control section named FORT)

IDENTIFY    FORT('LEVEL 03')
INCLUDE     PTFMOD(CSECT4)
IDENTIFY    CSECT4('PTF99999')
INCLUDE     OLDMOD(PROG1)
IDENTIFY    CSECT1('I/O ROUTINE'),CSECT2('SORT ROUTINE'),       X
            CSECT3('SCAN ROUTINE')
/*
```

Execution of this example produces IDR records containing the following identification data:

- The name of the linkage editor that produced the load module, the linkage editor version and modification level, and the date of the current linkage editor processing of the module. This information is provided automatically.

- User-supplied data describing the functions of several control sections in the module, as indicated on the third IDENTIFY statement.
- If the language translator used supports IDR, the Identification records produced by the linkage editor also contain the name of the translator that produced the object module, its version and modification level, and the date of compilation.

The IDR records created by the linkage editor can be referenced by using the LISTIDR function of the IMBLIST service aid program. For instructions on how to use IMBLIST, see IBM System/360 Operating System: Service Aids.

INCLUDE Statement

The INCLUDE statement specifies sequential data sets and/or libraries that are to be sources of additional input for the linkage editor. INCLUDE statements are processed in the order in which they appear in the input. However, the sequence of data sets and modules within the output load module does not necessarily follow the order of the INCLUDE statements.

Format: The format of the INCLUDE statement is:

Operation	Operand
INCLUDE	ddname[(membername[,membername]...)] [,ddname[(membername[,membername]...)]...]

ddname
: is the name of a DD statement that describes either a sequential or a partitioned data set to be used as additional input to the linkage editor. For a sequential data set, ddname is all that must be specified. For a partitioned data set, at least one member name must also be specified.

membername
: is the name of or an alias for a member of the library defined in the specified DD statement. The membername must not be specified again on the DD statement.

Placement: An INCLUDE statement can be placed before, between, or after object modules or other control statements.

Note: A NAME statement in any data set specified in an INCLUDE statement is invalid; the NAME statement is ignored. All other control statements are processed.

Example 1: In the following example, an INCLUDE statement specifies two data sets to be the input to the linkage editor:

```
//OBJMOD   DD    DSNAME=&&OBJECT,DISP=(OLD,DELETE)
//LOADMOD  DD    DSNAME=LOADLIB,DISP=SHR,...
                .
                .
                .
//SYSLIN   DD    *
  INCLUDE OBJMOD,LOADMOD(TESTMOD,READMOD)
/*
```

Note that a DD statement must be supplied for every ddname specified in an INCLUDE statement.

Example 2: Two separate INCLUDE statements could have been used in the preceding example, as follows:

```
INCLUDE OBJMOD
INCLUDE LOADMOD(TESTMOD,READMOD)
```

INSERT Statement

The INSERT statement repositions a control section from its position in the input sequence to a segment in an overlay structure. However, the sequence of control sections within a segment is not necessarily the order of the INSERT statements.

If a symbol specified in the operand field of an INSERT statement is not present in the external symbol dictionary, it is entered as an external reference. If the reference has not been resolved at the end of primary input processing, the automatic library call mechanism attempts to resolve it.

Format: The format of the INSERT statement is:

Operation	Operand
INSERT	csectname[,csectname]...

csectname
: is the name of the control section to be repositioned. A particular control section can appear only once within a load module.

Placement: The INSERT statement must be placed in the input sequence following the OVERLAY statement that specifies the origin of the segment in which the control section is to be positioned. If the control section is to be positioned in the root segment, the INSERT statement must be placed before the first OVERLAY statement.

Note: Control sections that are positioned in a segment must contain all address constants to be used during execution unless:

- The A-type address constants are located in a segment in the path.
- The V-type address constants used to pass control to another segment are located in the path. If an exclusive reference is made, the V-type address constant must be in a common segment.
- The V-type address constants used with the SEGLD and SEGWT macro instructions are located in the segment.

Example: The following INSERT (and OVERLAY) statements specify the overlay structure shown in Figure 37:

```
//          EXEC  PGM=IEWL,PARM='OVLY,XREF,LIST'
              .
              .
              .
//SYSLIN    DD    *
  INSERT CSA
  INSERT CSB
  OVERLAY ALPHA
  INSERT CSC,CSD
  OVERLAY ALPHA
  INSERT CSE
/*
```

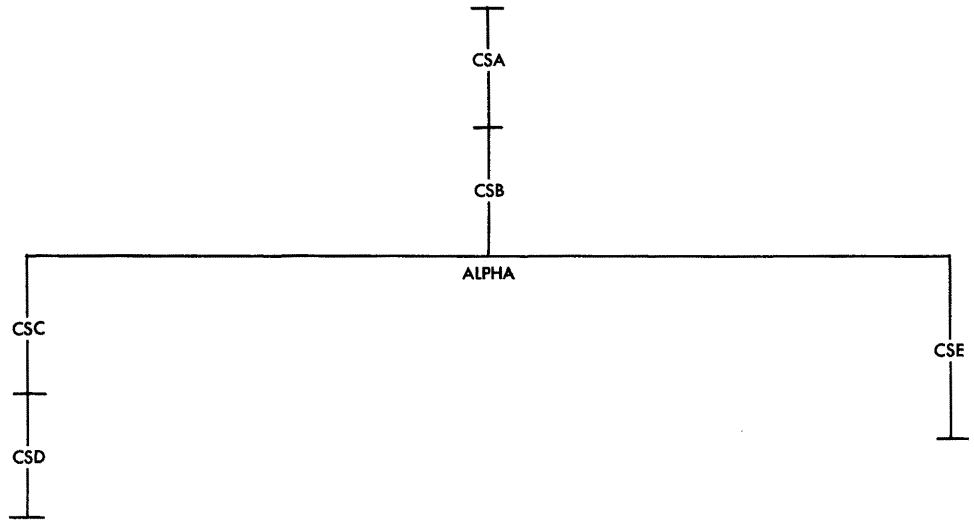


Figure 37. Overlay Structure for INSERT Statement Example

LIBRARY Statement

The LIBRARY statement can be used to specify:

- Additional automatic call libraries, which contain modules used to resolve external references found in the program.
- Restricted no-call function: External references that are not to be resolved by the automatic library call mechanism during the current linkage editor job step.
- Never-call function: External references that are not to be resolved by the automatic library call mechanism during any linkage editor job step.

Combinations of these functions can be written in the same LIBRARY statement.

Format: The format of the LIBRARY statement is:

Operation	Operand
LIBRARY	{ ddname(membername[,membername]...) / (externalreference[,externalreference]...) / *(externalreference[,externalreference]...) },...

ddname
: is the name of a DD statement that defines a library.

membername
: is the name of or an alias for a member of the specified library. Only those members specified are used to resolve references.

externalreference
: is an external reference that may be unresolved after primary input processing. The external reference is not to be resolved by automatic library call.

*
: indicates that the external reference is never to be resolved; if the * (asterisk) is missing, the reference is left unresolved only during the current linkage editor run.

Placement: A LIBRARY statement can be placed before, between, or after object modules or other control statements.

Notes:

- If the unresolved external symbol is not a member name in the library specified, the external reference remains unresolved unless defined in another input module.
- If the NCAL option is specified, the LIBRARY statement cannot be used to specify additional call libraries.

- Members called by automatic library call are placed in the root segment of an overlay program, unless they are repositioned with an INSERT statement.

Example: The following example shows all three uses of the LIBRARY statement:

```
//          EXEC  PGM=IEWL,PARM='LET,XREF,LIST'
//TESTLIB   DD    DSNAME=TEST,DISP=SHR,...
                .
                .
                .
//SYSLIN    DD    *
  LIBRARY TESTLIB(DATA,TIME),(FICACOMP),*(STATETAX)
/*
```

As a result, members DATE and TIME from the additional library TEST are used to resolve external references. FICACOMP and STATETAX are not resolved; however, because the references remain unresolved, the LET option must be specified on the EXEC statement if the module is to be marked executable. In addition, STATETAX will not be resolved in any subsequent reprocessing by the linkage editor.

NAME Statement

The NAME statement specifies the name of the load module created from the preceding input modules, and serves as a delimiter for input to the load module. As a delimiter, the NAME statement allows multiple load module processing in one linkage editor job step. The NAME statement can also indicate that the load module replaces an identically named module in the output module library.

Format: The format of the NAME statement is:

Operation	Operand
NAME	membername[(R)]

membername
: is the name to be assigned to the load module that is created from the preceding input modules.

(R)
: indicates that this load module replaces an identically named module in the output module library. If the module is not a replacement, the parenthesized value (R) should not be specified.

Placement: The NAME statement is placed after the last input module or control statement that is to be used for the output module.

Notes:

- Any ALIAS statement used must precede the NAME statement.
- A NAME statement found in a data set other than the primary input data set is invalid. The statement is ignored.

Example: In the following example, two load modules, RDMOD and WRTMOD, are produced by the linkage editor in one job step:

```
//SYSLMOD  DD    DSNAME=AUXMODS,DISP=MOD,... .
//NEWMOD   DD    DSNAME=&&WRTMOD,DISP=OLD
//SYSLIN   DD    DSNAME=&&RDMOD,DISP=OLD
//         DD    *
  NAME RDMOD(R)
  INCLUDE NEWMOD
  NAME WRTMOD
/*
```

As a result, the first module is named RDMOD and replaces an identically named module in the output module library AUXMODS; the second module is named WRTMOD and is added to the library.

OVERLAY Statement

The OVERLAY statement indicates either the beginning of an overlay segment, or the beginning of an overlay region. Since a segment or a region is not named, the programmer identifies it by giving its origin (or load point) a symbolic name. This name is then used on an OVERLAY statement to signify the start of a new segment or region.

Format: The format of the OVERLAY statement is:

Operation	Operand
OVERLAY	symbol[(REGION)]

symbol
is the symbolic name assigned to the origin of a segment. This symbol is not related to external symbols in a module.

(REGION)
specifies the origin of a new region.

Placement: The OVERLAY statement must precede the first module of the next segment, the INCLUDE statement specifying the first module of the segment, or the INSERT statement specifying the control sections to be positioned in the segment.

Notes:

- The OVLY option must be specified on the EXEC statement when OVERLAY statements are to be used.
- The sequence of OVERLAY statements should reflect the order of the segments in the overlay structure from top to bottom, left to right, and region by region.
- No OVERLAY statement should precede the root segment.

Example: The following OVERLAY and INSERT statements specify the overlay structure in Figure 38.

```
//          EXEC  PGM=IEWL,PARM='OVLY,XREF,LIST'
              .
              .
              .
//SYSLIN    DD    DSNAME=&&OBJ,...
//          DD    *
  INSERT CSA
  OVERLAY ONE
  INSERT CSB
  OVERLAY TWO
  INSERT CSC
  OVERLAY TWO
  INSERT CSD
  OVERLAY ONE
  INSERT CSE,CSF
  OVERLAY THREE(REGION)
  INSERT CSH
  OVERLAY THREE
  INSERT CSI
/*
```

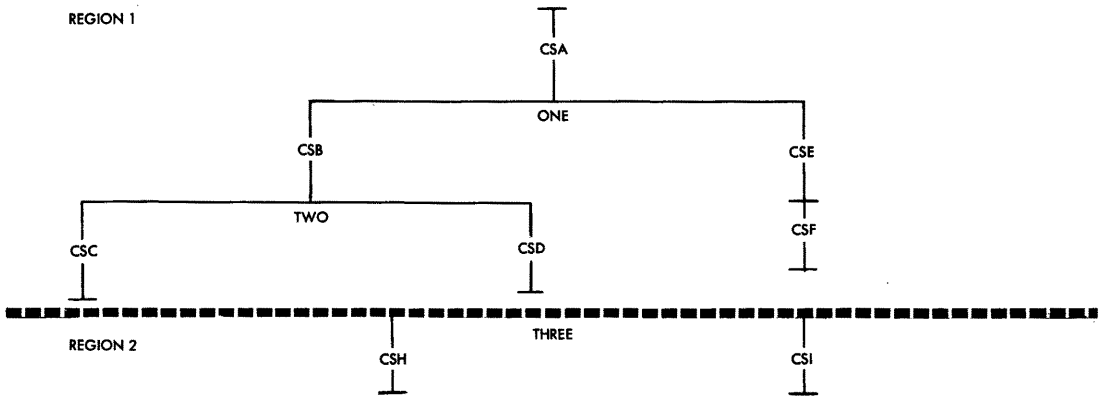


Figure 38. Overlay Structure for OVERLAY Statement Example

REPLACE Statement

The REPLACE statement specifies one of the following:

- The replacement of one control section with another.
- The deletion of a control section.
- The deletion of an entry name.

A REPLACE statement can specify more than one function.

When a control section is replaced, all references within the input module to the old control section are changed to the new control section. Any external references to the old control section from other modules are unresolved unless changed.

When a control section is deleted, the control section name is also deleted from the external symbol dictionary unless references are made to the control section from within the input module. If there are any such references, the control section name is changed to an external reference. External references from other modules to a deleted control section also remain unresolved.

When deleting an entry name, the entry name is changed to an external reference if there are any references to it within the same input module.

Format: The format of the REPLACE statement is:

Operation	Operand
REPLACE	{ csectname-1[(csectname-2)] / entry name },...

csectname
: is the name of a control section. If only csectname-1 is used, the control section is deleted; if csectname-2 is also used, the first control section is replaced with the second.

entry name
: is the entry name to be deleted.

Placement: The REPLACE statement must immediately precede either (1) the module containing the control section or entry name to be replaced or deleted, or (2) the INCLUDE statement specifying the module.

Notes:

- Unresolved external references are not deleted from the output module even though a deleted control section contains the only reference to a symbol.

- When some but not all control sections of a separately assembled module are to be replaced, A-type address constants that refer to a deleted symbol will be incorrectly resolved, unless the entry name is at the same displacement from the origin in both the old and the new control sections.

- If the control section specified on the REPLACE statement is inadvertently misspelled, the control section will not be replaced or deleted. Linkage editor output, such as the cross-reference listing and module map, can be used to verify each change.

Example: In the following example, assume that control section INT7 is in member LOANCOMP and that control section INT8, which is to replace INT7, is in data set &&NEWINT. Also assume that control section PRIME in member LOANCOMP is to be deleted.

```
//NEWMOD   DD    DSNAME=&&NEWINT,DISP=(OLD,DELETE)
//OLDMOD   DD    DSNAME=PVTLIB,DISP=OLD,...
//SYSLIN   DD    *
  ENTRY MAINENT
  INCLUDE NEWMOD
  REPLACE INT7(INT8),PRIME
  INCLUDE OLDMOD(LOANCOMP)
/*
```

As a result, INT7 is removed from the input module described by the OLDMOD DD statement, and INT8 replaces INT7. All references to INT7 in the input module now refer to INT8. Any references to INT7 from other modules remain unresolved. Control section PRIME is deleted; the control section name is also deleted from the external symbol dictionary if there are no references to PRIME in LOANCOMP.

SETSSI Statement

The SETSSI statement specifies hexadecimal information to be placed in the system status index of the directory entry for the output module.

Format: The format for the SETSSI statement is:

Operation	Operand
SETSSI	xxxxxxxx

xxxxxxxx
represents eight hexadecimal characters (0 through 9 and A through F) to be placed in the 4-byte system status index of the output module library directory entry.

Placement: The SETSSI statement can be placed before, between, or after object modules or other control statements. It must precede the NAME statement for the module, if one is present.

Note: A SETSSI statement must be provided whenever an IBM-supplied load module is reprocessed by the linkage editor. If the statement is omitted, no system status index information is present (see the publication IBM System/360 Operating System: Maintenance.)

This appendix contains sample linkage editor programs. The material presented for each program includes a description of the program, the job control language necessary for the linkage editor job step, linkage editor control statements (if any), and the linkage editor output. The sample programs are:

- Link editing a COBOL and a FORTRAN object module (COBFORT).
- Replacing one control section with another by using the REPLACE statement (RPLACJOB).
- Creating a multiple-region overlay program (REGNOVLY).
- Placing the control statements for the multiple region overlay program in a partitioned data set, and using them (PARTDS).

The output for each program includes a cross-reference table and module map, and a control statement listing and diagnostic messages, if any.

SAMPLE PROGRAM COBFORT

Sample program COBFORT link edits a COBOL object module and a FORTRAN object module to form one load module. The source programs were compiled in two steps previous to the linkage editor job step, and the output from each compilation was placed in data set &&OBJMOD.

Job Control Language

The job control language for the linkage editor job step of this sample program is:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF'
//SYSUT1   DD    DSNAME=&&UT1,UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSLIB   DD    DSNAME=SYS1.COBLIB,DISP=SHR
//         DD    DSNAME=SYS1.FORTLIB,DISP=SHR
//SYSLMOD  DD    DSNAME=&&LOADMD(GO),UNIT=SYSDA,DISP=(NEW,PASS),
//               SPACE=(TRK,(100,10,1))
//SYSPRINT DD    SYSOUT=A
//SYSLIN   DD    DSNAME=&&OBJMOD,DISP=(OLD,DELETE)
```

Statement	Explanation
EXEC	Causes the execution of the largest level linkage editor available in the system. The PARM field option requests a cross-reference table and a module map to be produced on the diagnostic output data set.
SYSUT1	Defines a temporary direct-access data set to be used as the intermediate data set.

Statement	Explanation
SYSLIB	Defines the automatic call library; the call libraries for COBOL and FORTRAN are concatenated; both are used to resolve external references.
SYSLMOD	Defines a temporary data set to be used as the output module library; the load module is assigned a member name of GO, and is passed to a subsequent step for execution.
SYSPRINT	Defines the diagnostic output data set, which is assigned to output class A.
SYSLIN	Defines the primary input data set, &&OBJMOD, which contains both input object modules; this data set was passed from a previous job step and is to be deleted at the end of this job step.

Linkage Editor Output

Figure 39 shows the linkage editor output for COBFORT. The listing header indicates the level editor (44K) used, options specified (XREF,LIST), and the SIZE option values used in decimal (65536 for $value_1$ and 6144 for $value_2$). Because XREF is specified, the heading CROSS REFERENCE TABLE precedes the rest of the output.

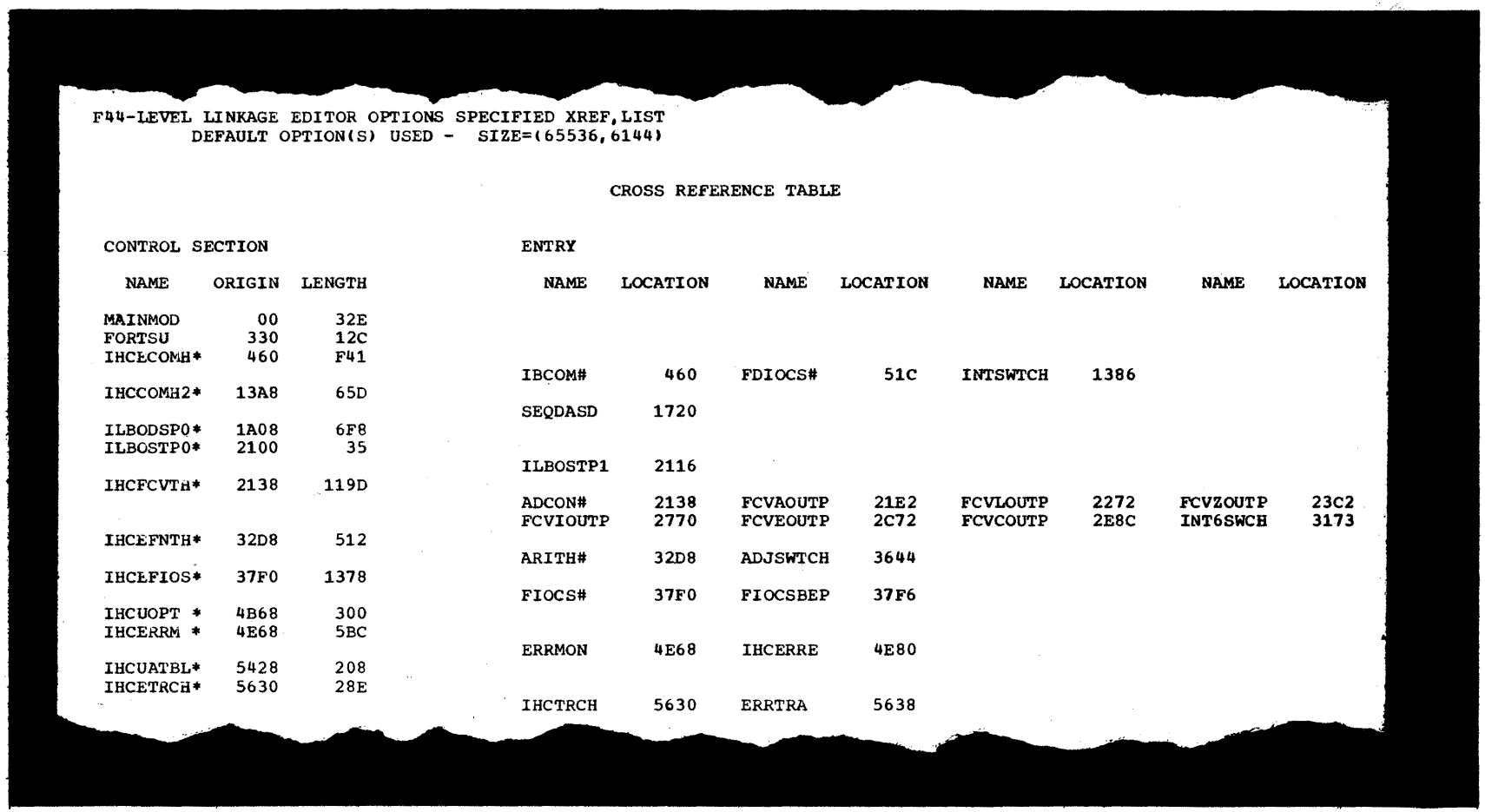
Part 1 of Figure 39 shows the module map for COBFORT. MAINMOD and FORTSU are the names of the input control sections. The rest of the control sections are either from the COBOL automatic call library or from the FORTRAN automatic call library. (They can be distinguished by the initial three letters; ILB indicates a COBOL control section, IHC a FORTRAN control section.) The origin and length (in hexadecimal) of each control section follows the name.

To the right of each control section is a list of the entry names defined in each control section. The location (in hexadecimal) of each entry name is also given. For example, in control section IHCCOMH2 (the asterisk is not a part of the name; it indicates that the control section is from the automatic call library), entry name SEQDASD is defined at location 1720.

Part 2 of Figure 39 shows the cross-reference table for COBFORT. The table contains the location of any address constant that refers to a symbol defined in another control section. The symbol that the address constant refers to is also listed, along with the control section in which the symbol is defined. For example, at location 250 in control section MAINMOD (determined by using the module map; 250 falls between origin 00 and origin 330), an address constant refers to symbol ILBOSTP0, defined in control section ILBOSTP0.

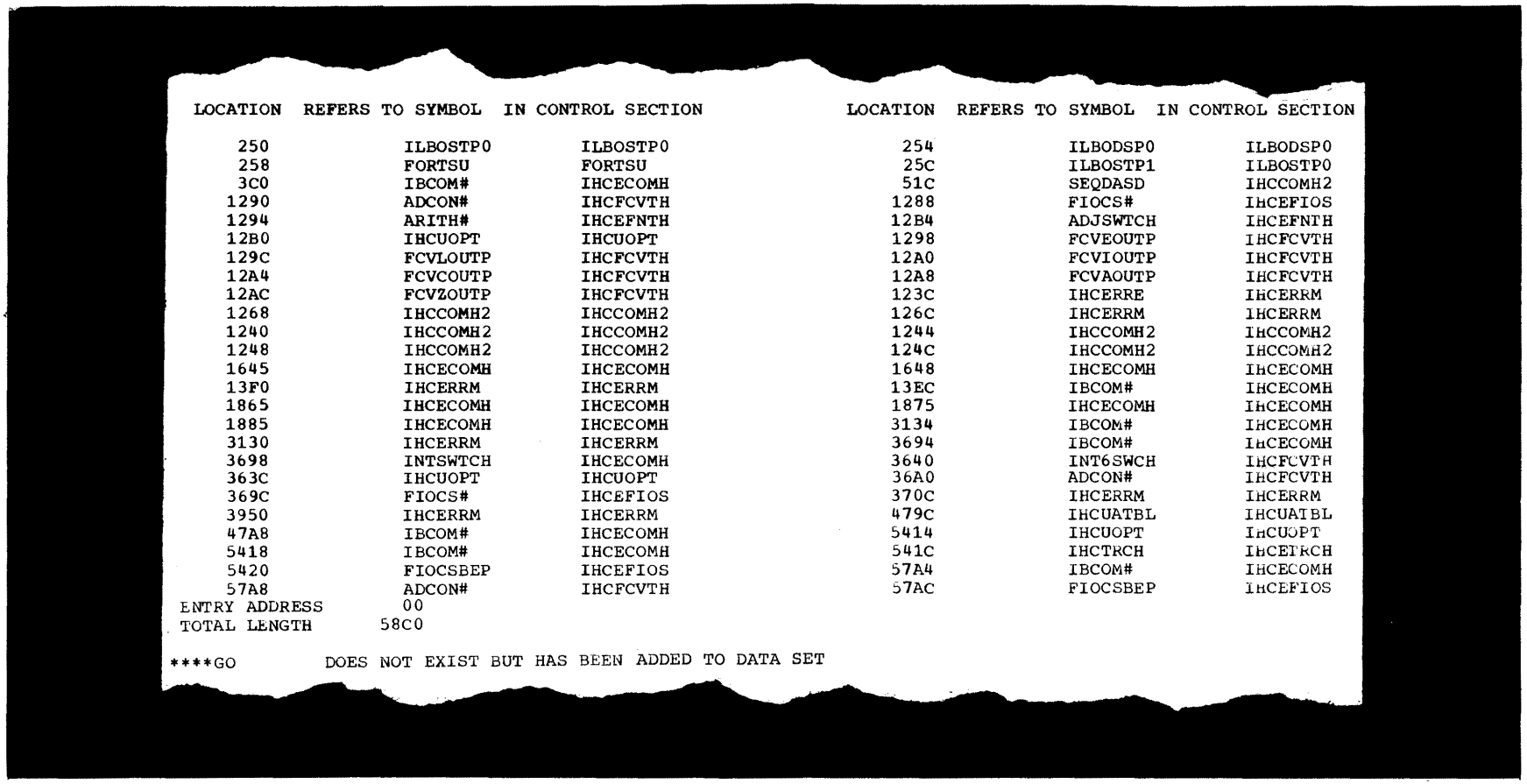
The entry address is 00 and the total length of the load module is 58C0. Note that the length of the module is rounded up to a doubleword boundary.

The disposition message at the end of the output in Figure 39 indicates that the load module GO has been added to the output module library. The library did not contain any other module with that name. The four asterisks identify the message.



```
F44-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED XREF,LIST
        DEFAULT OPTION(S) USED -  SIZE=(65536,6144)

                                CROSS REFERENCE TABLE

CONTROL SECTION                                 ENTRY

  NAME     ORIGIN  LENGTH      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

MAINMOD        00     32E
FORTSU        330     12C
IHCECOMH*     460     F41
                                IBCOM#       460    FDIOCS#      51C    INTSWTCH    1386
IHCCOMH2*    13A8     65D
                                SEQDASD     1720
ILBODSP0*    1A08     6F8
ILBOSTP0*    2100      35
                                ILBOSTP1    2116
IHCFCVTH*    2138    119D
                                ADCON#      2138    FCVAOUTP    21E2    FCVLOUTP    2272    FCVZOUTP    23C2
                                FCVIOUTP    2770    FCVEOUTP    2C72    FCVCOUTP    2E8C    INT6SWCH    3173
IHCEFNTH*    32D8     512
                                ARITH#      32D8    ADJSWTCH    3644
IHCEFIOS*    37F0    1378
                                FIOCS#      37F0    FIOCSBEP    37F6
IHCUOPT *    4B68     300
IHCERRM *    4E68     5BC
                                ERRMON      4E68    IHCERRE     4E80
IHCUATBL*    5428     208
IHCETRCH*    5630     28E
                                IHCTRCH     5630    ERRTRA      5638
```

Figure 39. Linkage Editor Output for Sample Program COBFORT (Part 1 of 2)



```
 LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION          LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION

     250           ILBOSTP0        ILBOSTP0                254           ILBODSP0        ILBODSP0
     258           FORTSU          FORTSU                  25C           ILBOSTP1        ILBOSTP0
     3C0           IBCOM#          IHCECOMH                51C           SEQDASD         IHCCOMH2
    1290           ADCON#          IHCFCVTH               1288           FIOCS#          IHCEFIOS
    1294           ARITH#          IHCEFNTH               12B4           ADJSWTCH        IHCEFNTH
    12B0           IHCUOPT         IHCUOPT                1298           FCVEOUTP        IHCFCVTH
    129C           FCVLOUTP        IHCFCVTH               12A0           FCVIOUTP        IHCFCVTH
    12A4           FCVCOUTP        IHCFCVTH               12A8           FCVAOUTP        IHCFCVTH
    12AC           FCVZOUTP        IHCFCVTH               123C           IHCERRE         IHCERRM
    1268           IHCCOMH2        IHCCOMH2               126C           IHCERRM         IHCERRM
    1240           IHCCOMH2        IHCCOMH2               1244           IHCCOMH2        IHCCOMH2
    1248           IHCCOMH2        IHCCOMH2               124C           IHCCOMH2        IHCCOMH2
    1645           IHCECOMH        IHCECOMH               1648           IHCECOMH        IHCECOMH
    13F0           IHCERRM         IHCERRM                13EC           IBCOM#          IHCECOMH
    1865           IHCECOMH        IHCECOMH               1875           IHCECOMH        IHCECOMH
    1885           IHCECOMH        IHCECOMH               3134           IBCOM#          IHCECOMH
    3130           IHCERRM         IHCERRM                3694           IBCOM#          IHCECOMH
    3698           INTSWTCH        IHCECOMH               3640           INT6SWCH        IHCFCVTH
    363C           IHCUOPT         IHCUOPT                36A0           ADCON#          IHCFCVTH
    369C           FIOCS#          IHCEFIOS               370C           IHCERRM         IHCERRM
    3950           IHCERRM         IHCERRM                479C           IHCUATBL        IHCUATBL
    47A8           IBCOM#          IHCECOMH               5414           IHCUOPT         IHCUOPT
    5418           IBCOM#          IHCECOMH               541C           IHCTRCH         IHCETRCH
    5420           FIOCSBEP        IHCEFIOS               57A4           IBCOM#          IHCECOMH
    57A8           ADCON#          IHCFCVTH               57AC           FIOCSBEP        IHCEFIOS
ENTRY ADDRESS      00
TOTAL LENGTH     58C0

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

Figure 39. Linkage Editor Output for Sample Program COBFORT (Part 2 of 2)

SAMPLE PROGRAM RPLACJOB

Sample program RPLACJOB shows the use of the REPLACE statement to replace one control section with another. The source program for the new control section (NEWMOD) is processed in a previous job step and passed to the linkage editor job step. The control section (SUBONE) to be replaced is in an existing load module. Figure 40 shows the linkage editor output for the job step that created this load module. Note that the entry address is F0 which is the location of the entry point MAINMOD (specified on the ENTRY control statement).

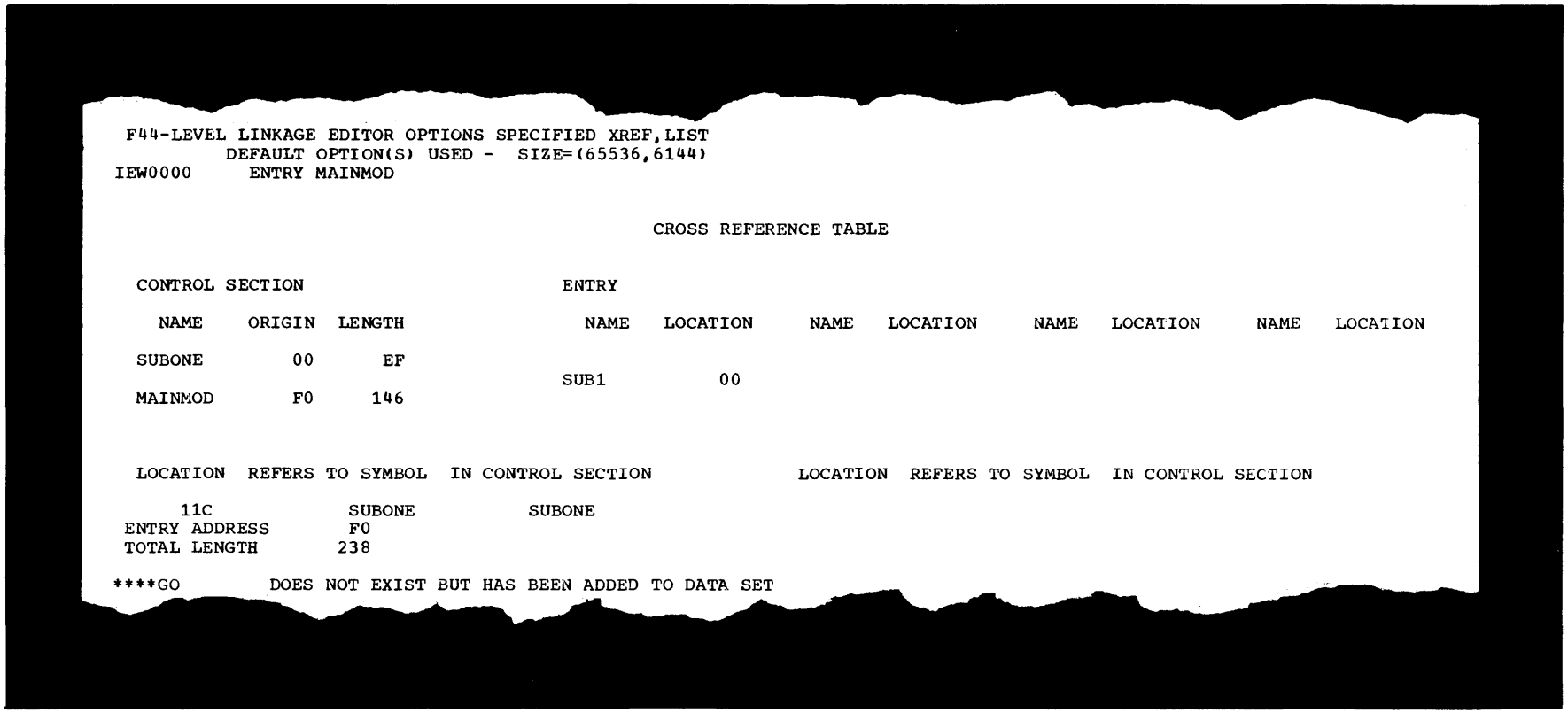
Job Control Language

The job control language for the replacement job step of this sample program is:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,LIST'
//SYSUT1   DD    DSNAME=&&UT1,UNIT=SYSDA,SPACE=(TRK,(100,10))
//INPUTX   DD    DSNAME=LOADLIB,DISP=OLD,UNIT=2311,VOL=SER=DEP613
//SYSLMOD  DD    DSNAME=LOADLIB(GO),DISP=MOD,UNIT=2311,
//                VOL=SER=DEP613
//SYSPRINT DD    SYSOUT=A
//SYSLIN   DD    DSNAME=&&OBJMOD,DISP=(OLD,DELETE),UNIT=2311,
//                VOL=SER=DEP613
//         DD    *
```

Linkage Editor Control Statements

```
/*
```



```
 F44-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED XREF,LIST
         DEFAULT OPTION(S) USED -  SIZE=(65536,6144)
IEW0000      ENTRY MAINMOD


                                          CROSS REFERENCE TABLE

  CONTROL SECTION                          ENTRY

    NAME     ORIGIN  LENGTH                 NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

  SUBONE         00      EF
                                           SUB1          00
  MAINMOD        F0     146


  LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION            LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION

      11C            SUBONE          SUBONE
 ENTRY ADDRESS       F0
 TOTAL LENGTH       238

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

Figure 40. Linkage Editor Output for Job Step that Created SUBONE

Statement	Explanation
EXEC	Causes the execution of the largest level linkage editor available in the system. The PARM field options request a cross-reference table and a module map (XREF), and a control statement listing (LIST) to be produced on the diagnostic output data set.
SYSUT1	Defines a temporary direct-access data set to be used as the intermediate data set.
INPUTX	Defines a permanent data set, used later as additional linkage editor input.
SYSLMOD	Defines a permanent data set to be used as the output module library. Note that it is the same data set that was described on the INPUTX DD statement. The output load module is added to the data set, under the member name GO.
SYSPRINT	Defines the diagnostic output data set, which is assigned to output class A.
SYSLIN	Defines the primary input data set, &&OBJMOD, which contains the object module for the replacement control section. This data set is temporary and was passed from a previous job step; it is to be deleted at the end of this job. This statement also concatenates the input stream to the primary input data set. The input stream contains linkage editor control statements that must be followed by a /* statement.

Linkage Editor Control Statements

The input stream contains the linkage editor control statements that are necessary for the replacement of SUBONE with NEWMOD. The control statements are:

```
ENTRY   MAINMOD
REPLACE  SUBONE(NEWMOD)
INCLUDE  INPUTX(GO)
```

Statement	Explanation
ENTRY	Specifies that the entry point is to be MAINMOD.
REPLACE	Specifies that control section SUBONE in the module that follows the REPLACE statement is to be replaced by control section NEWMOD.
INCLUDE	Specifies additional input: member GO of the data set described on the INPUTX DD statement. This library member contains the control section to be replaced. Since this member name is identical to that specified on the SYSLMOD DD statement, the output load module replaces the existing library member.

Linkage Editor Output

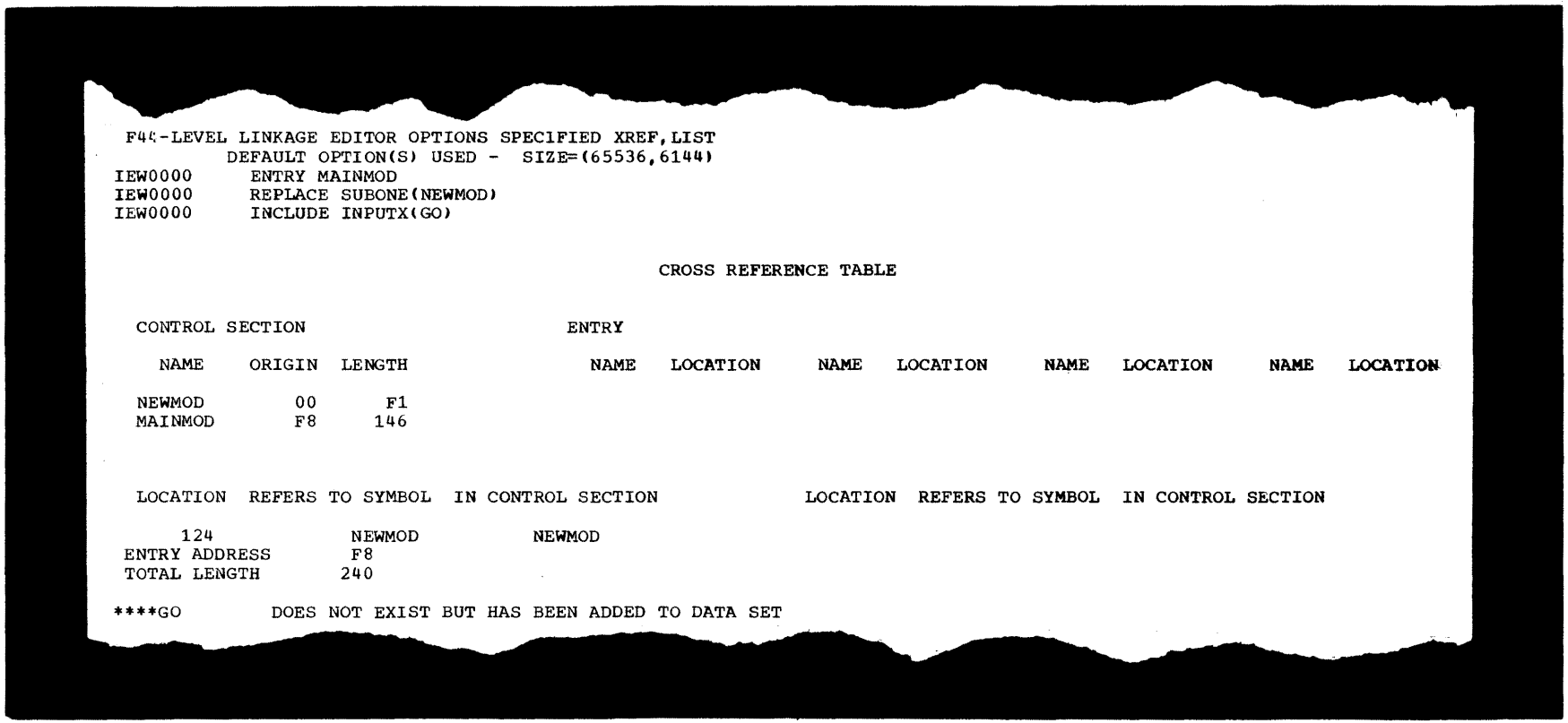
Figure 41 shows the linkage editor output for sample program RPLACJOB. The listing header indicates the level editor (44K) used, the options specified (XREF and LIST), and the SIZE option values used (65536 for $value_1$ and 6144 for $value_2$).

Because the LIST option is specified, a control statement listing is produced. Each control statement is preceded by a special message number, IEW0000. Because XREF is specified, the heading CROSS REFERENCE TABLE precedes the rest of the output.

The module map shows that control section NEWMOD is now part of the load module, and that control section SUBONE has been deleted. The new entry address is F8, because NEWMOD is longer than SUBONE. The total length of the load module is 240 bytes.

The cross-reference table indicates that at location 124 in MAINMOD, an address constant refers to symbol NEWMOD, defined in control section NEWMOD. Note that before the replacement occurred, the address constant in MAINMOD referred to SUBONE, defined in control section SUBONE (Figure 40). When the REPLACE statement is used to replace a control section, references to the old control section from within the same input module are also changed.

The disposition message indicates that the output load module (GO) has been added to the output module library.



```
 F4?-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED XREF,LIST
          DEFAULT OPTION(S) USED -  SIZE=(65536,6144)
IEW0000      ENTRY MAINMOD
IEW0000      REPLACE SUBONE(NEWMOD)
IEW0000      INCLUDE INPUTX(GO)


                                          CROSS REFERENCE TABLE

  CONTROL SECTION                         ENTRY

    NAME     ORIGIN  LENGTH               NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

  NEWMOD         00      F1
  MAINMOD        F8     146


  LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION            LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION

      124             NEWMOD          NEWMOD
 ENTRY ADDRESS        F8
 TOTAL LENGTH        240

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

Figure 41. Linkage Editor Output for Sample Program RPLACJOB

SAMPLE PROGRAM REGNOVLY

Sample program REGNOVLY creates a multiple-region overlay structure. The structure produced is shown in Figure 42. In this program, some of the references between control sections are:

CSA to CSE
CSB to CSE
CSB to CSD
CSD to CSC

The reference from CSB to CSE is a valid exclusive call because there is a reference to CSE in the segment common to both CSB and CSE; the reference from CSD to CSC is invalid because there is no reference to CSC in the common segment.

The source programs for all the control sections were compiled in previous job steps. All of the object modules were placed in the same data set, which was passed to the linkage editor job step.

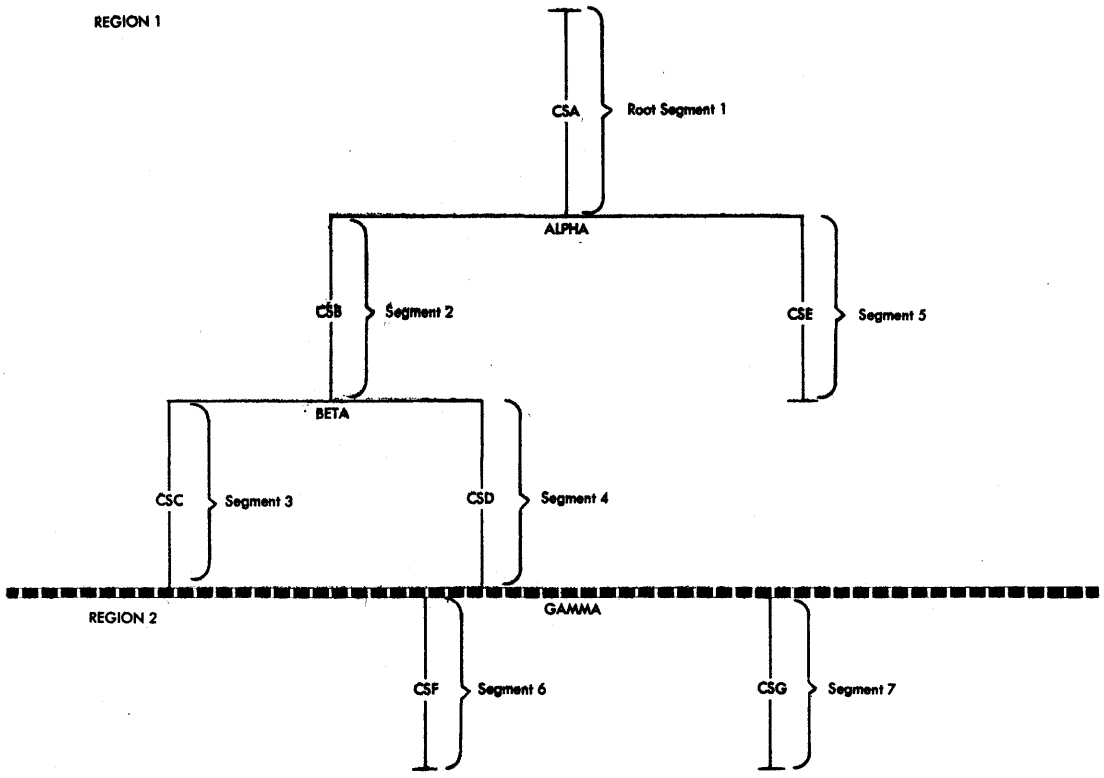


Figure 42. Overlay Tree for Multiple-Region Sample Program REGNOVLY

Job Control Language

The job control language for the linkage editor job step of this sample program is:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,LIST,OVLY,LET'
//SYSUT1   DD    DSNAME=&&UT1,UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSLIB   DD    DSNAME=SYS1.COBLIB,DISP=SHR
//SYSLMOD  DD    DSNAME=&&OVLYJB(GO),UNIT=SYSDA,DISP=(NEW,PASS),
//               SPACE=(TRK,(100,10,1))
//SYSPRINT DD    SYSOUT=A
//SYSLIN   DD    DSNAME=&&OBJMOD,DISP=(OLD,DELETE)
//         DD    *
┌-------------------------------------------------------------------┐
|Linkage Editor Control statements                                  |
└-------------------------------------------------------------------┘
/*
```

Statement	Explanation
EXEC	Causes the execution of the largest level linkage editor available in the system. The PARM field options request a cross-reference table and a module map (XREF), and a control statement listing (LIST) to be produced on the diagnostic output data set. The module is to be assigned the overlay attribute (OVLY), and marked executable in spite of severity 2 errors (LET). The LET option is specified to permit testing of the output module, even though an invalid exclusive call is present. The XCAL option allows only valid exclusive calls.
SYSUT1	Defines a temporary direct-access data set to be used as the intermediate data set.
SYSLIB	Defines the automatic call library (SYS1.COBLIB) to be used to resolve external references. All control sections from this library are placed in the root segment; they remain there unless they are repositioned.
SYSLMOD	Defines a temporary data set to be used as the output module library; the load module is assigned the member name GO and is passed to a subsequent step for execution.
SYSPRINT	Defines the diagnostic output data set, which is assigned to output class A.
SYSLIN	Defines the primary input data set, &&OBJMOD, which contains the object modules for the overlay structure. This data set is temporary and was passed from a previous job step; it is to be deleted at the end of this job. This statement also concatenates the input stream to the primary input data set. The input stream contains linkage editor control statements, which must be delimited by a /* statement.

Linkage Editor Control Statements

The input stream contains the linkage editor control statements that structure the overlay program. The control statements are:

```
INSERT CSA
ENTRY CSA
OVERLAY ALPHA
INSERT CSB
OVERLAY BETA
INSERT CSC
OVERLAY BETA
INSERT CSD
OVERLAY ALPHA
INSERT CSE
OVERLAY GAMMA(REGION)
INSERT CSF
OVERLAY GAMMA
INSERT CSG
```

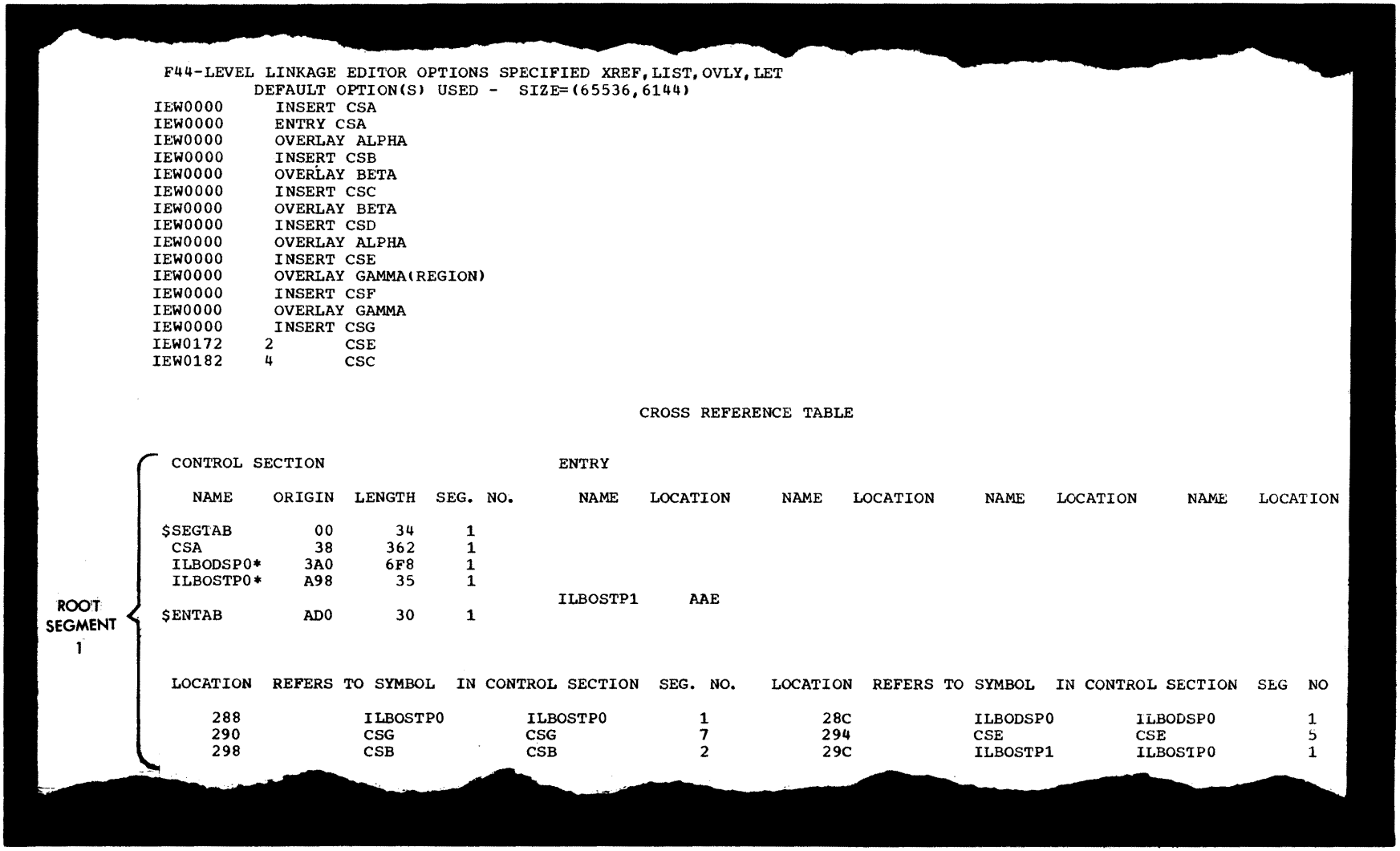
Linkage Editor Output

Figure 43 shows the linkage editor output for sample program REGNOVLY. The listing header indicates the level editor (44K) used, the options specified (XREF,LIST,OVLY, and LET), and the SIZE option values used (65536 for $value_1$ and 6144 for $value_2$).

Because the LIST option was specified, the control statement listing is produced. Each control statement is preceded by a special message number, IEW0000.

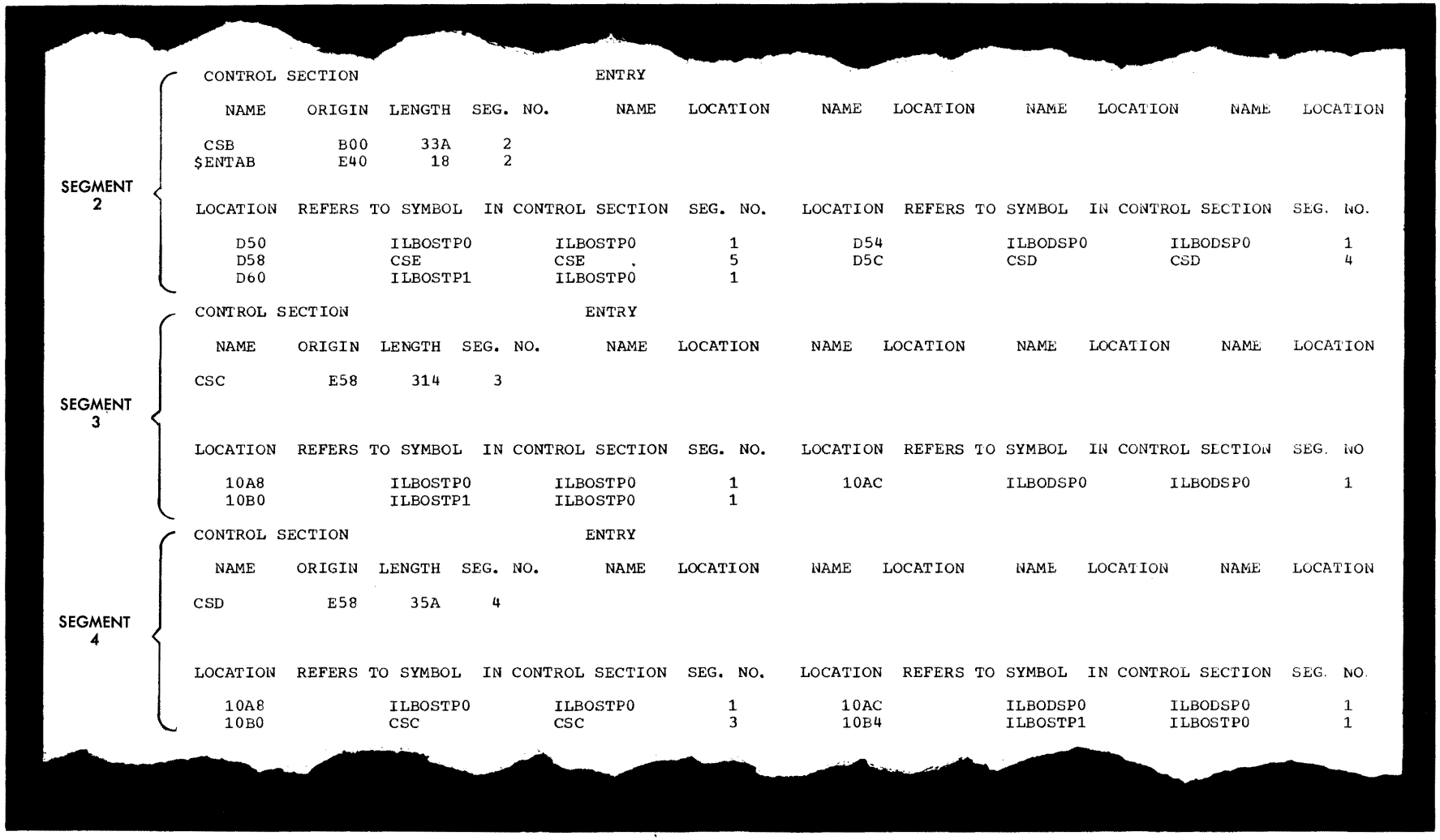
The control statement listing is followed by two diagnostic message numbers (IEW0172 and IEW0182). The explanation of the messages and the information following each message is given at the end of the output in the diagnostic message directory.

The output for each segment contains a module map and a cross-reference table. The segments are listed as they appear in the overlay structure, top to bottom, left to right, and region by region. (Note that this is also the sequence in which the OVERLAY and INSERT statements must be given.)



```
F44-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED XREF,LIST,OVLY,LET
          DEFAULT OPTION(S) USED -  SIZE=(65536,6144)
IEW0000     INSERT CSA
IEW0000     ENTRY CSA
IEW0000     OVERLAY ALPHA
IEW0000     INSERT CSB
IEW0000     OVERLAY BETA
IEW0000     INSERT CSC
IEW0000     OVERLAY BETA
IEW0000     INSERT CSD
IEW0000     OVERLAY ALPHA
IEW0000     INSERT CSE
IEW0000     OVERLAY GAMMA(REGION)
IEW0000     INSERT CSF
IEW0000     OVERLAY GAMMA
IEW0000     INSERT CSG
IEW0172    2       CSE
IEW0182    4       CSC


                                        CROSS REFERENCE TABLE

ROOT SEGMENT 1

CONTROL SECTION                                ENTRY
  NAME     ORIGIN   LENGTH   SEG. NO.     NAME    LOCATION     NAME    LOCATION     NAME    LOCATION     NAME    LOCATION
$SEGTAB       00       34      1
 CSA          38      362      1
 ILBODSP0*   3A0      6F8      1
 ILBOSTP0*   A98       35      1
                                          ILBOSTP1    AAE
$ENTAB        AD0       30      1


 LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG  NO
      288          ILBOSTP0          ILBOSTP0          1        28C          ILBODSP0          ILBODSP0          1
      290          CSG               CSG               7        294          CSE               CSE               5
      298          CSB               CSB               2        29C          ILBOSTP1          ILBOSTP0          1
```

Figure 43. Linkage Editor Output for Sample Program REGNOVLY (Part 1 of 3)



SEGMENT 2

```
CONTROL SECTION                                ENTRY

   NAME     ORIGIN   LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

 CSB           B00      33A      2
$ENTAB         E40       18      2

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.

    D50           ILBOSTP0        ILBOSTP0         1          D54           ILBODSP0        ILBODSP0         1
    D58           CSE             CSE              5          D5C           CSD             CSD              4
    D60           ILBOSTP1        ILBOSTP0         1
```

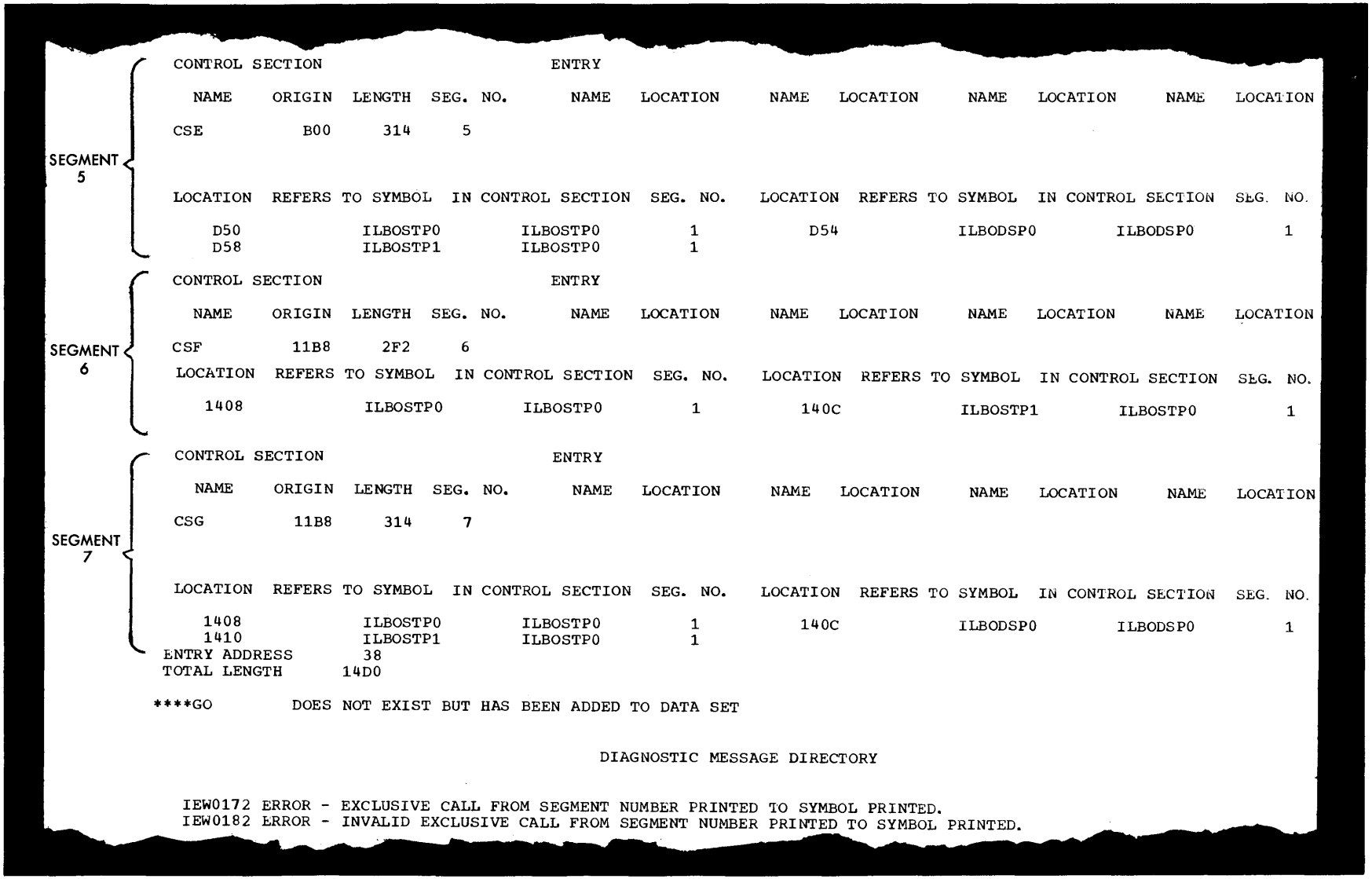
SEGMENT 3

```
CONTROL SECTION                                ENTRY

   NAME     ORIGIN   LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

CSC            E58      314      3

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO

   10A8           ILBOSTP0        ILBOSTP0         1          10AC           ILBODSP0        ILBODSP0         1
   10B0           ILBOSTP1        ILBOSTP0         1
```

SEGMENT 4

```
CONTROL SECTION                                ENTRY

   NAME     ORIGIN   LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION

CSD            E58      35A      4

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.

   10A8           ILBOSTP0        ILBOSTP0         1          10AC           ILBODSP0        ILBODSP0         1
   10B0           CSC             CSC              3          10B4           ILBOSTP1        ILBOSTP0         1
```

Figure 43. Linkage Editor Output for Sample Program REGNOVLY
(Part 2 of 3)



```
SEGMENT 5
CONTROL SECTION                          ENTRY
  NAME     ORIGIN  LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
CSE          B00     314     5

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.
    D50           ILBOSTP0        ILBOSTP0        1          D54           ILBODSP0        ILBODSP0        1
    D58           ILBOSTP1        ILBOSTP0        1

SEGMENT 6
CONTROL SECTION                          ENTRY
  NAME     ORIGIN  LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
CSF          11B8    2F2     6
LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.
   1408           ILBOSTP0        ILBOSTP0        1          140C           ILBOSTP1        ILBOSTP0        1

SEGMENT 7
CONTROL SECTION                          ENTRY
  NAME     ORIGIN  LENGTH  SEG. NO.      NAME   LOCATION     NAME   LOCATION     NAME   LOCATION     NAME   LOCATION
CSG          11B8    314     7

LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.   LOCATION  REFERS TO SYMBOL  IN CONTROL SECTION  SEG. NO.
   1408           ILBOSTP0        ILBOSTP0        1          140C           ILBODSP0        ILBODSP0        1
   1410           ILBOSTP1        ILBOSTP0        1
ENTRY ADDRESS     38
TOTAL LENGTH    14D0

****GO        DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET

                                  DIAGNOSTIC MESSAGE DIRECTORY

 IEW0172 ERROR - EXCLUSIVE CALL FROM SEGMENT NUMBER PRINTED TO SYMBOL PRINTED.
 IEW0182 ERROR - INVALID EXCLUSIVE CALL FROM SEGMENT NUMBER PRINTED TO SYMBOL PRINTED.
```

Figure 43. Linkage Editor Output for Sample Program REGNOVLY
(Part 3 of 3)

Within each segment, a module map lists the control sections in ascending sequence according to their assigned origin. The origin, length, and segment number is listed for each control section, along with any entry names and the location where each entry name is defined. For example, the root segment has five control sections: $SEGTAB, which is always the first control section in the root segment; CSA, which is from the object module input; ILBODSP0 and ILBOSTP0, which are from the automatic call library and were not repositioned; and $ENTAB, which, when present, is always the last control section in any segment (as also in segment 2). One entry name is defined, ILBOSTP1 at location AAE in control section ILBOSTP0.

The cross-reference table for each segment contains all of the address constants that refer to symbols defined in other control sections. The location of the address constant is followed by the symbol referred to, the control section in which the symbol is defined, and the segment in which the control section is located. For example, in the root segment, an address constant at location 290 refers to symbol CSG, which is defined in control section CSG in segment 7. Although the region is not given, the overlay tree in Figure 42 shows that segment 7 is in region 2.

At the end of the output for all the segments is the entry address and total length. The entry address is 38, which is the origin of CSA, the specified entry point. The total length given refers to main storage used, not device storage. The length given, therefore, is that of the longest path. The longest path is that formed by the root segment and segments 2, 4, and 7; the length given is 14D0.

However, if the given lengths of the control sections in each segment are added, the result is 14B3. The discrepancy exists because the given lengths do not include the padding bytes necessary to make control sections begin on a doubleword address (multiple of 8). For example, in the root segment, the length of $SEGTAB is 34; however, the origin of CSA which follows $SEGTAB is 38 (decimal 56). Four additional bytes are needed so that the origin of CSA is a multiple of 8.

The disposition message indicates that the load module GO has been added to the output module library. The library did not contain any other module by that name. The four asterisks identify the message.

The last item in the output for this sample program is the diagnostic message directory. The directory contains the text for the message numbers listed after the control statement listing. The directory must be correlated to the information following the number to interpret the message.

For example, message IEW0172 is an error message which indicates that an exclusive call was made from the segment number printed (2) following the message number to the symbol printed (CSE). The output for segment 2 indicates that this call is at location D58 in control section CSB, and the symbol is defined in control section CSE in segment 5. This is the valid exclusive call from CSB to CSE described earlier. (If XCAL were specified, a warning message is issued instead of an error message.)

If an invalid exclusive call is detected, message IEW0182 appears as shown. This is also an error message; it indicates that an invalid exclusive call was made from segment 4 to symbol CSC. This call is at location 10B0 in control section CSD, and the symbol is defined in control section CSC in segment 3. This is the invalid exclusive call from CSD to CSC, also described earlier.

SAMPLE PROGRAM PARTDS

Sample program PARTDS illustrates that linkage editor control statements can be placed in a separate data set and then used as input. For convenience, the control statements are those for sample program REGNOVLY, described previously. These control statements are placed in a partitioned data set. When the member that contains the control statements is referenced, the linkage editor uses the control statements to produce the overlay structure shown earlier in Figure 42.

Figure 44 shows the input statements for the IEBUPDTE utility program used to place the control statements in a partitioned data set. For a detailed description of this utility program and its use, see the publication IBM System/360 Operating System: Utilities.

The source programs for all the control sections were compiled in previous job steps. All the object modules were placed in the same data set, which was passed to the linkage editor job step. The input modules are those used for sample program REGNOVLY.

```
//PARTDS   JOB  ,SMITH,MSGLEVEL(2,0)
//CTLG     EXEC PGM=IEBUPDTE,PARM=(NEW)
//SYSUT2   DD   DSNAME=OVLYLIB,UNIT=2311,VOL=SER=DA028,DISP=NEW,
//              SPACE=(TRK,(10,5,2)),DCB=(LRECL=80,BLKSIZE=80,RECFM=F)
//SYSPRINT DD   SYSOUT=A
//SYSIN    DD   *
./         ADD  NAME=OVLY,LEVEL=00,SOURCE=00,LIST=ALL
./         NUMBER   NEW1=10,INCR=5
  INSERT CSA
  ENTRY CSA
  OVERLAY ALPHA
  INSERT CSB
  OVERLAY BETA
  INSERT CSC
  OVERLAY BETA
  INSERT CSD
  OVERLAY ALPHA
  INSERT CSE
  OVERLAY GAMMA(REGION)
  INSERT CSF
  OVERLAY GAMMA
  INSERT CSG
./       ENDUP
/*
```

Figure 44. Input Statements for IEBUPDTE Utility Program

Job Control Language

The job control language for the overlay program job step of this sample program is:

```
//LKED     EXEC  PGM=IEWL,PARM='XREF,LIST,OVLY,LET'
//SYSUT1   DD    DSNAME=&&UT1,UNIT=SYSDA,SPACE=(TRK,(100,10))
//OVLYCDS  DD    DSNAME=OVLYLIB,UNIT=2311,VOL=SER=DA028,DISP=OLD
//SYSLIB   DD    DSNAME=SYS1.COBLIB,DISP=SHR
//SYSLMOD  DD    DSNAME=&&OVLYJB(GO),UNIT=SYSDA,DISP=(NEW,PASS),
//              SPACE=(TRK,(100,10,1))
//SYSPRINT DD    SYSOUT=A
//SYSLIN   DD    DSNAME=&&OBJMOD,DISP=(OLD,DELETE)
//         DD    *
+-----------------------------------------------------------------------+
|Linkage Editor Control Statements                                      |
+-----------------------------------------------------------------------+
/*
```

Statement	Explanation
EXEC	Causes the execution of the largest level linkage editor available in the system. The PARM field options request a cross-reference table and a module map (XREF), and a control statement listing (LIST) to be produced on the diagnostic output data set. The output load module is to be assigned the overlay attribute (OVLY), and is to be marked executable despite severity 2 errors (LET).
SYSUT1	Defines a temporary direct-access data set to be used as the intermediate data set.
OVLYCDS	Defines a permanent data set to be used later as additional input; this is the partitioned data set which was created by IEBUPDTE and contains the control statements for structuring the overlay program.
SYSLIB	Defines the automatic call library (SYS1.COBLIB) to be used to resolve external references. All control sections from this library are placed in the root segment; they remain there unless they are repositioned.
SYSLMOD	Defines a temporary data set to be used as the output module library; the load module is to be assigned the member name GO, and is passed to a subsequent step for execution.
SYSPRINT	Defines the diagnostic output data set, which is assigned to output class A.
SYSLIN	Defines the primary input data set, &&OBJMOD, which contains the object modules for the overlay structure. This data set is temporary and was passed from a previous job step; it is to be deleted at the end of this job. This statement also concatenates the input stream to the primary input data set. The input stream contains linkage editor control statements that must be delimited by a /* statement.

Linkage Editor Control Statements

The input stream contains an INCLUDE statement, as follows:

```
INCLUDE  OVLYCDS(OVLY)
```

This statement causes the control statements to be read from the partitioned data set described on the OVLYCDS DD statement. The member name of the statements is OVLY, the same name used in the ADD statement for the utility program.

Linkage Editor Output

The output for this sample program is identical to the output from the REGNOVLY sample program, with one exception. The list of control statements begins with the statement

```
IEW0000  INCLUDE  OVLYCDS(OVLY)
```

This statement is followed by a list of the control statements read from the additional input data set specified in this INCLUDE statement. The rest of the output is identical to that shown in Figure 43.

The linkage editor can be invoked by a problem program at execution time through the use of the ATTACH, LINK, LOAD, or XCTL macro instruction. Figure 45 shows the basic format of these macro instructions.

Name	Operation	Operand
[symbol]	{LINK / ATTACH}	EP=linkeditname, PARAM=(optionlist[,ddnamelist]),VL=1
	{LOAD / XCTL}	EP=linkeditname

Figure 45. Macro Instruction Basic Format

EP=linkeditname
specifies the symbolic name of the linkage editor. The entry point at which execution is to begin is determined by the control program (from the library directory entry).

PARAM
specifies, as a sublist, address parameters to be passed from the problem program to the linkage editor. The first fullword in the address parameter list contains the address of the option and attribute list for the load module. The second fullword contains the address of the ddname list. If standard ddnames are to be used, this list may be omitted.

optionlist
specifies the address of a variable length list containing the options and attributes. This address must be written even though no list is provided.

The option list must begin on a halfword boundary. The two high-order bytes contain a count of the number of bytes in the remainder of the list. If no options or attributes are specified, the count must be zero. The option list is free form with each field separated by a comma. No blanks or zeros should appear in the list.

ddnamelist
specifies the address of a variable length list containing alternative ddnames for the data sets used during linkage editor processing. If standard ddnames are used, this operand may be omitted.

The ddname list must begin on a halfword boundary. The two high-order bytes contain a count of the number of bytes in the remainder of the list. Each name of less than 8 bytes must be left justified and padded with blanks. If an alternate ddname is omitted from the list, the standard name will be assumed. If the name is omitted within the list, the 8-byte entry must contain binary zeros. Names can be omitted from the end by merely shortening the list.

The sequence of the 8-byte entries in the ddnamelist is as follows:

Entry	Alternate Name For:
1	SYSLIN
2	member name (the name under which the output load module is stored in the SYSLMOD data set; this entry is used if the name is not specified on the SYSLMOD DD statement or if there is no NAME control statement)
3	SYSLMOD
4	SYSLIB
5	not applicable
6	SYSPRINT
7	not applicable
8	SYSUT1
9-11	not applicable
12	SYSTERM

VL
specifies that the sign bit is to be set to 1 in the last fullword of the address parameter list.

When the linkage editor completes processing, a condition code is returned in register 15 (see "Linkage Editor Return Code").

Two levels of the linkage editor are available: level E and level F. Both can operate as part of any System/360 Operating System; for a particular system, the design of the linkage editor programs is selected during system generation.

Both linkage editor programs will accept as input the load modules of either linkage editor; however, the input records for the level E program cannot exceed 1K and cannot contain more than one control section. The input records for the level F program can be any length as long as $value_2$ of the SIZE parameter is at least as large as the input record length. The following discussion contrasts the two levels.

Level E: This level is intended for a 32K[1] computing system; however, it can be executed in a larger main storage. Two designs of the level E program are available: 15K and 18K. These sizes represent the minimum amounts of main storage that must be available for each of the designs of the level E linkage editor program.

In comparison, for a given amount of available main storage, the 15K design has bigger capacities, but the 18K design is faster.

The two designs of the level E program have the same base; i.e., the logic and control flow of these programs is identical. Each design size processes programs in all environments where the available main storage is equal to or greater than the design size.

Level F: This level is intended for a 64K or larger computing system. Three designs of the level F program are available: 44K, 88K, and 128K. These sizes represent the minimum amounts of main storage that must be available for each of the designs of the level F linkage editor program.

In comparison, for a given amount of available main storage, the 44K design has bigger capacities, but the 88K design is faster. The 128K design offers the best performance of all.

The three designs of the level F program have the same base; i.e., the logic and control flow is identical. Each design size processes programs in all environments where the available main storage is equal to or greater than the design size.

Capacities

When the main storage available to either of these programs is increased, the program has increased capacities for external symbol dictionary entries, intermediate text records, and relocation dictionary records.

The capacities of the two linkage editor programs are shown in Table 14. (Different designs of the level E and level F programs are shown separately.) For the level E program, the capacities are given first for the program in the minimum amount of available main storage and then for the program in a greater amount that reflects a typical machine size.

---

[1]1K = 1,024 bytes

Table 14. Capacities of Linkage Editor Programs (Part 1 of 2)

Linkage Editor Program	E Level				F Level		
	15K		18K		44K	88K	128K
Main storage allocated to program (in bytes)	15K	18K	18K	20K	44K	88K	128K
Maximum number of entries in composite external symbol dictionary (ESD)	119	229	75	140	350	1098	1846
Maximum number of intermediate text records	67	147	35	83	288	676	1064
Maximum number of relocation dictionary (RLD) records	63	143	31	79	200	620	1044
Maximum number of segments per program	33	38	32	34	200	255	255
Maximum number of overlay regions per program	4	4	4	4	4	4	4
Maximum blocking factor for input object modules (i.e., number of 80-column card images per physical record)	1	1	1	1	5[1]	40	40
Maximum blocking factor for SYSPRINT output (i.e., number of 121-character logical records per physical record)	1	1	1	1	5[1]	40	40

[1]From 52K to 88K for $value_1$ of the SIZE option, the blocking factor for input object modules and SYSPRINT output is 10; for $value_1$ greater than 88K, the blocking factor is 40. For further information on blocking factors, see the "SIZE Option" section.

[2]When downward compatibility has been specified, the value is 1024.

[3]When downward compatibility has been specified, the value is 1024. The maximum output text record length is achieved when $value_2$ of the SIZE parameter is at least twice the record length size. For example, on a 2301, 18432 byte records will be written if $value_2$ is at least 36864.

Note: The block size in the DSCB reflects the maximum block size for the device, not necessarily the current record (RECFM=U) size.

Table 14. Capacities of Linkage Editor Programs (Part 2 of 2)

Linkage Editor Program		E Level				F Level		
		15K		18K		44K	88K	128K
Output text record length (in bytes)	On IBM 2311 Disk Storage Drive	1024	1024	1024	1024	3072[2]	3072[2]	3072[2]
	On IBM 2314,2319 Storage Facility	1024	1024	1024	1024	3072[2]	6144[3]	6144[3]
	On IBM 2302 Disk Storage Drive	1024	1024	1024	1024	3072[2]	4096[3]	4096[3]
	On IBM 2301 Drum Storage Drive	1024	1024	1024	1024	3072[2]	18432[3]	18432[3]
	On IBM 2303 Drum Storage Drive	1024	1024	1024	1024	3072[2]	4096[3]	4096[3]
	On IBM 2321 Data Cell	1024	1024	1024	1024	1024	1024	1024
	On IBM 2305 Fixed Head Storage Facility	N/A	N/A	N/A	N/A	3072[2]	13312[3]	13312[3]
	On IBM 3330 Disk Storage Facility	N/A	N/A	N/A	N/A	3072[2]	12288[3]	12288[3]

[1]From 52K to 88K for $value_1$ of the SIZE option, the blocking factor for input object modules and SYSPRINT output is 10; for $value_1$ greater than 88K, the blocking factor is 40. For further information on blocking factors, see the "SIZE Option" section.
[2]When downward compatibility has been specified, the value is 1024.
[3]When downward compatibility has been specified, the value is 1024. The maximum output text record length is achieved when $value_2$ of the SIZE parameter is at least twice the record length size. For example, on a 2301, 18432 byte records will be written if $value_2$ is at least 36864.
Note: The block size in the DSCB reflects the maximum block size for the device, not necessarily the current record (RECFM=U) size.

For the composite external symbol dictionary, the number of entries permitted for either program can be computed by subtracting, from the maximum number given in Table 14, one entry for each of the following:

- A data definition name (ddname) specified in LIBRARY statements.
- A data definition name (ddname) specified in INCLUDE statements.
- An ALIAS statement.
- A symbol in REPLACE or CHANGE statements that are in the largest group of such statements preceding a single object module in the input to the linkage editor.
- The segment table (SEGTAB) in an overlay program.
- An entry table (ENTAB) in an overlay program.

To compute the number of intermediate text records that will be produced during processing of either program, add one record for each group of x bytes within each control section, where x is the record size for the intermediate data set. For the level E program, x is 1024. For the level F program, x is 1024 minimum; a maximum is chosen depending on

the amount of main storage available to the linkage editor and the devices allocated for the intermediate and output data sets.

The number of text records that can be handled by a linkage editor program is less than the maximums given in Table 13 if the text of one or more control sections is not in sequence by address in the input to the linkage editor.

To compute the number of relocation dictionary records in either program, add one record for each group of 30 relocatable address constants within each control section. In determining the number of records, add one record for a remainder of less than 30 address constants.

There is no maximum limit to the number of CSECT Identification records associated with a load module produced by the level F linkage editor. To determine the number of bytes of identification data contained in a particular load module, use the following formula:

$$269 + 16A = 31B + 2C + I(n + 6) = SIZE$$

where:

A = the number of compilations or assemblies by a processor supporting CSECT Identification that produced the object code for the module.

B = the number of pre-processor compiler compilations by a processor supporting CSECT Identification that produced the object code for the module.

C = the number of control sections in the module with END statements that contain identification data.

I = the number of control sections in the module that contain user-supplied data supplied during link editing by the optional IDENTIFY control statement.

n = the average number of characters in the data specified by IDENTIFY control statements.

Notes:

- The size computed by the formula includes space for recording up to 19 IMASPZAP modifications. When 75% of this space has been used, a new 251-byte record is created the next time the module is reprocessed by the linkage editor.
- To determine the approximate number of records involved, divide the computed size of the identification data by 256.

Example: A module contains 100 control sections produced by 20 unique compilations. Each control section is identified during link editing by 8 characters of user data specified by the IDENTIFY control statement. The size of the identification data is computed as follows:

A = 20
I = 100
n = 8

$$269 + 320 + 1400 = 1989 \text{ bytes}$$

If the optional user data specified on the IDENTIFY control statements is omitted, the size can be reduced considerably, as computed below:

269 + 320 = 589 bytes

For the level E linkage editor, the maximum number of downward calls made from a segment to other segments lower in its path is 58; the maximum for the level F linkage editor can never exceed 340. To compute the maximum number of downward calls allowed when using the level F linkage editor, subtract 12 from the SYSLMOD record size and then divide the difference by 12. Examples of maximum downward calls are 84 for a SYSLMOD record size of 1024 bytes and 340 for a SYSLMOD record size of 6144 bytes.

Intermediate Data Set

The intermediate data set (SYSUT1) is used by the linkage editor to hold intermediate data records during processing. The level E linkage editor always places intermediate data in this data set. The level F linkage editor places intermediate data in this data set when main storage allocated for input data or certain forms of out-of-sequence text is exhausted.

The following direct access devices, if supported by the system, can be used for this data set:

IBM 2321 Data Cell
IBM 2311 Disk Storage Drive
IBM 2302 Disk Storage Drive
IBM 2303 Drum Storage Drive
IBM 2314 Storage Facility
IBM 2319 Storage Facility
IBM 2301 Drum Storage Drive
IBM 2305 Fixed Head Storage Facility
IBM 3330 Disk Storage Facility

Linkage Editor Storage Requirements

The amount of dynamic main storage required by the linkage editor for execution depends on the design level and on the operating system configuration used. Table 15 contains the minimum dynamic main storage required by each design level when used with MFT, and a suggested region size for each design level when used with MVT.

Table 15. Minimum Dynamic Storage Requirements for the Linkage Editor

Design Level	Minimum Storage Requirement	
	MFT	MVT
15K level E	15,500	24K
18K level E	18,432	26K
44K level F	45,056	54K
88K level F	90,112	96K
128K level F	131,072	136K

All of the linkage editor programs, except the 128K level F linkage editor, are in overlay format and use the overlay supervisor. The storage required by the overlay supervisor must be added to the minimum dynamic storage requirement for the linkage editor. The amount of additional storage required depends on the overlay supervisor included in the system during system generation. Table 16 contains the storage requirements for the overlay supervisor.

Table 16. Overlay Supervisor Storage Requirements

Overlay Supervisor	Storage Required
Basic (MFT)	436
Advanced (MFT)	512
Asynchronous (MVT)	992

The storage requirements in Table 15 include the storage required by the access method modules used by the linkage editor. The linkage editors use the basic sequential and basic partitioned access methods (BSAM and BPAM, respectively). A list of access method modules and the storage they require can be found in the publication IBM System/360 Operating System: Storage Estimates.

This appendix contains linkage editor diagnostic messages.

Each message contains a severity code that indicates the nature of the condition causing the message to be generated. Severity codes used in linkage editor diagnostic messages appear as the final position of the message code and are defined as follows:

Severity Code	Meaning
0	Indicates a condition that will not cause an error during execution of the output module.
1	Indicates a condition that may cause an error during execution of the output module. A module map or cross-reference table is produced if specified by the programmer. The output module is marked executable.
2	Indicates an error that could make execution of the output module impossible. Processing continues. When possible, a module map or a cross-reference table is produced if specified by the programmer. The output module is marked "not executable" unless the LET option has been specified.
3	Indicates an error that will make execution of the output module impossible. Processing continues. When possible, a module map or cross-reference table is produced if specified by the programmer. The output module is marked "not executable."
4	Indicates an error condition from which no recovery is possible. Processing terminates. The only output is diagnostic messages.

IEW0000 (control statement)

Explanation: The control statement is printed as a result of the LIST option.

IEW0012 ERROR - INPUT CONTAINS INVALID TWO-BYTE RELOCATABLE ADDRESS CONSTANT, CONSTANT HAS NOT BEEN RELOCATED.

Explanation: A relocatable A-type or V-type address constant of less than three bytes has been found in the input.

System Action: The constant is not relocated.

Programmer Response: Probable user error. Check assembler language input for Y-type address constants, which cannot be relocated. Delete or correct the invalid address constant. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the object module input and associated listings available.
- If the incorrect module is an object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.

IEW0022 ERROR - INPUT CONTAINS INVALID V-TYPE ADDRESS CONSTANT, CONSTANT HAS NOT BEEN RELOCATED.

Explanation: A V-type address constant of less than four bytes has been found in the overlay structure.

System Action: The constant is not relocated.

Programmer Response: Probable user error. Either (1) specify a length of four bytes for all V-type address constants; or (2) if a 3-byte V-type address constant refers to a symbol within its overlay segment, you can assemble it as an A-type address constant with an EXTRN statement. One method of isolating an invalid address constant is (1) link edit with OVLY and XREF options specified; (2) link edit again without the OVLY option; (3) compare the external reference lists. Any reference appearing in the second run and not the first is invalid in an overlay structure. If the problem recurs, do the following before calling IBM for programming support:

- Have the output used to isolate the address constant available.
- Have source listings of all input modules available.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0033 ERROR - INVALID ENTRY POINT FROM END CARD, NO ENTRY POINT ASSIGNED.

Explanation: The entry point for the program was specified as a relative address in an END card. The entry point that was specified appeared to be valid when the END card was processed, however, the entry point was found to be invalid when the entry point of the load module was being determined.

System Action: No entry point is assigned.

Programmer Response: Check object module input for completeness. Then either specify an entry point name on the ENTRY control statement, or, if entry points were specified at compilation or assembly, make sure the object module containing the desired entry point precedes all other object modules with assembled or compiled entry points. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

- Have the object module input and associated listings available.

- If the incorrect module is an object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.

IEW0043 ERROR - INPUT CONTAINS INVALID EXTERNAL SYMBOL ID.

Explanation: An ESD card is probably mispunched.

System Action: The invalid item is ignored.

Programmer Response: Probable user error. Check the input object modules for completeness and proper sequence. If necessary, either (1) re-create any module which has been in card form, or (2) isolate the incorrect module by executing the linkage editor with the NCAL option specified, using the NAME control statement for each input module. Diagnostic IEW0043 should recur and isolate the incorrect module. Re-create the module and rerun the step. If the problem recurs, do the following before calling IBM for programming support:

- Have available the output used to isolate the module as described above.

- If the incorrect module is a load module, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function, and save the resulting load module and cross-reference listings.

- If the incorrect module is an object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0053 ERROR - ENTRY STATEMENT SYMBOL PRINTED IS INVALID (NOT AN EXTERNAL NAME), NO ENTRY POINT ASSIGNED.

Explanation: The symbolic entry point specified in an ENTRY statement is not a control section or entry name.

System Action: No entry point is assigned.

Programmer Response: Probable user error. Correct the ENTRY control statement, or make sure that the control section containing the entry point is included in the input and has not been accidentally deleted or redefined by a REPLACE or CHANGE control statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

- Have the object module input and associated listings available.

- If the incorrect module is an object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.

IEW0063 ERROR - END CARD SYMBOL PRINTED IS INVALID (NOT AN EXTERNAL NAME), NO ENTRY POINT ASSIGNED.

Explanation: The symbolic entry point specified in an END statement is not a control section or entry name.

System Action: No entry point is assigned.

Programmer Response: Check that the entry point control section or entry name has not been accidentally deleted or redefined by a REPLACE or CHANGE control statement. Check the module containing the entry point for completeness. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Have the object module input and associated listings available.

IEW0073 ERROR - ENTRY STATEMENT SYMBOL PRINTED IS NOT IN ROOT SEGMENT OF OVERLAY STRUCTURE, NO ENTRY POINT ASSIGNED.

Explanation: The entry point specified by the programmer is in a segment other than the root segment. Either (1) the module containing the entry point was placed in a segment other than the root segment by means of the INSERT statement or (2) the entry point is incorrectly specified on the ENTRY statement.

System Action: No entry point is assigned.

Programmer Response: Probable user error. Either correct the ENTRY control statement, or move the module containing the entry point to the root segment. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the object module input and associated listings available.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.

IEW0083 ERROR - END CARD SYMBOL PRINTED IS NOT IN ROOT SEGMENT OF OVERLAY STRUCTURE, NO ENTRY POINT ASSIGNED.

Explanation: The entry point is in a segment other than the root segment. Either (1) the INSERT statement was used to place the control section containing the entry point in another segment or (2) the symbol specified on the END statement is incorrect.

System Action: No entry point is assigned.

Programmer Response: Probable user error. Move the object module containing the entry point to the root segment, or specify an entry point in the root segment using the ENTRY control statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Have the object module input and associated listings available.

IEW0093 ERROR - END CARD ENTRY POINT ADDRESS PRINTED IS NOT IN ROOT SEGMENT OF OVERLAY STRUCTURE, NO ENTRY POINT ASSIGNED.

Explanation: The entry point is in a segment other than the root segment. Either (1) the INSERT statement was used to place the control section containing the entry point in another segment or (2) the address specified on the END statement is incorrect.

System Action: No entry point is assigned.

Programmer Response: Probable user error. Move the object module containing the entry point to the root segment, or specify an entry point in the root segment using the ENTRY control statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Have the object module input and associated listings available.

IEW0102 ERROR - INVALID ENTRY POINT ON END CARD, ENTRY POINT IGNORED.

Explanation: A possible entry point for the program was specified as a relative address in an END card. When the END card was processed, the control section identification of the specified entry point was found to be invalid.

System Action: The entry point is ignored. The first valid entry point encountered is used; if there is none, no entry point is assigned.

Programmer Response: Probable user error. Check the input object modules for completeness and proper sequence. If necessary, either (1) re-create any module that has been in card form, or (2) isolate the incorrect module by executing the linkage editor with the NCAL option specified, using the NAME control statement for each input object module. Diagnostic IEW0102 should recur and isolate the incorrect module. Re-create the module and rerun the step. If the problem recurs, do the following before calling IBM for programming support:

- Have available the output used to isolate the module.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the job stream and output listing of the step used to create the incorrect module available.

IEW0113 ERROR - OUTPUT MODULE CONTAINS NO CONTROL SECTIONS IN ROOT SEGMENT OF OVERLAY STRUCTURE, NO ENTRY POINT ASSIGNED.

Explanation: There are no control sections in the root segment. Either (1) all control sections originally in the root segment have been deleted, or (2) there were no control sections originally in the root segment, or (3) an OVERLAY statement preceded the input.

System Action: No entry point is assigned.

Programmer Response: Probable user error. Place at least one control section in the root segment. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have a root segment module and its associated listings available.
- If the root segment module is a load module, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function.

IEW0123 ERROR - NO ESD ENTRIES, EXECUTION IMPOSSIBLE.

Explanation: There are no external symbol dictionary entries. There are no control sections in the output.

System Action: Processing is terminated.

Programmer Response: Probable user error. Check other messages issued for cause of error (i.e., invalid input from object module). Insure that at least one control section appears in the input and is not deleted by the REPLACE control statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have at least one input module with its associated source listing available.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.
- Execute the IMBLIST service aid program, using the LISTOBJ function and save the resulting listing of the questionable object module.

IEW0132 ERROR - SYMBOL PRINTED IS AN UNRESOLVED EXTERNAL REFERENCE.

Explanation: An external reference is unresolved at the end of input processing. None of the following is specified: restricted no-call, never-call, or NCAL.

System Action: The module is marked not executable unless LET is specified.

Programmer Response: Probable user error. Check that the reference is valid and not the result of a keypunch or programming error. If the reference is valid, add the needed module or alias to one of the input data sets. Make sure the SYSLIB data set DD statement has been specified, if needed. If resolution is not desired, specify NCAL, never-call, or restricted no-call. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- If the needed module is in a partitioned data set, execute the IEHLIST utility program, using the LISTPDS function to print out the data set's directory.
- If the needed module is a load module, execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings.
- If the needed module is an object module, have the module and associated source listing available.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- If the module containing the unresolved external reference is an object module, execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing. If the module is a load module, execute the IMBLIST service aid program, using the LISTLOAD function with the OUTPUT=BOTH option, and save the resulting listing.

IEW0143 ERROR - NO TEXT.

Explanation: No text remains in the output module. Either (1) all the control sections originally in the input are deleted or (2) there are no control sections that originally contained text.

System Action: Processing is terminated.

Programmer Response: Probable user error. Check other messages issued for cause of error (i.e., invalid input from object module). Insure that at least one control section contains text and is not deleted by the REPLACE control statement or by automatic replacement. If the problem recurs, do the following before calling IBM for programming support:

- Have a module containing text and its associated listing available.
- Make sure that the XREF and LIST options were specified for the failing job step.

- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.

IEW0152 ERROR - INVALID OVERLAY STRUCTURE, NO CALLS OR BRANCHES MADE FROM ROOT SEGMENT.

Explanation: There are no calls or branches from the root segment to a segment lower in the tree structure. Other segments cannot be loaded.

System Action: The module is marked not executable unless LET is specified.

Programmer Response: Probable user error. Make sure the root segment contains a control section that refers to at least one other segment in the overlay structure by means of a V-type address constant. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have a root segment module which calls another segment available with its associated listing.
- Execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function, and save the resulting listings.

IEW0161 WARNING - EXCLUSIVE CALL FROM SEGMENT NUMBER PRINTED TO SYMBOL PRINTED -- XCAL WAS SPECIFIED.

Explanation: There is a valid exclusive branch-type reference; the XCAL option is specified for this job step.

System Action: Processing continues.

Programmer Response: No response is necessary normally. You can check that the printed branch-type references between exclusive segments are correct according to your overlay structure. If you suspect that the message fails to appear when it should or appears incorrectly, do the following before calling IBM for programming support:

- Execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings of the output load module.
- Have modules that contain the calls and symbol available with associated source listings.
- Make sure that the XREF and LIST options were specified for the failing step.

IEW0172 ERROR - EXCLUSIVE CALL FROM SEGMENT NUMBER PRINTED TO SYMBOL PRINTED.

Explanation: A valid branch-type reference is made from a segment to an exclusive segment; the XCAL option is not specified.

System Action: The module is marked not executable unless the LET option is specified.

Programmer Response: Probable user error. Either (1) rearrange the overlay structure to place both segments in the same path or (2) specify the XCAL option. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the modules containing the symbol and the calls to it available with associated listings.
- Execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings of the output load module.

IEW0182 ERROR - INVALID EXCLUSIVE CALL FROM SEGMENT NUMBER PRINTED TO SYMBOL PRINTED.

Explanation: There is an invalid exclusive branch-type reference from a segment to a symbol in an exclusive segment.

System Action: The module is marked not executable unless the LET option is specified.

Programmer Response: Probable user error. Either, (1) place the segments in the same path, or (2) place a V-type address constant in a common segment. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the modules containing the symbol and the calls to it available with associated listings.
- Execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings of the output load module.

IEW0191 WARNING - MAIN STORAGE REQUIREMENTS FOR OUTPUT LOAD MODULE HAVE EXCEEDED 512K BYTES.

Explanation: With MFT, a request block (RB) will not accommodate an address greater than 524,287.

System Action: Processing continues. The output load module will run only under MVT.

Programmer Response: Probable user error. If the program is to be rerun under MFT, divide the load module into several load modules that are dynamically loaded by assembler language macro instructions. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0201 WARNING - OVERLAY STRUCTURE CONTAINS ONLY ONE SEGMENT -- OVERLAY OPTION CANCELLED.

Explanation: There are no OVERLAY statements in the input.

System Action: The overlay option is canceled.

Programmer Response: Probable user error. Either place OVERLAY statements in the input, or remove the OVLY options from the EXEC statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.
- Execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings of the output load module.

IEW0212 ERROR - EXPECTED CONTINUATION CARD NOT FOUND.

Explanation: A linkage editor control statement specifying a continuation (nonblank in column 72) is not followed by a continuation card.

System Action: The card is not processed as a continuation, but as normal input.

Programmer Response: Probable user error. Either remove the nonblank character in column 72 or insert the necessary continuation record. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0222 ERROR - CARD PRINTED CONTAINS INVALID INPUT FROM OBJECT MODULE.

Explanation: A control statement may have been placed within an object module, or a record that is not an object module record contains a non-blank character in column 1.

System Action: The questionable record is ignored and processing continues.

Programmer Response: Probable user error. Check object module input for invalid records. Column 1 should contain a 12-2-9 punch. Columns 2-4 should contain a TXT, RLD, ESD, END, or SYM identifier. Because any record with a non-blank punch is taken as an object module record, this error message can also occur when a control statement is erroneously begun in column 1. Remove incorrect records or re-create the module, and rerun the job. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have object module input available.

IEW0232 ERROR - INPUT FROM LOAD MODULE IS INVALID.

Explanation: An unrecognizable record type was found while reading a load module.

System Action: The questionable record is ignored and processing continues.

Programmer Response: Probable user error. (1) Check that all input data sets are specified correctly on DD statements. (2) If load module input occurs in the primary input, rerun the step with the NCAL option specified. If error message IEW0232 recurs, the incorrect load module is in primary input. Otherwise it is in SYSLIB input. (3) Isolate the incorrect load module by executing the linkage editor with INCLUDE and NAME statements for each suspect load module. When the incorrect load module is isolated, re-create it and rerun the job step. If the incorrect load module contains CSECT identification records (IDRs) and is processed by a version of a linkage editor earlier than Release 21.0 of the operating system, obtain a later version of the linkage editor that supports IDRs and rerun the job step. If the problem recurs, do the following before calling IBM for programming support:

- If an incorrect load module was created, execute the IMBLIST service aid program, using the OUTPUT=MODLIST option of the LISTLOAD function, and save the resulting listing.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0241 WARNING - EXTERNAL SYMBOL PRINTED IS DOUBLY DEFINED -- ESD TYPE DEFINITIONS CONFLICT.

Explanation: Probable user error. Two identical external names have been found in the input. (1) The invalid match involves a label reference (LR) or label definition (LD) matching an existing section definition (SD), common (CM) or label reference (LR). The section definition for the input LR or LD must be marked delete in order for this not to be an error. (2) It is always invalid for a CM to match an existing LR.

System Action: References to the name are resolved with respect to the first occurrence of the name.

Programmer Response: Probable user error. Correct the existing symbol conflict. To isolate the problem, load module symbols can be printed using the LISTLOAD function of the IMBLIST service aid program, specifying the OUTPUT=XREF option. Object module symbols can be printed using the LISTOBJ function of the IMBLIST service aid program. If the error recurs, do the following before calling IBM for programming support:

- Have all object module and load module input available.
- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the output of IMBLIST available.

IEW0254 ERROR - TABLE OVERFLOW -- TOO MANY EXTERNAL SYMBOLS IN ESD.

Explanation: There are too many external symbols or control statement operands in the problem program.

System Action: Processing is terminated.

Programmer Response: Probable user error. Check that no unnecessary modules or control statements are included in the input. Then, either (1) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased, if necessary; or (2) reduce the number of external symbols in the input (control sections, entry points, and named common areas). If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0264 ERROR - TABLE OVERFLOW -- INPUT MODULE CONTAINS TOO MANY EXTERNAL SYMBOLS IN ESD.

Explanation: Either (1) an input module contains too many external symbols in the ESD or (2) an ESD card is mispunched.

System Action: Processing is terminated.

Programmer Response: Probable user error. Check that input object modules are complete and not mispunched. Then either (1) break down any large input module into a number of smaller modules, or (2) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased, if necessary. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Have all object and load module input available.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.

IEW0272 ERROR - LOAD MODULE FROM LIBRARY SPECIFIED UNACCEPTABLE TO LEVEL (x).

Explanation: In the message text, x is either E for the level E linkage editor or F for the level F linkage editor.

When the load module was created, it was marked not editable, or, for the level E, the downward compatible attribute was not specified.

System Action: The load module is not accepted as input.

Programmer Response: Probable user error. If the module is unacceptable because it is marked not editable, it must be re-created before it can be input to either linkage editor. If the module is unacceptable because it has not been marked downward compatible, either re-create the module or rerun the step using the level F linkage editor. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTPDS function with the FORMAT option to print out the module's directory entry and show the not editable and downward compatible indicators.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0284 ERROR - DDNAME PRINTED CANNOT BE OPENED.

Explanation: The specified data set cannot be opened. The DD statement defining the data set is missing.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) supply the missing DD statement, or (2) correct erroneous information on the DD statement. If the linkage editor was invoked by a macro instruction such as LINK rather than through the EXEC statement, make sure the ddname list, if passed, was correct. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- If possible, execute the IEHLIST utility program, using the LISTVTOC function to print out the Data Set Control Block for the data set that cannot be opened.
- Have the associated job stream and output listings available.

IEW0294 ERROR - DDNAME PRINTED HAD SYNCHRONOUS ERROR.

Explanation: Either (1) a physical uncorrectable I/O error occurred, or (2) an object module is missing an END card as the last card, or (3) if the data definition name that was printed is for a DD statement that defines a blocked input data set of fixed format, an input record larger than the specified block size or logical record length was found.

System Action: Processing was terminated. The data definition name in the name field of the DD statement for the input data set was printed after the message code. If an I/O error occurred, the information provided by the SYNADAF macro instruction was printed after the message code in the following format: SYNAD EXIT, jobname, stepname, unit address, device type, ddname, operation attempted, error description, block count or BBCCHHR, access method.

Programmer Response: For any fixed format, specify the correct block size. If the block size was correct and the data set was an input data set, re-create or restore the data set. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- If possible, execute the IEHLIST utility program using the LISTVTOC function to print out the Data Set Control Block for the data set containing the error.
- Have the associated job stream and output listings available.

IEW0302 ERROR - INVALID STATEMENT -- SCAN TERMINATED.

Explanation: Either (1) there is an error on a linkage editor control statement, or (2) an OVERLAY control statement was encountered and the OVLY attribute was not specified on the EXEC statement, or (3) a HIARCHY control statement was encountered and the HIAR attribute was not specified on the EXEC statement.

System Action: A statement in error is accepted as input up to the point of the error; the OVERLAY statements are ignored and the module is not in overlay format.

Programmer Response: Probable user error. Either (1) correct the error, if necessary, or (2) specify OVLY on the EXEC statement, or (3) specify HIAR on the EXEC statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the associated job stream and output listings available.

IEW0314 ERROR - MAXIMUM NUMBER OF REGIONS (four) EXCEEDED.

Explanation: There are five or more regions specified in this overlay structure.

System Action: Processing is terminated.

Programmer Response: Probable user error. Reduce the number of regions in the overlay structure to four. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0324 ERROR - MAXIMUM NUMBER OF SEGMENTS EXCEEDED.

Explanation: Either (1) the number of segments exceeded 256; or (2) the number of segments, although less than 256, could not be handled in existing table and buffer space.

System Action: Processing is terminated.

Programmer Response: Probable user error. If the number of segments in the overlay structure exceeded 256, reduce it to 256. Otherwise, increase linkage editor table and buffer space by increasing $value_1$ of the SIZE parameter. Be sure to increase region or partition size also, if necessary. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0332 ERROR - MAXIMUM NUMBER OF ALIASES EXCEEDED, EXCESS IGNORED.

Explanation: More than sixteen aliases were specified for the output load module.

System Action: The excess aliases are ignored.

Programmer Response: Probable user error. Either (1) reduce the number of aliases, or (2) create a second copy of the module under a different name with the additional aliases specified. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST option was specifed for the failing job step.
- Execute the IEHLIST utility program, using the LISTPDS function to print out the directory entries for the partitioned data set containing the output load module.

IEW0342 ERROR - LIBRARY SPECIFIED DOES NOT CONTAIN MODULE.

Explanation: The module or alias name specified on an INCLUDE or LIBRARY control statement was not found in the specified library.

System Action: Any references to the module are not resolved. The output load module is marked not executable unless the LET option has been specified.

Programmer Response: Probable user error. Correct the library or module name on the DD, INCLUDE, or LIBRARY control statement. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTPDS function to print out the library's directory entries.
- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0354 ERROR - TABLE OVERFLOW -- TOO MANY CALLS BETWEEN CONTROL SECTIONS.

Explanation: There are too many V-type address constants referring to external symbols in a program that is being structured in overlay. The table recording these V-type address constants has overflowed.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased, if necessary; or (2) reduce the number of V-type address constants by combining control sections; or (3) change V-type address constants that do not refer across segments to A-type address constants with EXTRN statements. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0364 ERROR - TABLE OVERFLOW -- INPUT TEXT EXCEEDED MAXIMUM OR TOO MANY CHANGES OF ORIGIN IN INPUT.

Explanation: There are too many discontinuities in the input addresses of text or too much text for the linkage editor to handle in existing table space.

System Action: Processing is terminated.

Programmer Response: Probable user error. (1) Increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased if necessary. If this fails, (2) increase the linkage editor's buffer space by increasing both $value_1$ and $value_2$ of the SIZE parameter, making sure the region or partition size is increased proportionately; or (3) reduce the number of ORG statements specified in assembler

language routines; or (4) break down the step into a number of link edits, performing only part of the necessary linkage function in each successive step; or (5) if the SYSLMOD data set is new (DISP=NEW), make sure that the block size is valid. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified for the JOB statement for the failing job step.
- Have the job stream and associated output listings available.

IEW0374 ERROR - TABLE OVERFLOW -- INPUT CONTAINS TOO MANY RELOCATABLE ADDRESS CONSTANTS OR TOO MANY CONTROL SECTIONS CONTAINING SUCH CONSTANTS.

Explanation: Either (1) there are too many control sections with relocation dictionaries or (2) there are too many relocatable address constants.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased, if necessary; or (2) reduce the number of relocatable address constants in the input. (One method is to assemble the coding of two or more control sections into one control section.) If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0382 ERROR - TEXT RECORD ID IS INVALID, CARD IGNORED.

Explanation: The ID of the text record refers to an invalid external symbol dictionary entry; i.e., it does not refer to a section definition entry or a private code entry. The input deck may be out of sequence or incomplete.

System Action: The record is ignored. Processing continues.

Programmer Response: Probable user error. Check the input object modules for completeness and proper sequence. If necessary, either (1) recreate any module which has been in card form, or (2) isolate the incorrect module by executing the linkage editor with the NCAL option specified, using the NAME control statement for each input module. Diagnostic IEW0382 should recur and isolate the incorrect module. Recreate the module and rerun the step. If the problem recurs, do the following before calling IBM for programming support:

- Have available the output used to isolate the module as described above.

- If the incorrect module is a load module, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function, and save the resulting load module and cross-reference listings.

- If the incorrect module is an object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.

- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0394 ERROR - MEMBER NOT STORED IN LIBRARY -- PERMANENT DEVICE ERROR.

Explanation: This is either an input/output error, or no space was allocated for the library directory.

System Action: Processing is terminated.

Programmer Response: Check the SYSLMOD data set to make sure it is a partitioned data set with space allocated for a directory. If necessary, restore the library to a different volume, and rerun the job. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC function to print out the Data Set Control Block for the SYSLMOD data set.

- Have the output from a run with the library on a different volume available.

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.

- Have the job stream and associated output listings available.

IEW0404 ERROR - MEMBER NOT STORED IN LIBRARY -- NO SPACE LEFT IN DIRECTORY.

Explanation: All directory blocks allocated when the output data set was created have been used.

System Action: The member is not stored in the specified library.

Programmer Response: Probable user error. Either (1) reprocess, placing the output module in a new library; when the original library is used as input, concatenate the new one with it; or (2) use a utility program to copy the library, allowing for more directory entries. Edit the member into the new library. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC and LISTPDS statements to print out the Data Set Control Block and directory entries for the SYSLMOD data set.

- Make sure that the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0412 ERROR - ALIAS NOT STORED IN LIBRARY -- NO SPACE LEFT IN DIRECTORY.

Explanation: All directory blocks allocated when the output data set was created have been used.

System Action: The alias is not stored in the specified library; however, the member can be referred to by the member name.

Programmer Response: Probable user error. Either (1) reprocess, placing the output module in a new library; when the original library is used as input, concatenate the new one with it; or (2) use a utility program to copy the entire library (except the member whose alias was not stored), and allow for more directory entries. Edit the member into the new library. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC and LISTPDS statements to print out the Data Set Control Block and directory entries for the SYSLMOD data set.
- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0421 WARNING - IDENTICAL NAME IN DIRECTORY, WILL TRY TO STORE UNDER 'TEMPNAME'.

Explanation: The output module name has been used previously in the library. The replace function is not specified.

System Action: An attempt is made to store the output module into the library under the name TEMPNAME.

Programmer Response: Probable user error. Either, (1) reprocess, using a different name in the SYSLMOD DD statement or NAME statement, or (2) reprocess, and specify the replacement function for the name originally specified in the SYSLMOD DD statement or the NAME statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST option was specified for the failing job step.
- Execute the IEHLIST utility program, using the LISTPDS statement to print out the directory entries for the SYSLMOD data set.

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.

- Have the job stream and associated output listings available.

IEW0432 ERROR - LIBRARY NAME PRINTED CANNOT BE OPENED, DD CARD MAY BE MISSING.

Explanation: The DD statement that defines the library is probably missing. This message also results when a sequential data set (encountered in the processing of an INCLUDE statement) cannot be opened.

System Action: Processing continues without input from the specified library.

Programmer Response: Probable user error. Either supply the missing DD statement, or correct erroneous information on the DD statement. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST option was specified for the failing job step.

- Execute the IEHLIST utility program using the LISTVTOC statement to print out the Data Set Control Block for the data set that can't be opened.

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.

- Have the job stream and associated output listings available.

IEW0444 ERROR - TABLE OVERFLOW -- TOO MANY DOWNWARD CALLS.

Explanation: There are too many V-type address constants that refer to segments lower in the tree structure.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased if necessary; or (2) use an overlay structure with fewer segments. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.

- Have the job stream and associated output listings available.

IEW0454 ERROR - TABLE OVERFLOW -- SEGMENT CONTAINS TOO MANY DOWNWARD CALLS.

Explanation: One segment in the overlay structure contains too many V-type address constants that refer to segments lower in the tree structure. The maximum is determined by the size of an output load module record.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) increase the size of an output load module record by specifying SYSLMOD as a library with a larger block size, (2) incorporate some of the called control sections in the requesting segment, or (3) divide the requesting segment into two or more segments. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and output listing of the step used to create the incorrect module available.

IEW0461 WARNING - SYMBOL PRINTED IS AN UNRESOLVED EXTERNAL REFERENCE, NCAL WAS SPECIFIED.

Explanation: The NCAL option, restricted no-call, or never-call function was specified for the external reference.

System Action: The automatic library call mechanism does not attempt to resolve the external reference.

Programmer Response: No response is necessary normally. Check that the reference is valid and not the result of a keypunch or programming error. If you wish the reference resolved, either (1) add the needed module to the primary or included input data sets; (2) remove the NCAL option, if specified; (3) remove the LIBRARY statement specifying restricted no-call or never-call; or (4) if an input load module contained a never-call reference, re-create the load module without specifying never-call. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- For each load module containing a call to the reference, execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings.
- Have available each object module that contains a call to the reference, and the associated source listing.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0472 ERROR - INVALID ALIAS ENTRY POINT IN OVERLAY STRUCTURE.

Explanation: The specified alias entry point is not in the root segment.

System Action: The entry point for the member name is used.

Programmer Response: Probable user error. Respecify the alias, entry point, or overlay structure. If the problem recurs, do the following before calling IBM for programming support:

- Have the module containing the alias entry point and its associated listing available.
- Execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting map and cross-reference listings of the output load module.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0484 ERROR - TABLE OVERFLOW -- TOO MANY EXTERNAL SYMBOLS AFFECTED BY RELOCATION.

Explanation: There are too many symbols being relocated.

System Action: Processing is terminated.

Programmer Response: Probable user error. Either (1) increase the linkage editor's table space by increasing $value_1$ (or decreasing $value_2$) of the SIZE parameter, making sure the region or partition size is also increased if necessary; or (2) break down the step into a number of link edits, performing only part of the necessary editing function in each successive step. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0492 ERROR - NAME CARD FOUND IN LIBRARY, CARD IGNORED.

Explanation: A NAME statement has been encountered in an included data set or an automatic call library. NAME statements may be placed only in the primary input.

System Action: The record is ignored. Processing continues.

Programmer Response: Remove the NAME statement from the library or sequential data set. Reprocess if the load module is incorrect. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that the XREF and LIST options were specified for the failing job step.

- Execute the IEBPTPCH utility program to print out all included and automatic call library modules.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0502 ERROR - ALIAS NOT STORED IN LIBRARY -- PERMANENT DEVICE ERROR.

Explanation: The alias could not be stored in the library directory because of a hardware error.

System Action: The load module has already been stored.

Programmer Response: Execution of the module is possible using the member name or aliases already stored. The module can be link edited again with the new alias specified. If diagnostic IEW0502 appears again, restore the library to a different volume and rerun. If the problem recurs, do the following before calling IBM for programming support:

- Have the output from a run with the library on a different volume available.
- Execute the IEHLIST utility program, using the LISTVTOC and LISTPDS statements to print out the Data Set Control Block and directory entries for the SYSLMOD data set.
- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0512 ERROR - INCLUDE STATEMENT SYNTAX CONFLICTS WITH RECORD FORMAT OF SPECIFIED DATA SET -- DDNAME PRINTED.

Explanation: The INCLUDE statement syntax conflicts with the characteristics of the data set specified on the DD statement.

System Action: The specified module is ignored.

Programmer Response: Probable user error. Either (1) specify a member name on the INCLUDE or DD statement if the data set is partitioned; or (2) remove all member names from the INCLUDE statement if the data set is not partitioned. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST option was specified for the failing job step.
- Execute the IEHLIST utility program using the LISTVTOC statement to print out the Data Set Control Block for the specified data set.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.

- Have the job stream and associated output listings available.

IEW0522 ERROR - SPECIFIED DATA SET HAS UNACCEPTABLE RECORD FORMAT --DDNAME PRINTED.

Explanation: The record format of the specified data set is not type U or F and cannot be processed by the linkage editor.

System Action: The data set is not processed.

Programmer Response: Probable user error. Correct the data set specification. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC statement to print out the Data Set Control Block for the rejected data set.
- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0532 ERROR - BLOCKSIZE OF LIBRARY DATA SET EXCEEDED MAXIMUM -- DDNAME PRINTED.

Explanation: The block size of the specified library data set cannot be handled by the linkage editor.

System Action: The data set is not processed.

Programmer Response: Probable user error. Either (1) decrease the block size of the data set, or (2) increase $value_2$ of the SIZE parameter to allow for larger buffers, and increase $value_1$ accordingly, if necessary. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC statement to print out the Data Set Control Block for the specified data set.
- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0543 ERROR - IDENTICAL NAME IN DIRECTORY

Explanation: The member name already exists in the directory. In the case of a member, an attempt was made to store under TEMPNAME; however, TEMPNAME was also found in the directory.

System Action: The output module is not stored under this member name.

Programmer Response: Probable user error. Either (1) specify a unique member name for the module on the NAME control statement or the SYSLMOD DD statement, or (2) specify the replace function on the NAME statement. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTPDS statement to print out the directory entries for the SYSLMOD data set.
- Make sure the LIST option was specified for the failing job step.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0552 ERROR - COMMON PRINTED EXCEEDED SIZE OF CONTROL SECTION WITH IDENTICAL NAME

Explanation: A named common area has been encountered which is larger than a control section with the same name.

System Action: The linkage editor uses the longest length specified for the name at the time it encounters the control section. Processing continues.

Programmer Response: Ensure that no named common area is larger than the control section initializing it. FORTRAN programmers should make sure that any named COMMON in a BLOCK DATA subprogram is at least as large as any other FORTRAN program or subprogram with which the BLOCK DATA subprogram is to be link edited. To isolate the problem, run the step with the NCAL option specified. If the error recurs, the long COMMON occurs in the primary data set or an included data set. Otherwise it occurs in a module from the automatic call library. In either case, execute the LISTOBJ function of the IMBLIST service aid program to list all object module symbols, and execute the LISTLOAD function of IMBLIST with the OUTPUT=XREF option to list all load module symbols in the appropriate input data sets. Check the listings for all modules that contain the named COMMON in question and correct the lengths. If the problem recurs, do the following before calling IBM for programming support:

- Have available the output from IMBLIST used to isolate the problem.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0572 ERROR - COMMON PRINTED AND SUBROUTINE HAVE IDENTICAL NAME.

Explanation: This message appears only when the linkage editor is processing an object program originally written in FORTRAN. It is issued when a COMMON defined in the program has the same name as a subprogram.

System Action: Processing continues. The output module is marked not executable unless the LET option is specified.

User Response: Change the name of either the COMMON or the subprogram so that the names are no longer the same. Compile and link edit the program again. If the problem recurs, do the following before calling IBM for programming support:

- Have the source program listing and the linkage editor output listing available.
- Have the associated job stream and output listings available.
- Make sure that the XREF and LIST options were specified for the failing job step.

IEW0594 INPUT DATA SET BLKSIZE IS INVALID

Explanation: The block size for the primary input data set (SYSLIN) is not an even multiple of the logical record length, or exceeds the allowable maximum.

System Action: Linkage editor processing is terminated.

Programmer Response: Probable user error. Determine whether the values specified in the SIZE parameter are sufficient to accommodate the blocking factor of the primary input data set (SYSLIN). Blocking factors are discussed in the "SIZE Option" section. If the SIZE values are not large enough, increase them and execute the linkage editor step again. In an MVT system, the region for the job step must be large enough to allow the SIZE values specified, as described in "EXEC Statement -- REGION Parameter." If the region is not large enough, increase the REGION parameter before executing the linkage editor step again.

If the blocking factor is greater than 40 to 1 or is not a multiple of the logical record length, correct the BLKSIZE field, or re-create the data set, or both. Execute the linkage editor step again.

If the problem recurs, do the following before calling IBM for programming support:

- If possible, execute the IEHLIST utility program, using the LISTVTOC statement to print out the Data Set Control Block for the specified data set.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0602 ERROR - INPUT FROM OBJECT MODULE IS INVALID, END CARD MISSING.

Explanation: The END card of an object module being processed by the linkage editor is missing.

System Action: Linkage editor processing continues. The load module produced is marked not executable unless the LET option has been specified.

Programmer Response: If input to the linkage editor was in the form of an object deck, verify that the last card is an END card (END in columns 2, 3, and 4). If the card is not an END card, recompile or reassemble the source program. If input to the linkage editor was not in the form of an object deck, recompile or reassemble the source program with the DECK option specified.

In either case, verify that the last card is an END card. Rerun the linkage editor step using the object deck. If the problem recurs, do the following before calling IBM for programming support:

- Have the object module input and associated source listings available.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Have the job stream and output listings available.

IEW0614 LENGTH NOT SPECIFIED FOR EXTERNAL SYMBOL PRINTED

Explanation: An object module contained a control section that had a length field containing zero in its external symbol dictionary (ESD) entry, and either (1) the control section was not last in the object module or (2) the length was not specified on the END card.

System Action: The module was not processed, and the linkage editor terminated processing.

Programmer Response: Probable user error. Check the input object modules for completeness and proper sequence. If necessary, either (1) re-create any module that has been in card form, or (2) isolate the incorrect module by executing the linkage editor with the NCAL option specified, using the NAME control statement for each input object module. Diagnostic IEW0614 should recur and isolate the incorrect module. Re-create the module and rerun the step. If the problem recurs, do the following before calling IBM for programming support:

- Have available the output used to isolate the module.
- To list the incorrect object module, execute the LISTOBJ function of the IMBLIST service aid program and save the resulting object module listing.
- Make sure that the XREF and LIST options were specified for the failing job step.
- Have the job stream and output listing of the step used to create the incorrect module available.

IEW0630 DDNAME PRINTED HAD SYNCHRONOUS ERROR -- XREF ABORTED.

Explanation: A permanent input/output error occurred while attempting to produce a cross-reference table. The output module was successfully edited.

System Action: The information provided by the SYNADAF macro instruction was printed after the message code in the following format: SYNAD EXIT, jobname, stepname, unit address, device type, ddname, operation attempted, error description, block count or BBCCHHR, access method.

Programmer Response: Rerun the linkage editor step. If the problem recurs, do the following before calling IBM for programming support:

- Save the output from the SYNADAF macro instruction.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- If possible, execute the IEHLIST utility program using the LISTVTOC function to print out the data set control block for the data set specified in the SYNAD output.
- Have the job stream and associated listings available.

IEW0661 CONTROL STATEMENT IGNORED

Explanation: A control statement used to specify functions not available under the IBM System/360 Operating System was found in the input to the linkage editor.

System Action: The statement is ignored. Linkage editor processing continues.

Programmer Response: If the output load module is to be run under an operating system with page alignment and/or control section sequencing, execute the linkage editor step again using the appropriate linkage editor, which includes support for the specified control statements. If the output load module is to be executed under the IBM System/360 Operating System, ignore the message. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the LIST and XREF options were specified for the failing step.
- Have the job stream and associated output listings available.

IEW0670 THE SPECIFIED IDENTIFY DATA HAS BEEN ADDED TO THE IDR FOR THE CONTROL SECTION NAME PRINTED.

Explanation: The linkage editor has added the data specified on the IDENTIFY control statement to the IDR record for the control section indicated.

System Action: Processing continues.

Programmer Response: None. This message is for information only; because no error occurred, no response is required.

IEW0682 ERROR - CONTROL SECTION NAME ON AN IDENTIFY CONTROL STATEMENT IS INCORRECT OR THE STATEMENT IS MISPLACED -- IDENTIFY DATA IGNORED.

Explanation: The control section named on the IDENTIFY control statement either (1) does not exist in the load module or (2) had not been read in by the linkage editor by the time it encountered the IDENTIFY statement.

System Action: The data specified on the IDENTIFY statement is ignored. Linkage editor processing continues.

Programmer Response: Probable user error. Check the IDENTIFY statement to verify that the control section name has been specified correctly and that the IDENTIFY statement has been placed correctly in the input. Verify that the required control section has been included in the input to the linkage editor step. Correct the input and rerun the linkage editor step. If the problem recurs, do the following before calling IBM for programming support:

- Have the job stream and associated output listings available.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Make sure that the LIST and MAP or XREF options were specified for the failing step.

IEW0694 ERROR - TABLE OVERFLOW - SIZE VALUE SPECIFIED NOT LARGE ENOUGH FOR CSECT IDR INPUT -- LINKAGE EDITOR PROCESSING TERMINATED.

Explanation: The space available for CSECT Identification records was insufficient for the actual input.

System Action: Linkage editor processing is terminated.

Programmer Response: Probable user error. Increase the space available to the linkage editor by increasing $value_1$ (or decreasing $value_2$) of the SIZE option, making sure that the region or partition size is also increased correspondingly, if necessary. Rerun the linkage editor step. If the problem recurs, do the following before calling IBM for programming support:

- Have the job stream and associated output listings available.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Make sure that the LIST and XREF options were specified for the failing step.

IEW0704 UNRECOVERABLE ERROR DETECTED IN CSECT IDR INPUT -- LINKAGE EDITOR PROCESSING TERMINATED.

Explanation: An unrecoverable error was detected while processing an input module containing CSECT Identification (IDR) records. The cause of the error was a load module IDR record that contained an invalid code in its subtype field (the third byte of the record).

System Action: Linkage editor processing is terminated.

Programmer Response: Probable user error. Examine all data sets containing input load modules. Check all secondary input sources (either defined by the SYSLIB DD statement or specified on an INCLUDE statement). If any user modifications were made to any record other than text in any of these modules, re-create any affected modules from the source or object level and execute the linkage editor step again. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IMBLIST service aid program with the LISTLOAD function and the OUTPUT=BOTH option to list all load modules in the input to the linkage editor.
- Execute the IMBLIST service aid program with the LISTIDR function to list CSECT IDR records for all members of the data set SYS1.LINKLIB cataloged on the system when the error occurred.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job and that the LIST option was specified on the EXEC statement for the linkage editor step.
- Have the job stream, all input data sets, and all associated output listings available.

IEW0714 ERROR -- MEMBER NOT STORED IN LIBRARY -- STOW WORKSPACE UNAVAILABLE.

Explanation: The conditional GETMAIN macro instruction issued by the STOW routine to obtain work space in main storage was unnsuccessful (that is, not enough contiguous main storage was available.)

System Action: The member is not stored in the specified library; linkage editor processing is terminated.

Programmer Response: Rerun the linkage editor job step. The error may be a temporary one caused by fragmentation of main storage. If the problem persists, check for user-written programs or user-written SVC (supervisor call) routines that may be executing concurrently with the linkage editor and causing main storage fragmentation, as would occur when a GETMAIN macro is issued without a FREEMAIN in an uncontrolled loop. If the problem still persists, do the following before calling IBM for programming support:

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream, all associated output listings, and the system console sheet available.

IEW0984 ERROR - SYSPRINT BLOCKSIZE EXCEEDS MAXIMUM -- LINKEDIT PROCESSING TERMINATED.

Explanation: The block size specified for the SYSPRINT data set cannot be handled by the linkage editor.

System Action: The data set is not opened. Linkage editor processing is terminated.

Programmer Response: Probable user error. Either (1) decrease the block size of the data set, or (2) increase $value_2$ of the SIZE option to allow for larger buffers, and increase $value_1$ accordingly, if necessary. Increase the region or partition size correspondingly, if necessary. Rerun the linkage editor step. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC statement to print out the Data Set Control Block for the SYSPRINT data set.
- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW0994 ERROR - SYSPRINT DD CARD MISSING - LINKAGE EDITOR PROCESSING TERMINATED.

Explanation: The SYSPRINT data set cannot be opened.

System Action: Linkage editor processing is terminated.

Programmer Response: Probable user error. The SYSPRINT DD statement is probably missing. Supply the missing SYSPRINT DD statement, and execute the job step again. If the problem recurs, do the following before calling IBM for programming support:

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Execute the IMBLIST service aid program, using the LISTLOAD and LISTIDR statements to print out the linkage editor and a list of all modifications to it from the link library (SYS1.LINKLIB).
- Have the job stream and associated output listings available.

The Loader is one of the IBM System/360 Operating System processing programs. It combines basic editing and loading functions of the linkage editor and program fetch in one job step. Therefore, the load function is equivalent to the link edit-go function. The loader can be used for compile-load and load jobs.

The loader will load object modules produced by a language processor and load modules produced by the linkage editor into main storage for execution. Optionally, it will search a call library (SYSLIB) or a resident link pack area, or both, to resolve external references. The loader does not produce load modules for program libraries.

The functional characteristics, compatibility and restrictions, performance considerations, and storage considerations of the loader are described in the following sections.

FUNCTIONAL CHARACTERISTICS

The loader can be used with MFT and MVT. The loader is re-enterable and, therefore, can reside in the resident link pack area.

The loader combines the following basic functions of the linkage editor and program fetch:

1. Resolution of external references between program modules.
2. Optional inclusion of modules from a call library (SYSLIB) or from a link pack area, or from both (Figures 46 and 47). (Inclusion of modules from a call library or the link pack area is performed, if requested, when external references remain unresolved after processing the primary input to the loader. If both are requested, the link pack area is searched first.)
3. Automatic deletion of duplicate copies of program modules (Figure 48). (The first copy is loaded and all succeeding requests use that copy.)
4. Relocation of all address constants so that control may be passed directly to the assigned entry point in main storage.

The diagnostics produced by the loader are similar to those of the linkage editor.

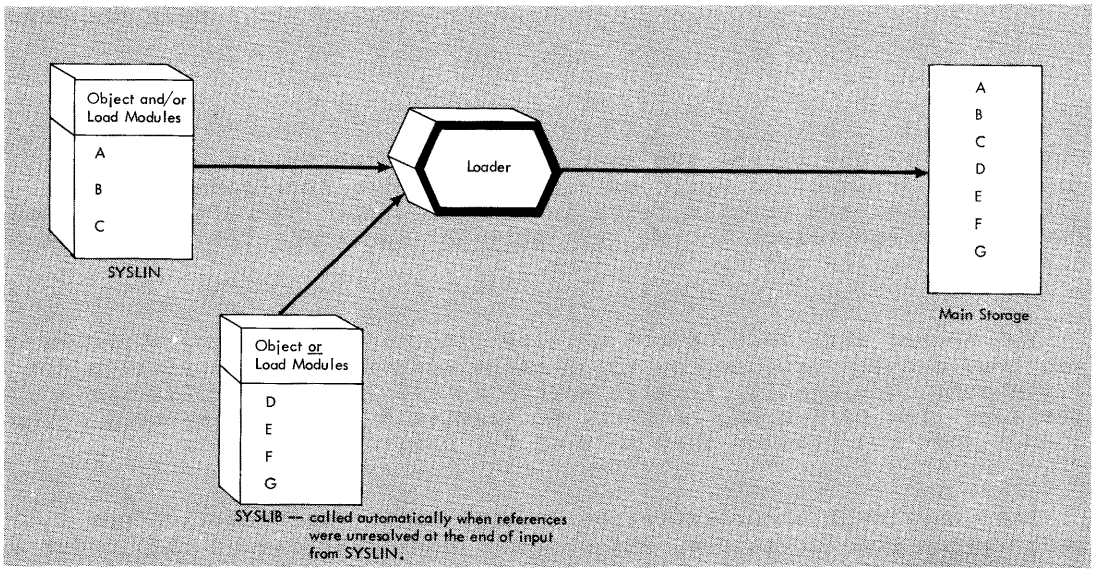


Figure 46. Loader Processing -- SYSLIB Resolution

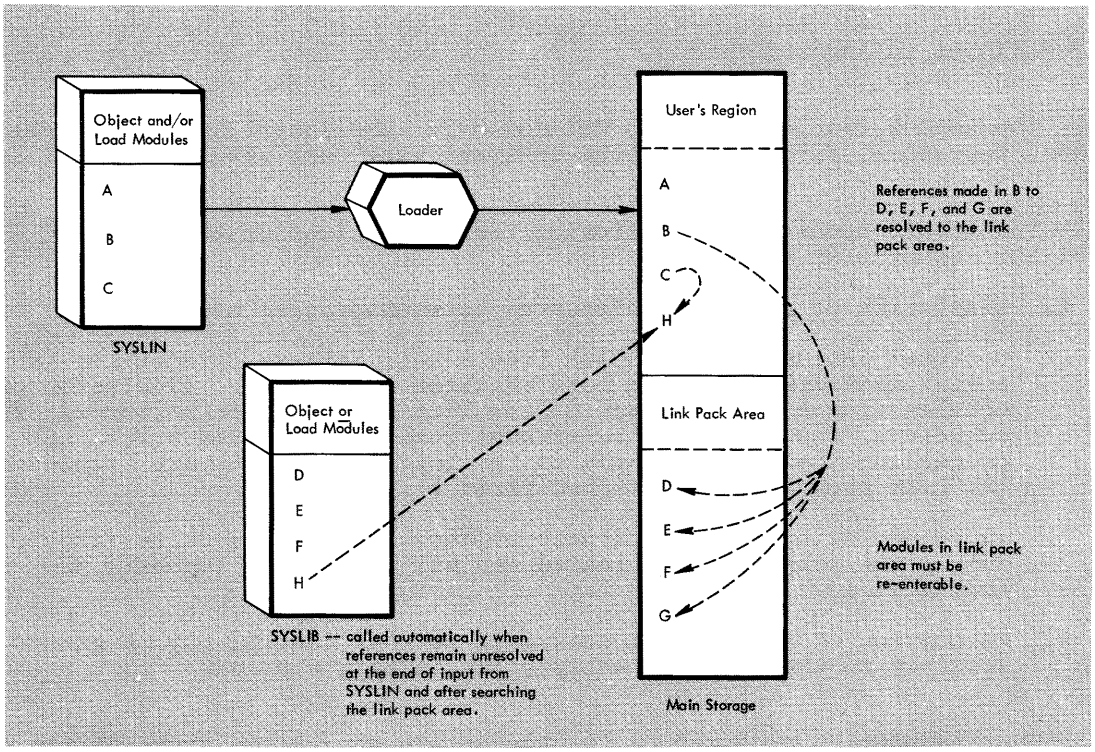


Figure 47. Loader Processing -- Link Pack Area and SYSLIB Resolution

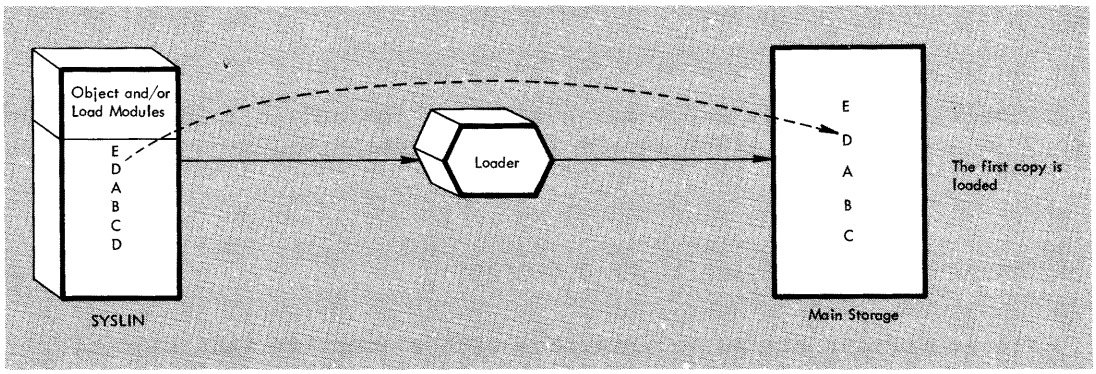


Figure 48. Loader Processing -- Automatic Editing

COMPATIBILITY AND RESTRICTIONS

The loader accepts the same basic input as the linkage editor:

1. All object modules that can be processed by the linkage editor can be input to the loader.

2. All load modules produced by the linkage editor can be input to the loader (except load modules edited with the NE option).

The loader supports the following linkage editor options: MAP, LET, NCAL, SIZE, and TERM. All other linkage editor options and attributes are not supported, but, if used, they will not be considered as errors. A message will be listed on SYSLOUT indicating that they are not supported. The supported options are specified in the PARM field of the EXEC statement, or with the LINK, ATTACH, LOAD, or XCTL macro instruction. In addition to the supported linkage editor options, the loader provides several other options. All loader options are described under "EXEC Statement" in the section "Using the Loader."

The loader does not process linkage editor control statements (for example, INCLUDE, NAME, OVERLAY, etc.). If they are used, they will not be treated as errors and a message will be listed on SYSLOUT indicating that the control statements are not supported.

The loader and the linkage editor are bound by the same input conventions. (These conventions are discussed in Part 1 of this publication.) In addition, the loader can accept load modules in the SYSLIN data set and object modules from a data area in main storage.

The loader does not use auxiliary storage space for work areas; that is, there is no loader function corresponding to the linkage editor's creation of intermediate work data sets or output load modules.

Time Sharing Option (TSO)

When the loader is used under TSO, it is invoked by the loader prompter, a program that acts as an interface between the user and the operating system and the loader. Under TSO, execution of the loader and definition of the data sets used by the loader are described to the system through use of the LOADGO command that causes the prompter to be executed. Operands of the LOADGO command can also be used to specify the loader options a job requires.

Complete procedures for using the LOADGO command to load and execute an object module are given in the Terminal User's Guide.

Processing Object Modules in Main Storage

The loader can act as an interface with a compiler that has the ability to construct a data area of one or more object modules in main storage as an alternative to a data set on a secondary storage volume (such as a tape or disk). Such a compiler passes the loader a description of the internal data area, which the loader then processes as primary input. This internal data area replaces external SYSLIN data set input to the loader.

Instead of placing text records for the object module in the internal data area, the compiler can pass pointers to preloaded text. The loader can then perform its relocation and linkage functions on the preloaded text itself; text is not moved during processing.

Loaded Program Restrictions

Any loaded program that issues an XCTL macro instruction or an IDENTIFY macro instruction in an MFT environment will not execute properly. It is recommended that any such program be processed by the linkage editor.

If an IDENTIFY macro instruction is issued by the loaded program, IDENTIFY returns a '0C' code in register 15. This code means that the entry point address is not within an eligible load module and that the entry point was not added.

In an MFT environment, any data set opened by a loaded program should be closed by the program before execution is complete.

This section discusses how to prepare an input deck for the loader and how to invoke the loader; it also describes the output from the loader.

INPUT FOR THE LOADER

The input deck for the loader must contain job control language statements for the loader and, optionally, for the loaded program (Figure 49).

Only the EXEC statement and the SYSLIN DD statement are required for a loader step. The JOB statement is required if the loader is the first step in the job.

```
//name      JOB  parameters           (optional)
//name     EXEC  PGM=LOADER,PARM=(parameters)
//SYSLIN    DD   parameters
//SYSLIB    DD   parameters           (optional)
//SYSLOUT   DD   parameters           (optional)
//SYSTERM   DD   parameters           (optional)
//    (optional DD statements and data required for loaded program)
```

Figure 49. Input Deck for the Loader -- Basic Format

EXEC STATEMENT

The EXEC statement is used to call the loader and to specify options for the loader and for the loaded program. The loader is called by specifying PGM=IEWLDRGO or PGM=LOADER (see "Invoking the Loader"). Loader and loaded program options are specified in the PARM field of the EXEC statement. The PARM field must have the following format:

```
,PARM='[loaderoption[,loaderoption]...]
       [/programoption[,programoption]...]'
```

Note that the loaded program options, if any, must be separated from the loader options by a slash (/). If there are no loader options, the program options must begin with a slash. The entire PARM field may be omitted if there are no loader or loaded program options.

Parameters must be enclosed in single quotes when special characters (/ and =) are used.

The loader options are:

MAP
The loader produces a map of the loaded program that lists external names and their absolute storage addresses on the SYSLOUT data set. (If the SYSLOUT DD statement is not used in the input deck, this option is ignored.) The module map is described in "Loader Output" in this section.

NOMAP
A map is not produced.

RES
An automatic search of the link pack area queue is to be made. This search is always made after processing the primary input (SYSLIN), and before searching the SYSLIB data set. When this option is specified, the CALL option is automatically set.

NORES
No automatic search of the link pack area queue is to be made.

CALL
An automatic search of the SYSLIB data set is to be made. (If the SYSLIB DD statement is not included in the input deck, this option is ignored.)

NOCALL
or NCAL
An automatic search of the SYSLIB data set will not be made. When this option is specified, the NORES option is automatically set.

LET
The loader will try to execute the object program even though a severity 2 error condition is found. (A severity 2 error condition is one that could make execution of the loaded program impossible.)

NOLET
The loader will not try to execute the loaded program if a severity 2 error condition is found.

SIZE=size
specifies the size, in bytes, of dynamic main storage that can be used by the loader (see Appendix G).

EP=name
specifies the external name to be assigned as the entry point of the loaded program. This parameter must be specified if the entry point of the loaded program is in an input load module. For FORTRAN, ALGOL, and PL/I, these entry points must be MAIN, IHIFSAIN, and IHENTRY, respectively.

NAME=name
specifies the name to be used to identify the loaded program to the system. If this parameter is not used, the loaded program will be named **GO.

PRINT
Informational and diagnostic messages are produced on the SYSLOUT data set.

NOPRINT
Informational and diagnostic messages are not produced on the SYSLOUT data set. SYSLOUT is not opened.

TERM
: Numbered diagnostic messages are to be sent to the SYSTERM data set. Although intended to be used when operating under the Time Sharing Option (TSO), the SYSTERM data set can be used to replace or supplement the SYSLOUT data set at any time. (If the SYSTERM DD statement is not included in the input deck, this option is ignored.)

NOTERM
: Numbered diagnostic messages are not to be sent to the SYSTERM data set.

Unless otherwise specified with the LOADER macro instruction during system generation, the default options are: NOMAP, RES, CALL, NOLET, SIZE=100K, and PRINT. The default options NAME=**GO and NOTERM cannot be changed during system generation.

The following are examples of the EXEC statement. In these examples, X and Y are parameters required by the loaded program.

```
//LOAD    EXEC   PGM=LOADER

//LOAD    EXEC   PGM=IEWLDRGO,PARM='MAP,EP=FIRST/X,Y'

//LOAD    EXEC   PGM=LOADER,PARM='/X,Y'

//LOAD    EXEC   PGM=IEWLDRGO,PARM=(MAP,LET)

//LOAD    EXEC   PGM=LOADE,PARM=NOPRINT

//LOAD    EXEC   PGM=LOADER,PARM='NAME=NEWPROG,TERM,NOPRINT'
```

For further details in coding the EXEC statement refer to the Job Control Language Reference publication.

DD STATEMENTS

The loader uses four DD statements named SYSLIN, SYSLIB, SYSLOUT, and SYSTERM. (These ddnames can be changed during system generation with the LOADER macro instruction.) The SYSLIN DD statement must be used in every loader job. The other three are optional.

The following considerations apply to the DCB parameter of SYSLIN, SYSLIB, and SYSLOUT.

- For better performance, BLKSIZE and BUFNO can be specified.
- If BUFNO is omitted, BUFNO=2 is assumed.
- Any value given to BUFNO is assumed for NCP (number of channel programs).
- If RECFM=U is specified, BUFNO=2 is assumed, and BLKSIZE and LRECL are ignored.
- RECFM=V is not accepted.
- RECFM=FBSA is always assumed for SYSLOUT.

- If RECFM is omitted, RECFM=F is assumed for SYSLIN and SYSLIB.
- If BLKSIZE is omitted, the value given to LRECL is assumed.
- LRECL=121 is assumed for SYSLOUT unless the loader is operating under the Time Sharing Option (TSO), when LRECL=81 is assumed.
- If LRECL is omitted, LRECL=80 is assumed for SYSLIN and SYSLIB.
- If OPTCD=C is used to specify chained scheduling, an additional 2K (2048 bytes) of main storage is needed in the user's region if the necessary data management routines are not resident.

Note: The SYSTERM data set will always consist of unblocked 81-character records with BUFNO=2 and RECFM=FSA. Because these values are fixed, the DCB parameter need not be used.

In addition to the DD statements used by the loader, any DD statements and data required by the loaded program must be included in the input deck.

SYSLIN DD Statement

The SYSLIN DD statement defines the input data for the loader. This input can be either object modules produced by a language translator, or load modules produced by the linkage editor, or both. The data sets defined by the SYSLIN DD statement can be either sequential data sets, or members of a partitioned data set, or both. The DSNAME parameter for a partitioned data set must indicate the member name, that is, DSNAME=dsname(membername). Concatenation can be used to include more than one module in SYSLIN.

The following are examples of the SYSLIN DD statement. The first example defines a member of a previously cataloged partitioned data set:

```
//SYSLIN  DD      DSNAME=OUTPUT.FORT(MOD12),DISP=OLD,
                  DCB=(BLKSIZE=320,BUFNO=4)
```

The second example defines a sequential data set on magnetic tape:

```
//SYSLIN  DD      DSNAME=PROG15,UNIT=2400,DISP=(OLD,KEEP),
//                VOLUME=(PRIVATE,RETAIN,SER=MCS167)
```

The third example defines a data set which was the output of a previous step in the same job:

```
//SYSLIN  DD      DSNAME=*.COBOL.SYSLIN,DISP=(OLD,DELETE)
```

The fourth example shows the concatenation of three data sets. The first two data sets are members of different partitioned data sets; the first is an object module and the second is a load module. The third data set is in the input stream following a SYSIN DD statement (see "Loaded Program Data" in this section).

```
//SYSLIN  DD      DSNAME=PGMLIB.SET1(RFS1),DISP=OLD,
//                DCB=(BLKSIZE=3200,RECFM=FB)
//        DD      DSNAME=PGMLIB.SET2(ABC5),DISP=OLD,DCB=RECFM=U
//        DD      DDNAME=SYSIN
```

SYSLIB DD Statement

The SYSLIB data set contains IBM-supplied or user-written library routines to be included in the loaded program. The data set is searched when unresolved references remain after processing SYSLIN and optionally searching the link pack area.

The SYSLIB data set is used to resolve an external reference when the following conditions exist: the external reference must be (1) a member name or an alias of a module in the data set, and (2) defined as an external name in the external symbol dictionary of the module with that name. If the unresolved external reference is a member name or an alias in the library, but is not an external name in that member, the member is processed but the external reference remains unresolved unless subsequently defined.

The data set defined by the SYSLIB DD statement must be a partitioned data set that contains either object modules or load modules, but not both. Concatenation may be used to include more partitioned data sets in SYSLIB. All concatenated data sets must contain the same type of modules (object or load).

The following are examples of the SYSLIB DD statement. The first example defines a cataloged partitioned data set that can be shared by other steps:

```
//SYSLIB  DD      DSNAME=SYS1.ALGLIB,DISP=SHR
```

The second example shows the concatenation of two data sets:

```
//SYSLIB  DD      DSNAME=SYS1.PL1LIB,DISP=SHR
//        DD      DSNAME=LIBMOD.MATH,DISP=OLD
```

SYSLOUT DD Statement

The SYSLOUT DD statement is used for error and warning messages and for an optional map of external references (see "Loader Output" in this section). The data set defined by this DD statement must be a sequential data set. The DCB parameter can be used to specify the blocking factor (BLKSIZE) of this data set. For better performance, the number of buffers (BUFNO) to be allocated to SYSLOUT can also be specified.

The following are examples of the SYSLOUT DD statement. The first example specifies the system output unit:

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

The second example defines a sequential data set on a 1443 printer:

```
//SYSLOUT DD      UNIT=1443,DCB=(BLKSIZE=121,BUFNO=4)
```

SYSTERM DD Statement

The SYSTERM DD statement defines a data set that is used for numbered diagnostic messages only. When the loader is being used under the Time

Sharing Option (TSO) of the operating system, the SYSTERM DD statement defines the terminal output data set. However, SYSTERM can also be used at any time to replace or supplement the SYSLOUT data set. Because the SYSTERM data set is not opened unless the loader must issue a diagnostic message, using SYSTERM instead of SYSLOUT can reduce loader processing time.

When the SYSTERM data set replaces the SYSLOUT data set, the numbered messages in the SYSTERM data set are the only diagnostic output; when SYSTERM supplements the SYSLOUT data set, the numbered messages appear in both data sets, and optional diagnostic and informational output, such as a list of options or a module map, can be obtained on SYSLOUT.

The DCB parameters for SYSTERM are fixed and need not be specified. The SYSTERM data set always consists of unblocked 81-character records with BUFNO=2 and RECFM=FSA.

The following example shows the SYSTERM DD statement when used to specify the system output unit:

```
//SYSTERM   DD   SYSOUT=A
```

LOADED PROGRAM DATA

Loaded program data and loader data can both be specified in the input reader in MFT and MVT. Loaded program data can be defined by a DD statement following the loader data.

Figure 50 shows the loading of a previously compiled FORTRAN problem program under MFT or MVT. The program to be loaded (loader data) follows the SYSLIN DD statement. The loaded program data follows the FT05F001 DD statement.

```
//LOAD      JOB  MSGLEVEL=1
//LDR      EXEC  PGM=LOADER,PARM=MAP
//SYSLIB    DD   DSNAME=SYS1.FORTLIB,DISP=SHR
//SYSLOUT   DD   SYSOUT=A
//FT06F001  DD   SYSOUT=A
//SYSLIN    DD   *
           (Loader data)
/*
//FT05F001  DD   *
           (Loaded program data)
/*
```

Figure 50. Loader and Loaded Program Data in MFT or MVT Input Stream

INVOKING THE LOADER

The loader can be referred to by either its program name, IEWLDRGO, or its alias, LOADER. The loader can be invoked through the EXEC statement, as described in "Input for the Loader," or through the LOAD, ATTACH, LINK, or XCTL macro instruction. Figure 51 shows the basic format for the macro instruction.

Name	Operation	Operand
[symbol]	{LINK / ATTACH}	EP=loadername PARAM=(optionlist[,ddname list]) VL=1
	{LOAD / XCTL}	EP=loadername

Figure 51. Macro Instruction Basic Format

EP
specifies the symbolic name of the loader. The entry point at which execution is to begin is determined by the control program from the library directory entry.

PARAM
specifies, as a sublist, address parameters to be passed to the loader. The first fullword in the address parameter list contains the address of the option list for the loader and/or loaded program. The second fullword contains the address of the ddname list. If standard ddnames are to be used, this list may be omitted.

option list
specifies the address of a variable length list containing the loader and loaded program options. This address must be written even though no list is provided.

The option list must begin on a halfword boundary. The two high-order bytes contain a count of the number of bytes in the remainder of the list. If no options are specified, the count must be zero.

The option list is free form, with the loader and loaded program options separated by a slash (/), and with each option separated by a comma. No blanks or zeros should appear in the list.

ddname list
specifies the address of a variable length list containing alternative ddnames for the data sets used during loader processing. If the standard ddnames are used, this operand may be omitted.

The format of the ddname list is identical to the format of the ddname list for invoking the linkage editor; the 8-byte entries in the list are as follows:

Entry	Alternate Name For:
1	SYSLIN
2	not applicable
3	not applicable
4	SYSLIB
5	not applicable
6	SYSLOUT
7-11	not applicable
12	SYSTERM

VL
specifies that the sign bit is to be set to 1 in the last fullword of the address parameter list.

Figure 52 shows an assembler language program that uses the LINK macro instruction to refer to the loader.

```
            SAVE    (14,12)              initialize -- save
             .                           registers and point
             .                           to new save area
             .
            LA      13,SAVEAREA
             .
             .
             .
            LINK    EP=LOADER,PARAM=(PARM),VL=1
             .
             .
             .
            L       13,4(13)
            RETURN  (14,12),T
             .
             .
             .
            DS 0H
PARM        DC  AL2(LENGTH)              length of options
OPTIONS     DC  C'NOPRINT,CALL/X,Y,Z'    loader and loaded program
LENGTH      EQU *-OPTIONS                  options
SAVEAREA    DS  18F                      save area
             .
             .
             .
            END
```

Figure 52. Using the LINK Macro Instruction To Refer to the Loader

If desired, the loader may be used to process a program but not execute it. To invoke just the portion of the loader that processes input data, specify either the name IEWLOAD or the name IEWLOADR with a LOAD and CALL macro instruction.

IEWLOAD, which is used with MVT only, will both load and identify the program. IEWLOAD returns the address of an 8-character name in register 1. This name can be used with an ATTACH, LINK, LOAD, or XCTL macro instruction to invoke the loaded program.

IEWLOADR, which can be used with MFT or MVT, will load the program but will not identify it. IEWLOADR returns the entry point of the loaded program in register 0. Register 1 points to two full words: the first points to the beginning of storage occupied by the loaded program; the second contains the size of the loaded program. This location and size can then be used in a FREEMAIN macro instruction to free the storage occupied by the loaded program when it is no longer needed.

Figure 53 shows an assembler language program that uses the LOAD and CALL macro instructions to refer to IEWLOADR. Figure 54 shows an assembler language program that uses the LOAD and CALL macro instructions to refer to IEWLOAD.

For further information on the use of these macro instructions, refer to the publication IBM System/360 Operating System: Data Management Services.

```
            SAVE    (14,12),T           initialize -- save registers and
             .                            point to new save area
             .
             .
            ST      13,SAVEAREA+4
            LA      13,SAVEAREA
             .
             .
             .
            LOAD    EP=IEWLOADR         load the loader
            LR      15,0                get its entry point address
            CALL    (15),(PARM1),VL     invoke the loader
             .
             .
             .
            LR      7,15                save return code
            LR      5,0                 save entry to loaded program
            LR      6,1                 save pointer to list containing
*                                         start address and length
            DELETE  EP=IEWLOADR         delete loader
            CH      7,=H'4'             verify successful loading
            BH      FREE                negative branch
            LR      15,5                loading successful -- get entry
*                                         point address for CALL
            CALL    (15),(PARM2),VL     invoke program
             .
             .
             .
FREE        L       0,4(6)              get length into register 0
            L       1,0(6)              get start address
            FREEMAIN  R,LV=(0),A=(1)    delete loaded program
             .
             .
             .
            L       13,4(13)
            RETURN  (14,12),T
            DS  0H
PARM1       DC  AL2(LENGTH1)            length of loader options
OPTIONS1    DC  C'NOPRINT,CALL'         loader options
LENGTH1     EQU *-OPTIONS1
            DS  0H
PARM2       DC  AL2(LENGTH2)            length of loaded program options
OPTIONS2    DC  C'X,Y,Z'                loaded program options
LENGTH2     EQU *-OPTIONS2
SAVEAREA    DS    18F                   save area
             .
             .
             .
            END
```

Figure 53. Using the LOAD and CALL Macro Instructions to Refer to IEWLOADR (Loading Without Identification)

```
            SAVE    (14,12),T           initialize -- save registers and
*                                         point to new save area
             .
             .
             .
            ST      13,SAVEAREA+4
            LA      13,SAVEAREA
             .
             .
             .
            LOAD    EP=IEWLOAD          load the loader
            LR      15,0                get its entry point address
            CALL    (15),(PARM1),VL     invoke the loader
            LR      7,15                save the return code
            MVC     PGMNAM(8),0(1)      save program name
            DELETE  EP=IEWLOAD          delete the loader
            CH      7,=H'4'             verify successful loading
            BH      ERROR               negative branch
*
            LINK    EPLOC=PGMNAM,PARM=(PARM2),VL=1  loading successful,
*                                                     invoke program
             .
             .
             .
            L       13,4(13)
            RETURN  (14,12),T
            DS      0H
PARM1       DC      AL2(LENGTH1)        length of loader options
OPTIONS1    DC      C'MAP'              loader options
LENGTH1     EQU     *-OPTIONS1
            DS      0H
PARM2       DC      AL2(LENGTH2)        length of loaded program options
OPTIONS2    DC      C'X,Y,Z'            loaded program options
LENGTH2     EQU     *-OPTIONS2
SAVEAREA    DS      18F                 save area
PGMNAM      DS      2F                  program name
             .
             .
             .
            END
```

Figure 54. Using the LOAD and CALL Macro Instructions to Refer to IEWLOAD (Loading With Identification)

LOADER OUTPUT

Loader output consists of a collection of diagnostics and error messages, and of an optional storage map of the loaded program. This output is produced in the data set defined by the SYSLOUT DD and SYSTERM DD statements. If these are omitted, no loader output is produced.

SYSLOUT output includes a loader heading, and the list of options and defaults requested through the PARM field of the EXEC statement. The SIZE stated is the size obtained, and not necessarily the size requested in the PARM field. Error messages are written when the errors are detected. After processing is complete an explanation of the error is written. Loader error messages are similar to those of the linkage editor and are listed in Appendix H.

SYSTERM output includes only numbered warning and error messages. These messages are written when the errors are detected. After processing is complete, an explanation of each error is written.

The storage map includes the name and absolute address of each control section and entry point defined in the loaded program. Each map entry marked with an asterisk (*) comes from the data set specified on the SYSLIB DD statement. Two asterisks (**) indicate the entry was found in the link pack area; three asterisks (***) indicate the entry comes from text that was preloaded by a compiler.

The map is written as the input to the loader is processed, so all map entries appear in the same sequence in which the input ESD items are defined. The total size and storage extent of the loaded program are also included. For PL/I programs, a list is written showing pseudo-registers with their addresses assigned relative to zero. Figure 55 shows an example of a module map.

In an MVT environment, the loader issues an informational message when the loaded program terminates abnormally.

```
                                        OS/360 LOADER

OPTIONS USED - PRINT,MAP,NOLET,CALL,NORES,SIZE=424176

     NAME  TYPE  ADDR       NAME  TYPE  ADDR       NAME  TYPE  ADDR       NAME  TYPE  ADDR       NAME  TYPE  ADDR

   SAMPL2B    SD   161E0   SAMPL2BA  SD   16EC8   IHEMAIN    SD   17CF8   IHENTRY    SD   17D00   IHESPRT    SD   17D10
   SYSIN      SD   17D48   IHEVQC  * SD   17D80   IHEVQCA  * LR   17D80   IHEVQB   * SD   17FD8   IHEVQBA  * LR   17FD8
   IHEDIA   * SD   183C0   IHEDIAA * LR   183C0   IHEDIAB  * LR   183C2   IHEVPE   * SD   18608   IHEVPEA  * LR   18608
   IHEVPA   * SD   18870   IHEVPAA * LR   18870   IHEVFC   * SD   189D0   IHEVFCA  * LR   189D0   IHEVPC   * SD   189F8
   IHEVPCA  * LR   189F8   IHEVFE  * SD   18BE8   IHEVFEA  * LR   18BE8   IHEVSC   * SD   18C08   IHEVSCA  * LR   18C08
   IHEDNC   * SD   18CB8   IHEDNCA * LR   18CB8   IHEDOA   * SD   18F30   IHEDOAA  * LR   18F30   IHEDOAB  * LR   18F32
   IHEDMA   * SD   19010   IHEDMAA * LR   19010   IHEVFD   * SD   19108   IHEVFDA  * LR   19108   IHEVFA   * SD   19160
   IHEVFAA  * LR   19160   IHEVPB  * SD   19248   IHEVPBA  * LR   19248   IHEXIS   * SD   193F0   IHEXISO  * LR   193F0
   IHEIOB   * SD   19488   IHEIOBA * LR   19488   IHEIOBB  * LR   19490   IHEIOBC  * LR   19498   IHEIOBD  * LR   194A0
   IHESARC  * LR   1A9C8   IHESADD * LR   1A9DE   IHESAFF  * LR   1AA18   IHEPRT   * SD   1AB70   IHEPRTA  * LR   1AB70
   IHEBEGA  * LR   1AE28   IHEERR  * SD   1AE68   IHEERRD  * LR   1AE68   IHEERRC  * LR   1AE72   IHEERRB  * LR   1AE7C
   IHEERRA  * LR   1AE86   IHEERRE * LR   1B4E2   IHEIOF   * SD   1B580   IHEIOFB  * LR   1B580   IHEIOFA  * LR   1B582
   IHEITAX  * LR   1B81E   IHEITAX * LR   1B82A   IHEITAA  * LR   1B83E   IHEDCN   * SD   1B860   IHEDCNA  * LR   1B860
   IHEDCNB  * LR   1B862   IHEIOD  * SD   1BA50   IHEIODG  * LR   1BA50   IHEIODP  * LR   1BA52   IHEIODT  * LR   1BB4A
   IHEVTB   * SD   1BCF0   IHEVTBA * LR   1BCF0   IHEVQA   * SD   1BD78   IHEVQAA  * LR   1BD78



   IHEQINV    PR      00   IHEQERR   PR       4   SAMPL2BB   PR       8   SAMPL2BC   PR       C   IHEQSPR    PR      10
   SYSIN      PR      14   IHEQLSA   PR      18   IHEQLW0    PR      1C   IHEQLW1    PR      20   IHEQLW2    PR      24
   IHEQLW3    PR      28   IHEQLW4   PR      2C   IHEQLWE    PR      30   IHEQLCA    PR      34   IHEQVDA    PR      38
   IHEQFVD    PR      3C   IHEQCFL   PR      40   IHEQFOP    PR      48   IHEQADC    PR      4C   IHEQXLV    PR      50
   IHEQEVT    PR      58   IHEQSLA   PR      60   IHEQSAR    PR      64   IHEQLWF    PR      68   IHEQRTC    PR      6C
   IHEQSFC    PR      70


IEW1001  IHEUPBA
IEW1001  IHEUPAA
IEW1001  IHETERA
IEW1001  IHEM91C
IEW1001  IHEM91B
IEW1001  IHEM91A
IEW1001  IHEDDOD
IEW1001  IHEVPFA
IEW1001  IHEVPDA
IEW1001  IHEDBNA
IEW1001  IHEVSFA
IEW1001  IHEVSBA
IEW1001  IHEVCAA
IEW1001  IHEVSAA
IEW1001  IHEDNBA
IEW1001  IHEUPBB
IEW1001  IHEUPAB
IEW1001  IHEVSEB

  TOTAL LENGTH     5068
  ENTRY ADDRESS    17D00

IEW1001  WARNING - UNRESOLVED EXTERNAL REFERENCE (NOCALL SPECIFIED)
```

Figure 55. Module Map Format Example

Figure 56 shows an input deck for a load job. A previously assembled program, MASTER, is to be loaded. The SYSLOUT, SYSLIB, and SYSTERM DD statements are not used.

```
//LOAD      JOB  MSGLEVEL=1
//          EXEC PGM=LOADER
//SYSLIN    DD   DSNAME=MASTER,DISP=OLD
      (DD statements and data required for execution of MASTER)
/*
```

Figure 56. Input Deck for a Load Job

Figure 57 shows an input deck for a compile-load job. The COBOL F (IEQCBL00) compiler is used for the compile step. The loaded program requires the SYSOUT, TAXRATE, and SYSIN DD statements.

```
//JOB       JOB   22,MCS,MSGLEVEL=1
//COBOL     EXEC  PGM=IEQCBL00,PARM=MAP,REGION=86K,RD=R
//SYSPRINT  DD    SYSOUT=A
//SYSPUNCH  DD    UNIT=SYSCP
//SYSUT1    DD    UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSUT2    DD    UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSUT3    DD    UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSUT4    DD    UNIT=SYSDA,SPACE=(TRK,(100,10))
//SYSLIN    DD    DSNAME=&&LOADSET,DISP=(MOD,PASS),
//                UNIT=SYSSQ,SPACE=(TRK,(30,10))
//SYSIN     DD    *
      (source program)
/*
//LOAD      EXEC  PGM=LOADER,PARM='MAP,LET',COND=(5,LT,COBOL)
//SYSLIN    DD    DSNAME=*.COBOL.SYSLIN,DISP=(OLD,DELETE)
//SYSLOUT   DD    SYSOUT=A
//SYSLIB    DD    DSNAME=SYS1.COBLIB,DISP=SHR
//SYSOUT    DD    SYSOUT=A
//TAXRATE   DD    DSNAME=TAXRATE,DISP=OLD
      (Data for Loaded Program)
/*
```

Figure 57. Input Deck for a Compile-Load Job

Figure 58 shows the compilation and loading of three modules. In the first three steps, the FORTRAN H (IEKAA00) compiler is used to compile a main program, MAIN, and two subprograms, SUB1 and SUB2. Each of the object modules is placed in a sequential data set by the compiler and passed to the loader job step. In addition to the FORTRAN library, a private library, MYLIB, is used to resolve external references. In the loader job step, MYLIB is concatenated with the SYSLIB DD statement. SUB1 and SUB2 are included in the program to be loaded by concatenating them with the SYSLIN DD statement. The SYSTERM statement is used to define the diagnostic output data set. The loaded program requires the FT01F001 and FT10F001 DD statements for execution, and it does not require data in the input stream.

```
//JOBX      JOB
//STEP1     EXEC  PGM=IEKAA00,PARM='NAME=MAIN,LOAD'
                .
                .
                .
//SYSLIN     DD   DSNAME=&&GOFILE,DISP=(,PASS),UNIT=SYSSQ
//SYSIN      DD   *
       (Source module for MAIN)
/*
//STEP2     EXEC  PGM=IEKAA00,PARM='NAME=SUB1,LOAD'
                .
                .
                .
//SYSLIN     DD   DSNAME=&&SUBPROG1,DISP=(,PASS),UNIT=SYSSQ
//SYSIN      DD   *
       (Source module for SUB1)
/*
//STEP3     EXEC  PGM=IEKAA00,PARM='NAME=SUB2,LOAD'
                .
                .
                .
//SYSLIN     DD   DSNAME=&&SUBPROG2,DISP=(,PASS),UNIT=SYSSQ
//SYSIN      DD   *
       (Source module for SUB2)
/*
//STEP4     EXEC  PGM=LOADER
//SYSTERM    DD   SYSOUT=A
//SYSLIB     DD   DSNAME=SYS1.FORTLIB,DISP=OLD
//           DD   DSNAME=MYLIB,DISP=OLD
//SYSLIN     DD   DSNAME=*.STEP1.SYSLIN,DISP=OLD
//           DD   DSNAME=*.STEP2.SYSLIN,DISP=OLD
//           DD   DSNAME=*.STEP3.SYSLIN,DISP=OLD
//FT01F001   DD   DSNAME=PARAMS,DISP=OLD
//FT10F001   DD   SYSOUT=A
/*
```

Figure 58. Input Deck for Compilation and Loading of the Three Modules

The return code of a loader step is determined by the return codes resulting from loader processing and from loaded program processing.

The return code indicates whether errors occurred during the execution of the loader or of the loaded program. The return code can be tested through the COND parameter of the JOB statement specified for this job and/or the COND parameter of the EXEC statement specified in any succeeding job step. (For details, see the publication IBM System/360 Operating System: Job Control Language.) Table 17 shows the return codes.

Table 17. Return Codes (Part 1 of 2)

Return Code	Loader Return Code[1]	Loaded Program Return Code	Conclusion or Meaning
0	0	0	Program loaded successfully, and execution of the loaded program was successful.
	4	0	The loader found a condition that may cause an error during execution, but no error occurred during execution of the loaded program.
	8 (LET)	0	
4	0	4	Program loaded successfully, and an error occurred during execution of the loaded program.
	4	4	The loader found a condition that may cause an error during execution, and an error did occur during execution of the loaded program.
	8 (LET)	4	
8	0	8	Program loaded successfully, and an error occurred during execution of the loaded program.
	4	8	The loader found a condition that may cause an error during execution, and an error did occur during execution of the loaded program.
	8 (LET)	8	
	8		The loader found a condition that could make execution impossible. The loaded program was not executed.

[1]Error diagnostics (SYSLOUT and/or SYSTERM data set) for the loader will show the severity of errors found by the loader.

Table 17. Return Codes (Part 2 of 2)

Return Code	Loader Return Code[1]	Loaded Program Return Code	Conclusion or Meaning
12	0	12	Program loaded successfully, and an error occurred during execution of the loaded program.
	4	12	The loader found a condition that may cause an error during execution, and an error did occur during execution of the loaded program.
	8 (LET)	12	
	12		The loader could not load the program successfully, execution impossible.
16	0	16	Program loaded successfully, and the loaded program found a terminating error.
	4	16	The loader found a condition that may cause an error during execution, and a terminating error was found during execution of the loaded program.
	8 (LET)	16	
	16		The loader could not load program, execution impossible.

[1]Error diagnostics (SYSLOUT and/or SYSTERM data set) for the loader will show the severity of errors found by the loader.

The loader requires main storage space for the following items:

- Loader code.
- Data management access methods.
- Buffers and tables used by the loader (dynamic storage).
- Loaded program (dynamic storage).

Region size includes all four of the above items; the SIZE option refers to the last two items.

For the SIZE option, the minimum required main storage is 4K plus the size of the loaded program. This minimum requirement grows to accommodate the extra table entries needed by the program being loaded. For example: FORTRAN requires at least 3K plus the size of the loaded program, and PL/I needs at least 8K plus the size of the loaded program. Buffer number (BUFNO) and block size (BLKSIZE) could also increase this minimum size. Table 18 shows the appropriate storage requirements in bytes.

The maximum main storage that can be used is whatever main storage is available up to 8192K.

All or part of the main storage required is obtained from user storage. If the access methods are made resident at IPL time, they are allocated in system storage. However, 6K is always reserved for system use.

In an MVT environment the loader code could also be made resident in the link pack area. If so, it requires the following space: IEWLDRGO, the control/interface module (alias LOADER), approximately 400 bytes; IEWLOADR, the loader processing portion, approximately 13,250 bytes.

The size of the loaded program is the same as if the program had been processed by the linkage editor and program fetch.

The loader does not use auxiliary storage space for work areas.

Table 18. Main Storage Requirements

Consideration		Approximate Main Storage Requirements (in bytes)	Comments
Loader Code	Control	400 (MFT) 2000 (MVT)	--
	Processing	13250 (MFT) 14000 (MVT)	--
Data Management		6K	BSAM
Object Module Buffers and DECBs		BUFNO(BLKSIZE + 24)	Concatenation of different BLKSIZE and BUFNO must be considered. (Minimum BUFNO=2)
Load Module Buffer and DECBs		304	--
SYSTERM DCB Buffers, and DECBs		312	Allocated if TERM option is specified
SYSLOUT Buffers and DECBs		BUFNO(BLKSIZE + 24)	Buffer size rounded up to integral number of double words. (Minimum BUFNO=2)
Size of program being loaded		Program Size	Program size is restricted only by available main storage
Each external relocation dictionary entry		8	--
Each external symbol		20	--
Largest ESD number		4n n is the largest ESD number in any input module	Allocated in increments of 32 entries
Fixed Loader Table Size		1260	Subtract 88 if NOPRINT is specified
Condensed Symbol Table		12n n is the total number of control sections and common areas in the loaded program	Built only if TSO is operating and space is available
System Requirements		1600 (MFT) 4000 (MVT)	--

This appendix contains the loader diagnostic messages. Each message directed to the programmer contains a severity code in the final position of the message code. The severity codes are defined as follows:

Severity Code	Meaning
0	Indicates a condition that will not cause an error during execution of the loaded module.
1	Indicates a condition that may cause an error during execution of the loaded module.
2	Indicates an error that could make execution of the loaded module impossible. Processing continues.
3	Indicates an error that will make execution of the loaded module impossible. Processing continues.
4	Indicates an error condition from which no recovery is possible. Processing terminates.

Each message directed to the operator's console contains a type code in the last position of the message code. The type code indicates the action to be taken. The code used in loader diagnostic messages is as follows:

I Information: no operator action is required.

IEW1001 WARNING - UNRESOLVED EXTERNAL REFERENCE (NOCALL SPECIFIED)

Explanation: The NCAL, NOCALL, or NORES option or never-call function was specified for the external reference.

System Action: The SYSLIB data set is not searched if the NCAL or NOCALL option has been specified. The Link Pack Area queue is not searched if the NORES option has been specified. Neither the SYSLIB data set nor the Link Pack Area queue are searched if the ER is marked 'never-call' from a previous linkage editor run.

Programmer Response: No response is necessary normally. If you wish the reference resolved, either (1) add the needed module to the SYSLIN input data set; (2) remove the NOCALL, NCAL, or NORES option, if specified; or (3) if an input load module contained a never-call reference, re-create the load module without specifying never-call. If the problem recurs, do the following before calling IBM for programming support:

- Run the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure the MAP option was specified for the failing job step.

- For each load module containing a call to the reference, execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting output.

- Have available each object module that contains a call to the reference with its associated source listing.

IEW1012 ERROR - UNRESOLVED EXTERNAL REFERENCE

Explanation: The external reference was not found on the SYSLIB defined data set or in the Link Pack Area.

System Action: No attempt is made to execute the module unless the LET option is specified.

Programmer Response: Probable user error. Make sure that the reference is valid and not the result of a keypunch or programming error. If the reference is valid, add the needed module or alias to either (1) the SYSLIB data set, (2) the link pack area, or (3) the SYSLIN input data set. Make sure the SYSLIB data set DD statement has been specified if needed. If the problem recurs, do the following before calling IBM for programming support:

- If the needed module is in a SYSLIB or SYSLIN partitioned data set, execute the IEHLIST utility program using the LISTPDS statement to print out the data set directory.

- If the needed module is in a load module, execute the IMBLIST service aid program, using the OUTPUT=XREF option of the LISTLOAD function, and save the resulting output.

- If the needed module is an object module, have the module and associated source listing available.

- If the needed module is in the link pack area, execute the IMBMDMAP service aid program with the PARM=(LINKPACK) option and save the resulting link pack area map.

- Execute the failing job step using the linkage editor instead of the loader and save the resulting output.

- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.

- Make sure that the MAP option was in effect for the failing job step.

IEW1024 ERROR - DDNAME CANNOT BE OPENED.

Explanation: The SYSLIN data set cannot be opened. The DD statement defining the data set is missing or incorrect.

System Action: Processing is terminated. The Loader returns to the caller with a condition code of 16.

Programmer Response: Probable user error. Either (1) supply a missing SYSLIN DD statement, (2) correct erroneous information on the SYSLIN DD statement, or (3) make sure the correct DDNAME has been specified for the SYSLIN data set. If the loader was invoked by a macro instruction such as LINK rather than through the EXEC statement, make sure that the SYSLIN ddname, if passed, is correct. If the problem recurs, do the following before calling IBM for programming support:

- Either have the output of the SYSGEN of the loader available, or execute the IMASPZAP service aid program with the DUMPT IEWLOADR IEWLDDEF statement and save the resulting dump of loader default ddnames.
- Make sure that MSGLEVEL=(1,1) was specified in the job statement for the failing job.

IEW1034 ERROR - DDNAME HAS SYNCHRONOUS ERROR.

Explanation: A physical uncorrectable input/output error occurred. If it occurred on a blocked data set, the block size may have been specified incorrectly.

System Action: The message supplied by the SYNADAF macro instruction was printed. Processing was terminated.

Programmer Response: For any fixed format, specify the correct block size. If the block size was correct and the data set was an input data set, re-create or restore the data set. If the problem recurs, do the following before calling IBM for programming support:

- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing step.

IEW1044 ERROR - UNACCEPTABLE RECORD FORMAT (VARIABLE ON INPUT)

Explanation: Only object module (FIXED record format) and load module (UNDEFINED record format) data sets are accepted by the loader.

System Action: Processing was terminated. The Loader returns to caller with a condition code of 16.

Programmer Response: Probable user error. (1) Make sure that the record format specification is correct. The record format may have been mispunched. (2) Make sure that the correct data set has been specified. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program, using the LISTVTOC statement to print out the data set control blocks for the input data sets, and save the resulting output.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that MSGLEVEL=(1,1) was specified in the job statement for the failing job.
- Make sure that the MAP option was in effect for the failing job step.

IEW1053 ERROR - I/O ERROR WHILE SEARCHING LIBRARY DIRECTORY.

Explanation: A permanent input/output error occurred while attempting a BLDL.

System Action: Automatic library call processing is terminated.

Programmer Response: Insure that the SYSLIB defined data set is partitioned. If it is, re-create or restore the data set and rerun the job step. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IEHLIST utility program using the LISTPDS statement to print out the SYSLIB data set directory, and save the resulting output.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Makes sure that the MAP option was in effect for the failing job step.

IEW1072 ERROR - BLKSIZE IS INVALID

Explanation: In the specified data set, BLKSIZE was not an integral multiple of LRECL.

System Action: BLKSIZE was rounded up to the next highest multiple of LRECL and processing continued.

Programmer Response: Probable user error. Change BLKSIZE to be an integral multiple of LRECL. If the error recurs, do the following before calling IBM for programming support:

- If the data set was an input data set, execute the IEHLIST utility program using the LISTVTOC statement to print out the data set control block, and save the resulting output.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.

IEW1082 ERROR - INVALID LENGTH SPECIFIED

Explanation: The length of the Control Section was not specified on the ESD or the END card.

System Action: The total length of the text received was used.

Programmer Response: Check if an END record in any input object module is missing or has been replaced. If so, re-create the object module and rerun. If the problem recurs, do the following before calling IBM for programming support:

- Have the object module input and associated source listings available.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that the MAP option was in effect for the failing job step.

IEW1093 ERROR - NO TEXT RECEIVED

Explanation: No valid text has been received for the loaded module.

System Action: The loader returns to the caller with a condition code of 12.

Programmer Response: Probable user error. (1) Make sure that the SYSLIN data was specified correctly. (2) Check other error messages issued for cause of error (e.g., invalid record). Correct the error and rerun the job step. If the problem recurs, do the following before calling IBM for programming support:

- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable input module.
- Have all SYSLIN input available.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Make sure that the MAP option was in effect for the failing job step.

IEW1102 ERROR - DOUBLY DEFINED ESD

Explanation: Two identical external names have been found in the input. (1) The invalid match involves a label reference (LR) or label definition (LD) matching an existing section definition (SD), common (CM), or label reference (LR). The section definition for the input LR or LD must be marked delete in order for this not to be an error. (2) It is always invalid for a CM to match an existing LR.

System Action: References to the name are resolved with respect to the first occurrence of the name.

Programmer Response: Probable user error. Correct the existing symbol conflict. To isolate the problem, execute the LISTOBJ function of the IMBLIST service aid program to list all object module symbols, and execute the LISTLOAD function of IMBLIST with the OUTPUT=XREF option to list all load module symbols. If the error recurs, do the following before calling IBM for programming support:

- Have all object and load module input and the output from IMBLIST available.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.
- Make sure that the MAP option was in effect for the failing job step.

IEW1112 ERROR - INVALID 2-BYTE ADCON.

Explanation: A relocatable A-type or V-type address constant of less than 3 bytes has been found in the input.

System Action: The constant is not relocated.

Programmer Response: Probable user error. Check assembler language input for Y-type address constants, which can't be relocated. Delete or correct the invalid address constant. If the problem recurs, do the following before calling IBM for programming support:

- Have object module input and associated listings available.
- Execute the IMBLIST service aid program, using the LISTOBJ function and save the resulting listing of the questionable input module.
- Rerun the step using the linkage editor instead of the loader, and save the resulting output.
- Make sure the MAP option was specified for the failing job step.

IEW1123 ERROR - INVALID RECORD FROM LOAD MODULE.

Explanation: An unrecognizable type record was found while reading a load module.

System Action: The record was ignored and processing continued.

Programmer Response: (1) Check that all input data sets are specified correctly on DD statements. (2) If load module input occurs in the SYSLIN data set, rerun the step with the NOCALL option specified. If error message IEW1123 recurs, the incorrect load module is in SYSLIN input. Otherwise, it is in SYSLIB input. (3) Isolate the incorrect load module by executing the linkage editor with the NCAL option specified, using the INCLUDE and NAME statements for each suspect load module. When the incorrect load module is isolated, re-create it and rerun the job step. If the problem recurs, do the following before calling IBM for programming support:

- If an incorrect load module was created, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function, and save the resulting load module and cross-reference listings.
- Execute the failing step using the linkage editor instead of the loader and save the resulting output.

IEW1132 ERROR - INVALID ID RECEIVED.

Explanation: Input contains an invalid external symbol ID.

This error is the result of the following conditions:

1. The SD for an LD does not appear in the input module.
2. Text is received before the ESD defining it is received.
3. An RLD is received before the ESDs to which it pertains.
4. The ID defining the entry point on the END card is not a defined SD, PC, or LR ESD type.

System Action: The invalid item is ignored.

Programmer Response: (1) Check that input object modules are complete and that assembly or compilation errors did not occur when object modules were generated. (2) Rerun the step with the NOCALL option specified. If error message IEW1132 recurs, the incorrect module is in SYSLIN input. Otherwise, it is in SYSLIB input. (3) Isolate the incorrect module by executing the linkage editor with the NCAL option specified, using the INCLUDE and NAME statements for each suspect module. When the incorrect module is isolated, re-create it and rerun the step. If the problem recurs, do the following before calling IBM for programming support:

- If an incorrect object module was created, have the module and its associated listing available.
- If an incorrect load module was created, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function, and save the resulting load module and cross-reference listings.
- Run the failing step using the linkage editor instead of the loader, and save the resulting output.

IEW1141 WARNING - CARD RECEIVED NOT AN OBJECT RECORD.

Explanation: The card read has a blank in column one.

System Action: The card is ignored.

Programmer Response: Probable user error. Check input for a blank card or linkage editor control card. If other errors occur, re-create all object modules which have been in card form. If the problem recurs, do the following before calling IBM for programming support:

- Make sure the MAP option was specified for the failing job step.
- Rerun the step using the linkage editor instead of the loader, and save the resulting output.

- Make sure that MSGLEVEL=(1,1) was specified on the JOB statement for the failing job.
- Have the job stream and associated output listings available.

IEW1152 ERROR - INVALID RECORD FROM OBJECT MODULE.

Explanation: An unrecognizable record type was received while reading an object module.

System Action: The card is ignored.

Programmer Response: Probable user error. Check object module input for invalid records. Column 1 should contain a 12-2-9 punch. Columns 2-4 should contain a TXT, RLD, ESD, END, or SYM identifier. Remove incorrect records or re-create the module, and rerun. If the problem recurs, do the following before calling IBM for programming support:

- Have object module input available.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable input module.
- Rerun the step using the linkage editor instead of the loader, and save the resulting output.

IEW1161 WARNING - NO ENTRY POINT RECEIVED.

Explanation: No entry point was specified in the parameter field or the END card. The END card entry point specification could be incorrect (i.e., invalid ID, bad column alignment, etc.) The parameter field specification could also be incorrect.

System Action: The first assigned address is used as the entry point.

Programmer Response: Probable user error. (1) Specify the entry point name in the loader parameter list, EP=. If the entry point occurs in load module input, this parameter must be specified. (2) If you cannot use the EP= parameter and the entry point occurs in an object module, make sure that the module is included in the SYSLIN or SYSLIB input and that an entry point was specified during compilation or assembly. If the problem recurs, do the following before calling IBM for programming support:

- Have the module containing the entry point and its associated listing available.
- Make sure the MAP option was in effect for the failing job step.
- Rerun the step using the linkage editor instead of the loader, and save the resulting output.

IEW1173 ERROR - ENTRY POINT RECEIVED BUT NOT MATCHED.

Explanation: The entry point name specified in the parameter field or on an END card was not matched to an incoming LR, SD, or PC.

System Action: The first assigned address is used as the entry point address.

Programmer Response: Probable user error. (1) Check to see if the EP= parameter was specified correctly. (2) Check to see if the module containing the entry point is included in either the SYSLIN or SYSLIB input. (3) Check other messages issued for the cause of error (i.e., invalid record). If the problem recurs, do the following before calling IBM for programming support:

- Have the module containing the entry point and its associated listing available.
- If the module is a load module, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function. If the module is an object module, use the LISTOBJ function of the IMBLIST service aid. Save the resulting listing.
- Rerun the step using the linkage editor instead of the loader, and save the output.
- Make sure the MAP option was in effect for the failing job step.

IEW1182 WARNING - NO END CARD RECEIVED.

Explanation: An END card is missing for an input object module.

System Action: Processing continues.

Programmer Response: Probable user error. Check input object modules. The last record of each should have a 12-2-9 punch in column 1 and the END identifier in columns 2-4. If an END record is missing, re-create the module and rerun. If the problem recurs, do the following before calling IBM for programming support:

- Have object module input available.
- Execute the IMBLIST service aid program, using the LISTOBJ function, and save the resulting listing of the questionable object module.
- Rerun the step using the linkage editor instead of the loader, and save the resulting output.
- Make sure the MAP option was in effect for the failing job step.

IEW1194 ERROR - AVAILABLE STORAGE EXCEEDED.

Explanation: The amount of main storage available to the loader is insufficient to allow construction of the required tables and loaded program.

System Action: The loader returns to caller with a completion code of 16.

Programmer Response: Probable user error. (1) Increase the SIZE parameter, or (2) make sure the REGION specification is sufficient, or (3) make sure that sufficient main storage is available to satisfy the SIZE specification. If the problem recurs, do the following before calling IBM for programming support:

- Either have the output of the SYSGEN of the loader available or execute the IMASPZAP service aid program with the DUMPT IEWLOADR IEWLDDEF statement, and save the resulting dump of the loader's default SIZE value.
- Make sure that MSGLEVEL=(1,1) was specified in the JOB statement for the failing job.
- Make sure the MAP option was in effect for the failing job step.

IEW1204 ERROR - TOO MANY EXTERNAL NAMES IN INPUT MODULE.

Explanation: The external symbol ID is too large to fit in the translation table.

System Action: Processing is terminated. The loader returns to the caller with a completion code of 16.

Programmer Response: If the program is large and/or complex, either (1) run the step using the linkage editor, or (2) break down the large program module into a number of smaller routines. If the program is not particularly large or complex, check other messages issued for the cause of error. Object module input may be incomplete or mispunched. Re-create object modules and rerun. If the problem recurs, do the following before calling IBM for programming support:

- Have all input modules available.
- If the module is a load module, execute the IMBLIST service aid program, using the OUTPUT=BOTH option of the LISTLOAD function. If the module is an object module, use the LISTOBJ function of the IMBLIST service aid. Save the resulting listing.
- Make sure the MAP option was in effect for the failing job step.

IEW1214 ERROR - IDENTIFICATION FAILED - DUPLICATE PROGRAM NAME FOUND.

Explanation: When trying to identify the loaded program to the system, the IDENTIFY routine found a duplicate program name in the user's region or partition or in the link pack area.

System Action: Processing is terminated. The loader returns to the caller with a completion code of 16.

User Response: Probable user error. Specify a unique program name using the NAME option or let the loader default the name to **GO. Rerun the job. If the problem recurs, do the following before calling IBM for programming support:

- Have the job stream and associated output listings available.
- Use IEBPTPCH to obtain a dump of SYS1.PARMLIB to get a list of the routines in the link pack area.

IEW1224 ERROR - IDENTIFICATION FAILED.

Explanation: The IDENTIFY routine located an error in the parameter list passed to it by the loader. In an MFT environment, the name IEWLOAD may have been used to invoke the loader. In an MVT environment, the appropriate IDENTIFY macro instruction support may not be included in the operating system.

System Action: Processing is terminated. The loader returns to caller with a completion code of 16.

User Response: If IEWLOAD was used to invoke the loader in an MFT environment, specify IEWLOADR instead. Rerun the job. If the problem recurs, do the following before calling IBM for programming support:

- Have the job stream and associated output listings available.

In an MVT environment, verify that the appropriate IDENTIFY macro instruction support is included in the system. The release level of the IDENTIFY macro instruction should be the same as the release level of the loader. If the appropriate IDENTIFY support is included, do the following before calling IBM for programming support:

- Have the job stream and associate output listings available.

IEW199I ERROR - USER PROGRAM HAS ABNORMALLY TERMINATED.

Explanation: This message is issued by the loader when it determines that the loaded program has terminated abnormally. This message occurs only under MVT.

System Action: Loaded program execution is terminated abnormally, and control is returned to the loader. (Unless the user has included a SYSUDUMP DD statement for the loaded program, this message is the only indication that the program has terminated abnormally.)

Operator Response: None.

Programmer Response: To obtain a dump to aid in determining the cause of the abnormal termination, include a SYSUDUMP DD statement for the loaded program and rerun the job. If the problem recurs, do the following before calling IBM for programming support:

- Have the job stream and associated output listings available.

IBM is grateful to the American National Standards Institute (ANSI) for permission to reprint its definitions from the American National Standard Vocabulary for Information Processing (ANSI X3.12-1970), which was prepared by Subcommittee X3.5 on Terminology and Glossary of American National Standards Committee X3. ANSI definitions are preceded by an asterisk.

*address: An identification, as represented by a name, label, or number, for a register, location in storage, or any other data source or destination such as the location of a station in a communication network; any part of an instruction that specifies the location of an operand for the instruction.

address constant: A value, or an expression representing a value, used in the calculation of storage addresses; can be used for branching or retrieving data.

alias name: An alternate name or entry point for a load module that is also entered in the output module library directory entry along with the member name.

automatic library call mechanism: The process whereby control sections are processed by the linkage editor or loader to resolve external references to members of partitioned data sets not resolved by primary input processing.

auxiliary storage: Data storage other than main storage; for example, storage on magnetic tape or direct access devices.

common area: A control section used to reserve a main storage area that can be referred to by other modules; may be either named or unnamed (blank).

common segment: A segment upon which two exclusive segments are dependent.

control section: That part of a program (instructions and data) specified by the programmer to be a relocatable unit, all elements of which are to be loaded into adjoining storage locations for execution. Abbreviated CSECT.

control section name: The symbolic name of a control section.

downward reference: A reference made from a segment to another segment lower in the same path; i.e., farther from the root segment.

entry name: A name within a control section that defines an entry point, and can be referred to for execution by any control section.

exclusive reference: A reference between exclusive segments; that is, a reference from a segment in storage to an external symbol in a segment that will cause overlay of the calling segment.

exclusive segments: Segments in the same region of an overlay program, neither of which is in the path of the other; they cannot be in main storage simultaneously.

external name: A name that can be referred to by any control section or separately assembled or compiled module; i.e., a control section name or an entry name.

external reference: (1) A reference to a symbol that is defined as an external name in another module. (2) An external symbol that is defined in another module; that which is defined in the assembler language by an EXTRN statement or by a V-type address constant, and is resolved during linkage editing. See also weak external reference.

external symbol: A control section name, entry point name, or external reference that is defined or referred to in a particular module. A symbol contained in the external symbol dictionary.

hierarchy: An optional division of main storage that provides addressing distinction between processor storage (hierarchy 0) and IBM 2361 Core Storage (hierarchy 1).

inclusive reference: A reference between inclusive segments; that is, a reference from a segment in storage to an external symbol in a segment that will not cause overlay of the calling segment.

inclusive segments: Segments in the same region of an overlay program that are in the same path; they can be in main storage simultaneously.

invalid exclusive reference: An exclusive reference in which a common segment does not contain a reference to the symbol used in the exclusive reference.

library: In this publication, it is a partitioned data set that always contains named members.

load module: The output of the linkage editor; a program in a format suitable for loading into main storage for execution.

load module buffer: An entity of main storage used by the level F linkage editor to read input load module text records and possibly to retain the text information in storage for subsequent writing of the output load module text records.

*module: A program unit that is discreet and identifiable with respect to compiling, combining with other units, and loading, for example, the input to, or output from, an assembler, compiler, linkage editor, or executive routine.

multiple load module processing: A method of processing whereby two or more load modules can be produced in a single linkage editor job step.

*object module: A module that is the output of an assembler or compiler and is input to a linkage editor.

overlay program: A program in which certain control sections can use the same storage locations at different times during execution.

*overlay supervisor: A routine that controls the proper sequencing and positioning of segments of computer programs in limited storage during their execution.

overlay tree: A graphic representation showing the relationships of segments of an overlay program and how the segments are arranged to use the same main storage area at different times.

path: All of the segments in an overlay tree between a given segment and the root segment, inclusive.

private code: An unnamed control section.

program: A logically self-contained sequence of operations or instructions that, when followed in some predetermined sequence, will produce a specified result; a sequence of instructions to be performed by an electronic computer; one or more modules, in source language or relocatable object code, or one module in executable code, that are a logically self-contained process.

program fetch: A program that prepares load modules for execution by loading them at specific storage locations; it also readjusts each address constant.

pseudo register: In PL/I, a location in main storage that is used as a pointer to dynamically acquired main storage. It enables the PL/I compiler to generate re-enterable code. External dummy sections give the programmer using Assembler F or Assembler H the same facility.

re-enterable load module: A module that can be used concurrently by more than one task.

refreshable load module: A load module that cannot be modified by itself or by any other module during execution; can be replaced by a new copy during execution by a recovery management routine without changing either the sequence or results of processing.

region: In an overlay structure, it is a contiguous area of main storage within which segments can be loaded independently of paths in other regions. Only one path within a region can be in main storage at any one time.

relocation: The modification of address constants required to compensate for a change of origin of a module, program, or control section.

root segment: That segment of an overlay program that remains in main storage at all times during the execution of the overlay program; the first segment in an overlay program.

scatter format: A load module attribute that permits the programmer or the control program to dynamically load control sections into noncontiguous areas of main storage.

segment: The smallest functional unit (one or more control sections) that can be loaded as one logical entity during execution of an overlay program.

serially reusable load module: A module that cannot be used by a second task until the first task has finished using it.

source module: The source statements that constitute the input to a language translator for a particular translation.

upward reference: A reference made from a segment to another segment higher in the same path; i.e., closer to the root segment.

valid exclusive reference: An exclusive reference in which a common segment contains a reference to the symbol used in the exclusive reference.

weak external reference: An external reference that does not have to be resolved during linkage editing. If it is not resolved, it appears as though its value was resolved to zero. Abbreviated WXTRN.

(Where more than one page reference is given, the major reference appears first.)

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