Burroughs

Language Manual

B 1000 Systems Data Management System II (DMSII) Host Language Interface

(Relative to Mark 11.0 System Software Release)

SC

Priced Item
Printed in U.S.A
November 1984

1152451

Burroughs cannot accept any financial or other responsibilities that may be the result of your use of this information or software material, including direct, indirect, special or consequential damages. There are no warranties extended or granted by this document or software material.

You should be very careful to ensure that the use of this software material and/or information complies with the laws, rules, and regulations of the jurisdictions with respect to which it is used.

The information contained herein is subject to change without notice. Revisions may be issued to advise of such changes and/or additions.

Comments or suggestions regarding this document should be submitted on a Field Communication Form (FCF) with the CLASS specified as 2 (S.SW: System Software), the Type specified as 3 (DOC), and the product specified as the 7-digit form number of the manual (for example, 1152451).

LIST OF EFFECTIVE PAGES

Page	Issue
Title	Original
ii	Original
iii	Original
iv	Blank
v thru vii	Original
viii	Blank
1-1 thru 1-2	Original
2-1 thru 2-22	Original
3-1 thru 3-17	Original
3-18	Blank
4-1 thru 4-3	Original
4-4	Blank
A-1	Original
A-2	Blank
B-1 thru B-5	Original
B-6	Blank
C-1 thru C-5	Original
C-6	Blank
1 thru 4	Original

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

PREFACE

This manual, in four sections and three appendixes, provides key concepts regarding the interface between a host language and the DMSII system.

Section 1 includes a list of the components that form the nucleus of DMSII, gives information on the three B 1000 DMSII manuals, and includes a list of B 1000 manuals that are referenced in this manual.

Section 2 provides general information about the interfaces between DMSII and host languages. Included are discussions of the COBOL DATA DIVISION and the COBOL PROCEDURE DIVISION, programming notes pertinent to the COBOL compiler, and information on current record pointers.

Section 3 describes all the COBOL verbs used to manipulate data sets. COBOL compilation procedures are also included in this section.

Section 4 provides information on restart procedures employed during recovery processes.

Appendix A gives examples of COBOL qualification of DMSII identifiers.

Appendix B provides summaries of the DMSII verbs for RPG, COBOL, and COBOL74, and shows the differences between COBOL and RPG implementations of the DMSII interface.

Appendix C is the standard explanation of notation conventions and syntax specifications.

SECTION 1
INTRODUCTION

The information contained in this manual is relative to the Mark 11.0 System Software Release for the B 1000 Systems Data Management System II (DMSII).

The following components form the nucleus of DMSII:

- A DMSII Data and Structure Definition Language (DMS/DASDL) that describes a DMSII data base.
- An ANSI 68 COBOL, ANSI 74 COBOL, or RPGII language interface that provides programmatic access to the data in the data base.
- The DMSII access routines, contained within the program DMS/ACR, that control storage and retrieval.
- The DMS/REORGANIZE program that is used in conjunction with the DMS/DASDL compiler and redescribes portions of the data base.
- The DMS/RECOVERDB program that automatically restores the integrity of a data base that has been corrupted through a system failure.
- Security features to protect the operating system and the data bases.
- Utility programs to assist in debugging the DMSII system and DMSII data bases.
- DMS/INQUIRY, a program that allows ad hoc query of a DMSII data base.

DMSII DOCUMENTATION

The overall data management system for B 1000 systems is described in the three documents identified and outlined in the paragraphs that follow.

DMS/DASDL Language Manual

Full title: *B 1000 Systems DMSII Data and Structure Definition Language (DMS/DASDL) Language Manual.*

The main text includes an exposition of the DMSII structure types, identification and descriptions of the components of a data base, information on remap data sets and logical data bases, and a description of DMS/DASDL compilation.

The appendixes provide examples of DMS/DASDL physical structures, a DMS/DASDL glossary, the DMS/DASDL compiler messages, an example of data base development, and another example that shows the use of many of the elements of the DMS/DASDL syntax.

DMS Functional Description Manual

Full title: *B 1000 Systems Data Management System II (DMSII) Functional Description Manual.*

The main text describes the update and reorganization processes, the audit and recovery system, and data base security. Separate sections cover each of the following programs:

DMS/DECOMPILER
Reconstructs the original DMS/DASDL source of an existing DMSII data base.

DMS/DASDLANALY
Decodes the contents of the data structures within a DMSII data base dictionary.

DMS/DBLOCK
Locks the data base dictionary to block updating until this program terminates, thus providing protection against unwanted updating.

DMS/DBBACK
Part of a process to convert a data base created under the Mark 11.0 release to a Mark 10.0 release-compatible data base.

DMS/AUDITANALY
Decodes a DMSII audit file and prints the content of each audit record.

DMS/DBMAP
Checks the integrity of a data base and prints structure information from the data base dictionary, performs population summaries, and prints data base data.

The appendixes provide a glossary, summaries of the functions of the DMS/DASDL generated code, and record descriptions for all the DMSII data structures referenced in the main text.

DMS Host Language Interface Language Manual

Full title: *B 1000 Systems DMSII Host Language Interface Language Manual.*

The main text includes general information on interfaces between DMS and the host language (specifically COBOL, with summaries of COBOL 74, and RPGII), descriptions of all the COBOL68 language statements (verbs), a discussion of COBOL compilation procedures, and audit and recovery restart procedures as they relate to the host language interface.

The appendixes provide information on qualification of DMSII identifiers and a summary of DMSII operations.

RELATED DOCUMENTS

The following manuals include information pertinent to the B 1000 data management system:

- *B 1000 Systems Software Operation Guide, Volume 1,* form number 1151982.
- *B 1000 Systems COBOL Language Manual,* form number 1057197.
- *B 1000 Systems COBOL74 Language Manual,* form number 1168622.
- *B 1000 Systems Report Program Generator (RPGII) Language Manual,* form number 1152063.
- *B 1000 Systems Data Management System II (DMSII) Inquiry Language Manual,* form number 1108875.
- *B 1000 Series Generalized Message Control System (GEMCOS) User's Manual,* form number 1093499.

SECTION 2
HOST LANGUAGE INTERFACE

This section provides general information regarding the interface between a host language and the DMSII system, with specific reference to the COBOL language syntax. A summary of differences related to RPGII, COBOL, and COBOL74 is also given. Detailed explanations of the COBOL74 and RPGII language interfaces are included in the respective language manuals.

There are two interfaces between the host language and the data base system; one during compilation and one during execution. The compilation interface provides syntax allowing an application program to use any or all portions of a data base through the use of the INVOKE statement. In the INVOKE process, DMS/DASDL-generated library files are used to supply the language compiler with a description of the user-selected portions of the data base. The language compiler then compiles an appropriate execution-time interface with the data base.

The execution interface consists of a number of record areas, one for each data set invoked, and a number of paths, one for each set or subset.

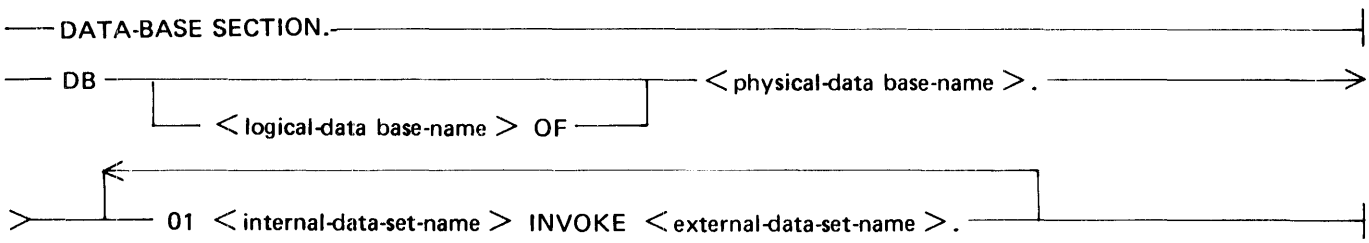
COBOL DATA DIVISION

A DATA-BASE SECTION must be inserted within the DATA DIVISION of a COBOL program supplying the COBOL compiler with a description of all or selected portions of a data base. The DATA-BASE SECTION is placed between the FILE SECTION and the WORKING-STORAGE SECTION.

DATA-BASE SECTION of DATA DIVISION

In the DATA-BASE SECTION all disjoint data sets intended for use must be invoked. This signals the compiler to include in the compilation the item names and all path names (sets and subsets) plus all embedded data sets and subsets within the invoked data set. The compiler also establishes the necessary user record areas and creates the interfaces to be used at run time.

Syntax:



Semantics:

The level indicator, DB, is used to select a particular data base. Only one data base can be selected in a program.

The <logical-data-base-name> can be used as a qualifier of data sets or set names. (The <physical-data-base-name> may be used if no <logical-data-base-name> is used.) The data-base-name is the family-name of the program-identifier used in the DMS/DASDL compilation (see appendix A). See appendix F for a discussion of qualification of DMSII identifiers in COBOL.

<logical-data base-name> must either be the name of the physical data base, or the name of a valid logical data base as described by a DATABASE statement in the DMS/DASDL source for <physical-data base-name>. When the physical data base is named, it is for documentation purposes only. When a valid logical data base is named, specification of $COBOLIB for the <logical-data-base-name> is required.

When using a logical data base, each invoked <external-data-set-name> must be included in the structure list for that logical data base.

Example 1:

```
001031    DATA-BASE SECTION.
001032    DB    UNIV.
```

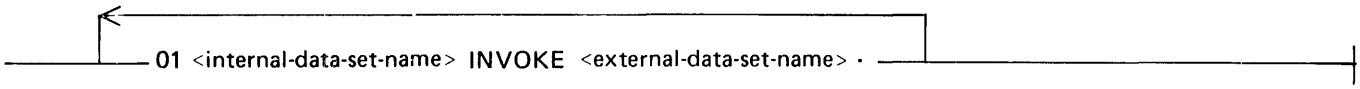
Example 2:

```
001031    DATA-BASE SECTION.
001032    DB    LDB1 OF UNIV.
```

Data Set References

The referenced data base can be followed by any number of data set references.

Syntax:



Semantics:

The level number 01 selects particular disjoint data sets from a data base.

Each compilation copies the description of each invoked data set into the program from a library file created by the DMS/DASDL compiler. The file-identifier of this library file for each data set has the following format:

#<data-base-name>/<data-set-name>

The internal-data-set-name allows synonym capability and can also be used to allow multiple invokes of the same external data set, establishing more than one record area and current pointer for that data set.

If a disjoint data set is invoked more than once in a program, each invocation of that data set must be assigned a unique internal-data-set-name. These unique names are necessary to allow proper qualification of data items within the data set.

Embedded data sets cannot be programmatically invoked. They are automatically invoked when the data set to which they belong is invoked.

Only disjoint data sets which are actually used within the program need be invoked. Disjoint data sets referenced by manual subsets but not explicitly used by the program need not be invoked.

Example:

```
001033    01 MASTER INVOKE MSF.
001034    01 ADDRESS INVOKE ADR.
```

Invoked Data Set

The COBOL compiler prints the names of all the paths and data items and also shows the structure number and remap number assigned during the DMS/DASDL compilation. The source statements supplied by the DMS/DASDL compiler are distinguished from the user-written source statements by an asterisk (*) appearing to the left of the print line, as the coding example below indicates.

Example:

```
001940 /
001945    01 ADR INVOKE ADR.

*
*         01 ADR DATA SET (  9 12:59:20  3/ 8/77 ) .
*          SAD SET ( 19 12:59:20  3/ 8/77 , AUTO) OF ADR (  9 12:59:20
*            3/ 8/77 )
*              KEY IS ZIPC.
*         STUAD SET ( 21 12:59:20  3/ 8/77 , AUTO) OF ADR (  9 12:59:20
*            3/ 8/77 )
*              KEYS ARE ZIPC, SNO.
*         FACAD SET ( 22 12:59:20  3/ 8/77 , AUTO) OF ADR (  9 12:59:20
*            3/ 8/77 )
*              KEYS ARE ZIPC, SNO.
*         ADMAD SET ( 24 12:59:20  3/ 8/77 , AUTO) OF ADR (  9 12:59:20
*            3/ 8/77 )
*              KEYS ARE ZIPC, SNO.
*           02 FACULTY-STUDENT                  PIC 9 COMP.
*           02 SNO                              PIC 9(9) COMP.
*           02 NUMLNS                           PIC 9 COMP.
*           02 ADLN OCCURS 9 TIMES              PIC X(30).
*           02 ZIPC                             PIC 9(5) COMP.
*           02 PHON                             PIC 9(12) COMP.
```

The structure number, along with an internally assigned invoke number allows the system to update the correct record areas. Even when the structure number is the same, the invoke number ensures that the correct record area is altered. The level numbers reflect the usage of data items. The listing also displays the time and date the files were created by the DMS/DASDL compilation.

Multiply-Invoked Data Set

Since one record area can only hold one record at a time, it may be more effective to have more than one record area. In the following example, MSF is invoked twice, creating two separate record areas for MSF so that two different records of MSF can be used at the same time. This example provides multiple current records.

The following example also provides multiple current path pointers for the same set. Each current path pointer is updated only when explicitly used. Either record area can be updated by any of the paths to MASTER or FILE1.

```
DATA-BASE SECTION
DB UNIV.
01 MASTER INVOKE MSF.
01 FILE1 INVOKE MSF.
```

Variable Format Records

The mechanism used by the COBOL and RPGII compilers to process variable format records results in multiple redefinitions of the variable format parts of the data set record. In the COBOL compiler, this redefinition is accomplished explicitly through the use of the COBOL REDEFINES clause in the DMS/DASDL-generated library files; each variable format part is a group item, and each variable format part redefines the same physical area of the data set record. In the RPGII compiler, the DMS/DASDL-generated library files contain offset and length information for each data item; an implicit redefinition of the variable format part of the data set record is easily accomplished by assigning common offsets to items which redefine the same data space.

When processing a data set that includes a variable format, no attempt is made, by the COBOL or RPGII compilers, by any of the interpreters, or by the DMSII system, to ensure that only data items included in the current variable format part are manipulated or stored. The only checking that is performed on data items within the variable format part of a record is that specified by the user through the REQUIRED, VERIFY, and INITIALVALUE clauses. The user has the responsibility to ensure that items within a variable format part are only used by a program when the value of the RECORD TYPE field is equal to the value required for that item.

COBOL PROCEDURE DIVISION

Special extensions to COBOL are used to manipulate data sets. Data base retrieval and storage are accomplished at the record level, with one record being transferred into or out of the record area during selected data base operations.

MOVE and MOVE CORRESPONDING

The COBOL definition for a data set contains two types of items: one type is control information, the other is the data. The portion containing data items is similar to a WORKING-STORAGE 01 entry indicating that all COBOL data manipulation statements can be utilized in the moving of data items. The control information cannot be accessed in any way by COBOL programs. This includes the group MOVE operation, as the following example illustrates.

Example:

```
 001930   01  MSF INVOKE MSF.
*
*         01 MSF DATA SET ( 13  9:12:54  3/15/77 ) .
*           MSFSET SET ( 18 9:12:54  3/15/77 , AUTO) OF MSF ( 13 9:12:54
*            3/15/77 )
*              KEY IS SSNO.
*           SEXSET SET ( 25 9:12:54  3/15/77 , AUTO) OF MSF ( 13 9:12:54
*            3/15/77 )
*              KEYS ARE SSNO.
*            02 SSNO                                PIC 9(9) COMP.
*            02 NONAM                               PIC 9 COMP.
*            02 LNAME                               PIC X(30).
*            02 QUARTER ORDERED DATA SET ( 15 9:12:54  3/15/77 )
*             QSET SET ( 15 9:12:54  3/15/77 )  OF QUARTER  ( 15  9:12:5
*            3/15/77 )
*              KEY IS QTR.                          PIC X(4).
*              03 QTR                               PIC 99 COMP.
*              03 QTTRHRS                           PIC 99 COMP.
*              03 QTRQP
```

The functional description of the preceding example is explained next.

1. MSFSET, QUARTER, and QSET are control items not actually contained in the data set record. They are not moved in a MOVE MSF TO... or a MOVE...TO MSF operation.
2. QTR, QTTRHRS, and QTRQP are items of the record in the QUARTER data set and are not moved in a MOVE MSF TO ... or a MOVE...TO MSF operation.
3. The MSF record area for a group MOVE operation can be considered as the following items:

```
01  MSF
    02 SSNO
    02 NONAM
    02 LNAME
```

4. Items SSNO, NONAM, and LNAME are the only candidates for a MOVE CORRESPONDING operation.

Exception Processing

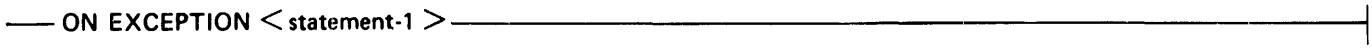
The COBOL PROCEDURE DIVISION has been extended by adding DMSII statements, providing an interface between a COBOL program and a data base. The system, when executing DMSII statements, can encounter any one of several exception conditions that prevents the operation from being performed as specified.

If an exception condition occurs, the program terminates with a DS OR DP condition unless the DMSII statement is followed by an ON EXCEPTION phrase. Therefore, if the program can continue to process in some fashion after an exception, an ON EXCEPTION phrase should be included. If the program will only terminate anyway when encountering an exception, it is best to leave off the ON EXCEPTION phrase. This will allow the system to display meaningful information (including structure number), and will allow a dump to be taken.

To further qualify the nature of an exception, there exists for each COBOL program a special register: DMSTATUS. The DMSTATUS register is set by the system at the completion of each DMSII operation.

ON EXCEPTION Phrase

Syntax:



Semantics:

Each DMSII statement yields a Boolean value which is TRUE if the operation resulted in an exception condition and FALSE if the operation completed with no exceptions encountered. If the Boolean value for the preceding statement is TRUE, <statement-1> of the ON EXCEPTION phrases is executed; otherwise, the next statement in the sequence is executed.

Logically, DMSTATUS can be used to qualify an ON EXCEPTION clause.

If the ON EXCEPTION phrase is not specified, the occurrence of an exception causes the program to be terminated with a DS or DP condition.

The following example illustrates the ON EXCEPTION programming technique:

Example:

```
STORE COURSES
  ON EXCEPTION
     PERFORM STATUS-BOOLEAN.

MODIFY MSFSET AT SSNO = C-SSNO
  ON EXCEPTION
    IF DMSTATUS(NOTFOUND)
      DISPLAY C-SSNO "NOT IN MSF"
    ELSE
      PERFORM STATUS-BOOLEAN.
```

DMSTATUS Register

The DMSTATUS register provides the capability to determine the nature of an exception should an exception occur. DMSTATUS is set by the system at the completion of each DMSII statement and is used to qualify an ON EXCEPTION phrase. To isolate the exception encountered, a number of attributes exist for DMSTATUS. Each attribute yields a Boolean value to indicate whether that particular category of exception has occurred. The DMSTATUS register, when used, has the following format:

Syntax:

Semantics:

The following is a list of each category-name and its description. Also listed is the RPGII indicator that can be specified for RPG/DMSII programs.

DMERROR (D1 Indicator)
This attribute is set whenever any exception occurs. One of the following DMSTATUS exceptions is also set. Note for COBOL and COBOL74 programs that NOT DMSTATUS(DMERROR) is TRUE on a successful DMSII operation. For RPGII programs the D1 indicator is OFF on a successful DMSII operation.

NOTFOUND (DA Indicator)
The specified record could not be found, locked, or modified.

FIND LAST or FIRST: The data set is empty.

FIND NEXT or PRIOR: There are no more records in the specified direction.

FIND AT KEY or FIND AT <expression>: No record meeting the conditions exists.

FIND NEXT AT KEY or FIND NEXT AT <expression>: No record meeting the condition is found following the current record.

FIND CURRENT: There is no current record or the current record has been deleted.

DUPLICATES (DB Indicator)
Duplicate keys not allowed in a set (STORE operation).

Duplicate keys not allowed in an ordered manual subset (INSERT operation).

Duplicate keys not allowed in an ordered embedded data set (STORE operation).

DEADLOCK (DC Indicator)
Either a deadly embrace condition occurred while trying to lock records, or the program waited for more seconds than the value of the MAXWAIT seconds for locked records to be unlocked (DMSII contention). In either case, the DMSII system performs a FREE operation on all records locked by this program.

DATAERROR (DD Indicator)
An attempt was made to store a record with a null key or null required item.

A DMS/DASDL VERIFY condition was not met.

A CREATE operation for a variable format record was done with an invalid record type.

NOTLOCKED (DE Indicator)
A STORE operation was not preceded by a CREATE, RECREATE, or LOCK operation.

KEYCHANGED (DF Indicator)
When updating a disjoint data set record, a key used in an automatic set or subset with a NO DUPLICATES clause (the default) was changed, or, when updating an ordered embedded data record, the key was changed.

SYSTEMERROR (DG Indicator)
There was a format error in a general selection expression, or recovery is incompatible with the access routines (only returned to the DMS/RECOVERDB program). This error is also returned if the program is DS-ed while getting a new disk area or more memory for a buffer, but the user program never sees the error in these cases. In the future, a SYSTEMERROR exception may be returned for DASDL code errors.

READONLY (DH Indicator)
A STORE, DELETE, INSERT, or REMOVE operation was attempted on a data base which was opened inquiry only.

An attempt was made to change the value of a data item declared as READYONLY in the data base description.

IOERROR (DJ Indicator)
An I/O error was encountered trying to read from or write to the data base.

LIMITERROR (DK Indicator)
There is insufficient file space to add a record to a data set or to add a table to a list or set. (Store only.)

OPENERROR (DL Indicator)
The data base has not been opened. (Any non-OPEN verb.)

The data base is already open. (OPEN verb only.)

The data base is not at proper level.

CLOSEERROR (DM Indicator)
The data base is not open. (CLOSE verb only.)

NORECORD (DN Indicator)
When trying to access an embedded structure, no current record exists for the owner data set.

INUSE (DO Indicator)
An attempt was made to delete a record with non-empty embedded structure.

AUDITERROR (DP Indicator)
A program attempted to close a data base or perform a BEGIN-TRANSACTION operation (BEGIN-TRANSACTION verb in COBOL or COBOL74 programs, TRBEG operation code in RPGII programs) while in transaction state.

A program attempted to perform an END-TRANSACTION, STORE, DELETE, INSERT, or REMOVE operation (END-TRANSACTION, STORE, DELETE, INSERT, or REMOVE verbs in COBOL and COBOL74 programs, and TREND, STORE, DELET, INSRT, REMOV operation codes in RPGII programs, respectively) on an audited data base while not in transaction state.

A program attempted to perform a BEGIN-TRANSACTION operation on an unaudited data base.

ABORT (DQ Indicator)

Another program aborted or went to EOJ while in transaction state. This error can only be returned when an update program attempts to close a data base or attempts to perform a BEGIN-TRANSACTION or an END-TRANSACTION with syncpoint operation (BEGIN-TRANSACTION or END-TRANSACTION SYNC verb in COBOL and COBOL74 programs, and TRBEG or TREND SYNC operation codes in RPGII programs, respectively). Refer to section 3 of the *B 1000 Systems Data Management System II (DMSII) Functional Description Manual* for information on program aborts and their implications within other programs.

SECURITYERROR (DR Indicator)

The usercode under which a program is executed is not authorized to open the data base in the requested mode (an OPEN verb).

VERSIONERROR (DS Indicator)

The current run-time description of the data base does not match the description used at COBOL or RPG compile time. (Recompile the program.)

FATALERROR (DT Indicator)

A FATALERROR exception occurs for interpreter-generated errors in the access routines or if an access routine or the DMSII-related code in the SMCP detects logically impossible conditions in the memory-resident tables, provided that the damage is likely to be restricted to the data base in memory.

The following actions occur when a FATALERROR exception is encountered:

1. The FATALERROR message is displayed on the ODT. The program that is being serviced is aborted. Any other program accessing the same data base receives a FATALERROR exception on its next DMSII operation. The data base is closed and the access routines attached to the data base are terminated. Subsequent DMSII operations by the same program (except for OPEN verb) receive an OPENERROR exception because the data base is not open. A program may test for a FATALERROR exception, reopen the data base, and go into a recovery routine all without operator intervention.
2. When the program that received the abort is discontinued (DS or DP system command), a system memory dump is automatically performed. This dump should be packaged and saved for analysis.
3. After the program has been discontinued, memory is cleaned up as if a clear/start operation had occurred. Files are closed and disk file headers cleaned up but no buffers are written to disk.
4. The next open of the data base automatically initiates a clear/start recovery.

INTEGRITYERROR (DU Indicator)

INTEGRITYERROR indicates that there is corruption in the data base. When an integrity error first occurs on a structure, the access routines pause and a request is made for a system dump (DM system command) to be taken. The dump output should be packaged and saved for further analysis, along with the audit trails preceding the error. Following the dump, the program may be resumed with the OK system command. It will then receive an INTEGRITYERROR exception which it handles in whatever way has been programmed. Other programs are not affected by the integrity error if it does not impact on their operation. Subsequent integrity errors on the same structure are returned to the program but do not cause the pause for the dump.

It is wise to bring the data base down shortly after an integrity error in order to examine it with the DMS/DBMAP program and repair it with a reorganization if necessary.

The following conditions may cause integrity errors:

A key and data mismatch occurred on an automatic set or subset, but only if the KEYCOMPARE option is set.

The automatic set or subset entry is missing during a DELETE operation.

The automatic set or subset points to a deleted record.

The program attempted to read an invalid logical address.

A record on the "available" list is not marked as "dead."

Addresses associated with the "available" list in the dictionary are bad.

The DMSII system encountered an invalid RECORD TYPE field.

The DMSII system encountered invalid control information in an index table or list table.

The DMSII system encountered missing areas in a data base file.

Selection Expression

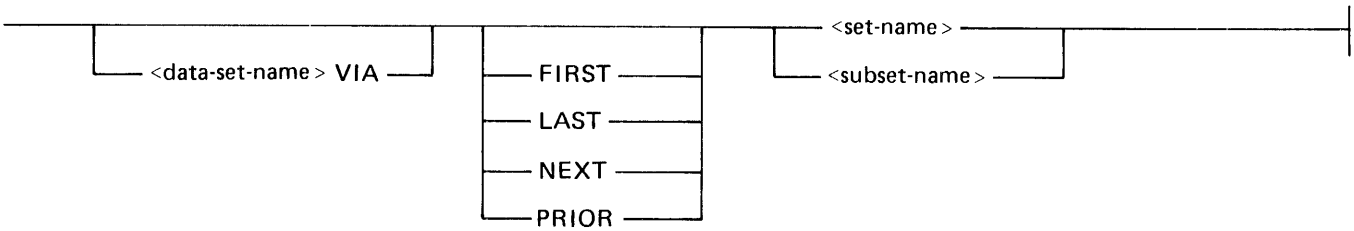
The selection expression specifies the desired record in a data set and also the record area into which the record is to be loaded. All record selections are made through paths. Paths are routes the system uses to locate records. The physical order of the records in a data set constitutes a path. Similarly, subsets, ordering keys, and retrieval keys are paths.

The verbs used with selection expressions are FIND and MODIFY (FIND and LOCK in COBOL74 and RPGII). Either of these verbs causes the record specified by the selection expression to be located and placed into the record area. If no record that satisfies the selection expression is found, a NOT FOUND exception is returned to the application program that made the request.

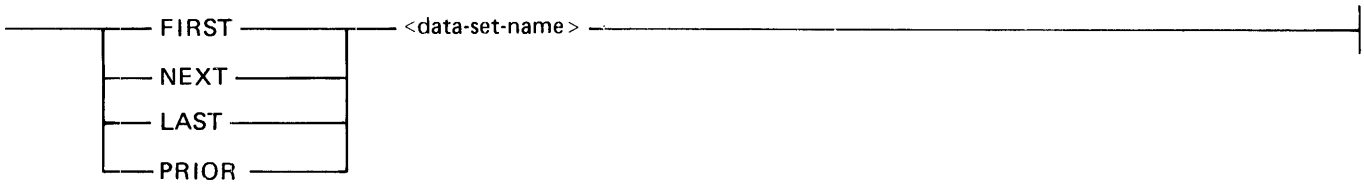
For a LOCK operation, the found record is locked so that a concurrent user cannot MODIFY (LOCK in COBOL74 and RPGII) or DELETE the same record. The current-record pointer is updated and, if a set or subset is used, the current-path pointer for the path is updated. Unused paths are unaffected. If an exception condition occurs, the current pointers are not affected unless the exception returned was a NOTFOUND on a FIND AT KEY for an index sequential structure. (See Current Record Pointer at the end of this section.)

Syntax:

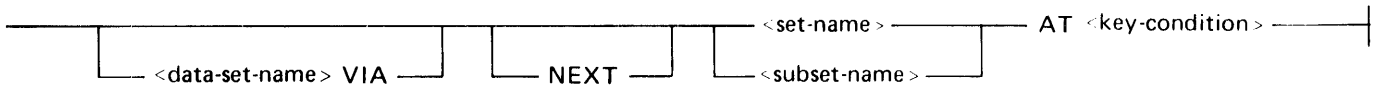
Form 1:



Form 2:



Form 3:



Semantics:

A selection expression is used in FIND and LOCK statements to identify a particular record in a data set.

The optional phrase <data-set-name> VIA at the beginning of some forms of the selection expression is required when the path used is a manual subset and may also be required to qualify a multiply-invoked data set.

The phrase <data-set-name> VIA identifies the affected record area and current-record pointer, provided that the desired record is found. By default, the data set is the data set referred to by the set used.

Note that <subset-name> is interchangeable with <set-name> in selection expressions.

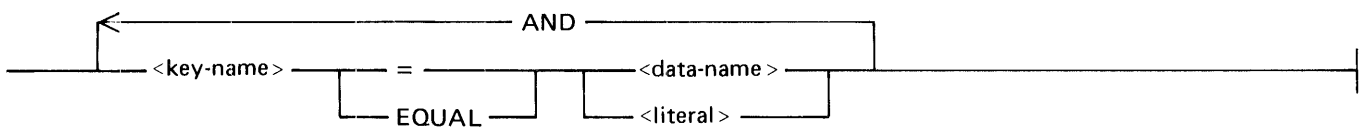
Examples:

```
FIND MSF VIA FIRST MSFSET
FIND FIRST MSF
LOCK MSFSET AT SSNO = C-SSNO
FIND MSF VIA MSFSET AT SSNO = C-SSNO
```

Key Condition

The key condition specifies values used to locate specific records in a data set spanned by a set or referenced by a subset.

Syntax:



Semantics:

The key-name must be a data-name in the key as defined by the DMS/DASDL description.

Each key-name in the key must appear only once and to the left side of the equal sign.

The valid item types for literal or data-name are determined by the COBOL MOVE rules. Therefore it must be legal to perform a MOVE operation on a literal or data-name to the key-name in order for the key condition to be valid.

The key-names of a multi-item key must appear in the same order as specified in the DMS/DASDL source file.

Example:

```
FIND S AT A = 50 AND B = 50
```

Selection Expression Forms

The three forms of selection expressions are considered separately for discussion purposes.

Whenever an ordering is required but no explicit ordering exists, an implicit physical ordering is used. Whenever a current-record pointer or current-path pointer is required but is not in the proper state, the operation terminates with an exception.

Form 1

The keyword FIRST specifies that the first record accessible by way of the specified path is to be selected. The path may not be a retrieval (index random) set. If a manual subset is used, the <data-set-name> VIA clause must be used. The record returned is the first in the physical order of the manual subset. If the manual subset is ordered, the entries are physically stored in key order so the physical and logical ordering are the same. Thus, a FIND FIRST will find the record with the lowest (or highest, for descending keys) key value.

The keyword NEXT specifies the next record to find by the path specified. Specifying this keyword for an ordered set or subset returns the record with the next higher (lower, if descending) key value. For ordered sets and automatic subsets, NEXT defaults to FIRST if this is the initial access of that set or subset since the data base was opened. For manual subsets, NEXT defaults to FIRST if this is the first access since the current owner record was established.

The keyword LAST locates the last record in the specified path.

The keyword PRIOR locates the preceding record. NEXT and PRIOR are always relative to the current-path pointer. FIND PRIOR of a data set (Form 2) can return a different record than FIND PRIOR of a set (Form 1). The current-path pointer is updated to reflect the record located.

Example:

```
D DATA SET
   (A NUMBER (3);
    B NUMBER (10));
K SET OF D KEY (A);
```

Since ascending sequence is the default ordering sequence for keys, the path K in the following example refers to members of D in sequence on A. A FIRST K therefore would transfer to the record area for D the record whose value of A was the lowest in the data set. The physical ordering of D might be different from the logical ordering presented by K. If another ordering key, K1, was added with the specification K1 SET OF D KEY (A DESCENDING), the statement FIND FIRST K1 would return the member of D with the highest value of A.

Example:

```
D DATA SET
   (A NUMBER (3);
    B NUMBER (10));
  K SET OF D KEY (A);
D1 DATA SET
   (X NUMBER (4);
    Y SUBSET OF D;
    Z SUBSET OF D KEY (B);
    Z1 ALPHA (2));
```

If D and D1 are both invoked, the statement FIND D VIA FIRST Y can then be used, returning the first physical record of D in the table of subset Y for the current record of D1. If the statement FIND D VIA FIRST Z is used, the record found is that record of D having the lowest value of B which was inserted into Z for the current record of D1.

Form 2

FIRST specifies that the record selected is the first physically located record in the file in which the data set is stored.

NEXT locates the next physical record.

LAST locates the last physical record in the data set.

PRIOR locates the preceding record.

If none of the above keywords is given, the current record will be found. If no current record exists, an exception is returned. The current-record pointer is updated to reflect the located record. The PRIOR keyword is valid only if the data set has already been accessed; otherwise, an exception condition is returned.

Form 3

If NEXT is omitted, the first record that satisfies the key condition is returned. If no record satisfies the key condition, a NOT FOUND exception is returned.

If NEXT is included, the access routines search forward from the current position of the set, seeking a record to satisfy the condition. If the desired key follows the current position, this is an implicit FIND FIRST. If the current position follows the desired key, a NOT FOUND exception is returned.

The purpose of the NEXT keyword in Form 3 is to find all records with duplicate keys.

Form 3 cannot be used with unordered manual subsets.

Example:

```
D DATA SET
  (A ALPHA (2);
   B NUMBER (10);
   C NUMBER (4));
K SET OF D KEY (A);
K1 SET OF D KEY (C), INDEX RANDOM;
K2 SET OF D KEY (C,B), INDEX RANDOM;
```

In the previous example, records of D could be selected based on the value of A using K, based on the value of C using K1, or based on the values of C and B using K2, as shown below:

```
FIND K AT A = "AA"
FIND K1 AT C = 100
FIND K2 AT C = 100 AND B = 1001007890
FIND K1 AT C = B1
FIND D VIA K AT A = A1
```

Generalized Selection Expression Feature

The generalized selection expression feature may be used by COBOL74 and RPGII DMSII programs as well as the DMS/INQUIRY program. This feature allows user programs to select records based upon incomplete key information, and is explicitly limited to these three software products.

A common use of general selection expressions is to retrieve all records with keys greater than some value. Even though COBOL68 lacks this feature, it can achieve the same result by means of a FIND AT <key condition> for the lower bound of the desired range, followed by FIND NEXTs to get following records. The fact that this works even when the first FIND yields a NOT FOUND is a special feature for COBOL68 and COBOL74. It is not available for RPGII.

For information concerning the COBOL74 syntax for the use of generalized selection expression, refer to the *B 1000 Systems COBOL74 Language Manual*.

For RPGII programs, the DMKEY option to the FIND and LOCK operation codes in the Calculation Specifications is used for this function. This is done by specifying successive DMKEY options connected by AND or OR lines according to the normal RPGII rules for the Calculation Specifications. Refer to the *B 1000 Systems Report Program Generator (RPG) Language Manual* for the complete syntax of DMSII selection expressions in the RPGII language.

No special user action is needed to invoke the generalized selection expression. Whenever any selection expression is encountered by the COBOL74 compiler, RPGII compiler, or the DMS/INQUIRY program, the DMSII system determines whether a simple DMSII FIND/MODIFY operation satisfies the request or whether the expression qualifies as a generalized selection expression. If the expression is a generalized selection expression and the structure being used for the request is an index sequential set or subset, further analysis is performed to determine whether lower and/or upper bounds can be established for each field in the key. The DMSII system automatically positions to the lower bound for a FIND NEXT <generalized-selection-expression> operation if the current position is less than the lower bound. If the current position is greater than the upper bound, a FIND NEXT <generalized-selection-expression> operation returns a NOTFOUND exception condition.

The following example demonstrates the use of the generalized selection expression, using the CUST-SET set which references a CUSTOMERS data set. The example includes COBOL74 code which can be used to find all members of the CUST-SET set for which the CUSTOMER-TYPE key item (an alphanumeric item) is equal to the letter D.

Example – DMS/DASDL Source:

```
CUSTOMERS DATA SET(
    CUSTOMER-TYPE     ALPHA(1);
    CUSTOMER-NUMBER   NUMBER(8);
      .
      .
      .
    );
CUST-SET SET OF CUSTOMERS KEY(CUSTOMER-TYPE,CUSTOMER-NUMBER);

    FIND CUST-SET AT CUSTOMER-TYPE = "D" ON EXCEPTION...

FIND-LOOP.
    .
    .
    .
    FIND NEXT CUST-SET AT CUSTOMER-TYPE = "D"
         ON EXCEPTION ... .
```

For index sequential structures, when the DMSII system actually encounters the communicate, the search is in two stages: (1) a binary search of the index tables for the entry which satisfies the lower bound and (2) a linear search of the tables, starting at the lower bound and continuing until either an entry is found which satisfies the request, or the upper bound is reached. For index random sets and ordered lists, only the linear search can be performed. For ordered lists, this search processes only the list tables pointed to by the current owner data set record for the list. For index random sets, all of the index tables for the index must be scanned.

Since any linear search is performed by the DMSII system, it can be costly in terms of processor utilization, though no more so than the same operations performed by an application program. The cost is a function of the following two factors: (1) the complexity of the selection expression, and (2) the physical length of the index tables being scanned.

As the logic within the selection expression becomes more and more complex, the likelihood decreases that a lower bound can be determined for the key items. If no lower bound can be determined for an item, zeroes are supplied. A lower bound of zero for a high-order key item results in a linear search which starts at or near the beginning of the index.

With regard to the physical length of the index tables being scanned, since the access routines must perform the linear search on an entry-by-entry basis, more entries cause longer searches.

Optimum performance can be derived from the generalized selection expression by stipulating a key condition in FIND or LOCK (MODIFY) operations for which most of the work can be accomplished by a binary search, with as little work as possible being done by a linear search. The rules given below enable the analysis of a given selection expression. The rules determine whether the expression qualifies as a generalized selection expression and, if it does, whether a lower bound exists for the expression.

Even a complicated general selection expression runs more quickly than an application program that must perform the same work by reading each record and making tests on the relevant fields. This is because there is less need for communication between the application program and the access routines and also because the access routines need not read each record but must only scan the tables of the set.

Study the rules that follow. If a frequently-used selection expression requires linear search of all the tables of a large set, it is recommended that another set or, possibly, an automatic subset be added to the data base.

NOTE

In the rules that follow, the selection expressions do not conform in syntax to any of the user languages but are, rather, general representations of the conditions that can be coded in those languages.

1. If the path specified is an ordered list, a linear search of the tables is always performed, regardless of the form of the selection expression.
2. If the following conditions are true, the expression can be satisfied by a FIND operation, using a binary search within the table to locate the exact entry requested:

   1) The path specified is either an index random set, or an index sequential set or subset.
   2) Each key item appears in the expression once.
   3) Simple equality is specified between each key item and the value supplied.
   4) All subconditions are connected by the AND logical operator.

   All other selection expressions are generalized selection expressions.

3. If the specified path is an index random set and any condition listed for item 2 is not met, a complete linear search must be performed on the entire index.

The following rules apply only to index sequential sets and subsets.

4. If the key items specified in the expression do not appear more than once but at least one item does not appear at all and all other conditions in item 2 are met, then a lower bound of zero is supplied for each of the unspecified key values. There is one lower and one upper bound for each key. Starting from the left and proceeding right (as keys are declared in the DMS/DASDL source), the first key that is missing either an upper or lower bound causes the start of a linear search.

Example – DMS/DASDL Code:

```
INVENTORY DATA SET (
      WAREHOUSE    NUMBER(2);
      PART-NO      ALPHA(6);
      BIN-NUMBER   NUMBER(4);
       ...
      );
PART-SET SET OF INVENTORY
      KEY (WAREHOUSE, PART-NO, BIN-NUMBER);
```

Selection Expressions

1) FIND PART-SET AT WAREHOUSE = 1 AND PART-NO = "A-123"
2) FIND PART-SET AT WAREHOUSE = 3 AND BIN-NUMBER = 15
3) FIND PART-SET AT PART-NUMBER = "A-123" AND BIN-NUMBER = 7

All three expressions are generalized selection expressions. Expression 1 results in a brief linear search, since the only unspecified key item is the BIN-NUMBER field, which is the least significant field. The result of this search is the first part number that is numbered A-123 in WAREHOUSE 1, regardless of bin number. Expression 2 results in a binary search that finds WAREHOUSE 3, then a linear search is made for BIN-NUMBER 15 on all paths in WAREHOUSE 3. Finally, selection expression 3 specifies only lower-order key items and leaves the major key item, WAREHOUSE, unspecified. The linear search for this expression includes the entire set.

5. If, instead of simple equality, the relational operators GREATER THAN (>) or GREATER THAN OR EQUAL (≥) appear in the expression, and all other conditions named by item 4 remain true, then the lower bound generated for the expression is the same as in item 4. Once that lower bound is found, the linear search may be, or need not be, more extensive.

   If any of the key items were declared to the DMS/DASDL compiler as DESCENDING, then the specification for that item can only contain the EQUAL (=), LESS THAN (<), or LESS THAN OR EQUAL (≤) operators for a non-zero lower bound to be established.

6. If the specification contains either of the LESS THAN or LESS THAN OR EQUAL operators for an ascending key item, or either of the GREATER THAN or GREATER THAN OR EQUAL operators for a descending key item, then the lower bound for any such item is zero. If all other conditions specified by items 4 and 5 are true, then the linear search for such an expression is analogous to the types of linear searches described above with the exception that the LESS THAN operator establishes an upper bound, which, when met, serves to terminate the linear search at an earlier point than if no upper bound is specified.
7. If a NOT EQUAL (≠) operator is specified in a subcondition, zero is used as the lower bound for that key.
8. If, in addition to the conditions specified by items 4 through 6, more than one subcondition is specified for a single key item, then both a lower bound and upper bound can be established for that item. Using the set described in item 4, the following selection expressions illustrate this condition.

Selection Expressions:

1) FIND PART-SET AT
   WAREHOUSE = 4 AND PART-NO ≧ "B15" AND PART-NO < "C"

2) FIND PART-SET AT
   WAREHOUSE = 4 AND PART-NO ≧ "B15" AND PART-NO ≠ "B75"

3) FIND PART-SET AT
   WAREHOUSE = 4 AND PART-NO ≧ "B15" AND PART-NO < "C"
   AND PART-NO ≠ "B75"

All three expressions have the same lower bound. In addition, expressions 1 and 3 have the same upper bound. Expression 2 has an upper bound for WAREHOUSE only.

If no upper bound is specified for any item, there is always an implied upper bound with all bits on; that is, each digit contains the hexadecimal value @F@. Explicit upper bounds on other key items normally serve to terminate the linear search before any of the implied upper bounds are reached.

When using the generalized selection expression, follow the preceding rules to specify the desired expression. Ideally, the stated expression makes the most efficient use of the DMSII system and the system resources. For example, the DMSII system returns the desired records if an expression which generates no lower bound is specified. However, the same results can often be obtained in less time, and with less impact on the rest of the system, by specifying several different expressions, each of which has a valid, non-zero, lower bound.

COBOL PROGRAMMING NOTES

This section is for those programmers using the COBOL compiler rather than the COBOL74 compiler. It is not intended for users of the RPGII compiler.

A COBOL program which is using a path (set, subset, or access) to retrieve a data set record is required to specify all of the key items for that path. In addition, the only relationship which can be specified between the key items and the values supplied in a selection expression is simple equality. Also, all subconditions have to be logically connected by the AND operator. A single operation cannot specify relationships such as LESS THAN, GREATER THAN, or NOT EQUAL, or compound relationships. The OR operator cannot appear in a selection expression, and it is not possible to specify values for just a subset of the items which comprise a key.

Because of these restrictions, an extension to index sequential (ordered sets and automatic subsets) is available in the DMSII system. This extension, called the Partial Key Search, stipulates that the current-record pointers (currents) for an index sequential structure be updated after FIND AT KEY and FIND NEXT AT KEY operations only, whether successful or not. The currents for all other structure types, data sets, index random sets, and lists are updated only after a successful operation. This allows a user to perform a FIND NEXT operation on an index sequential structure, after a NOTFOUND DMSTATUS exception condition was returned on a FIND AT KEY operation on that same structure. The effect of this implementation is that the unsuccessful FIND AT KEY operation establishes a position within the index (at the point the key would have been), and the FIND NEXT operation can then be used to retrieve records immediately after that position.

The following example demonstrates the use of the Partial Key Search technique, using the CUST-SET set which references the CUSTOMERS data set. The example includes COBOL source code which finds all the members of the CUST-SET set for which the key item CUSTOMER-TYPE (an alphanumeric item) is equal to the letter D.

In the following example, we are retrieving all records with a "D" customer-type.

DMS/DASDL Source:

```
CUSTOMERS DATA SET(
    CUSTOMER-TYPE     ALPHA(1);
    CUSTOMER-NUMBER   NUMBER(8);
      .
      .
      .
    );
CUST-SET SET OF CUSTOMERS KEY(CUSTOMER-TYPE,CUSTOMER-NUMBER);
```

COBOL Source:

```
        FIND CUST-SET AT CUSTOMER-TYPE = "D" AND CUSTOMER-NUMBER = 0
             ON EXCEPTION IF DMSTATUS(NOTFOUND) FIND NEXT CUST-SET
             ELSE ...

    FIND-LOOP.
        .
        .
        .
        FIND NEXT CUST-SET ON EXCEPTION ...
        IF CUSTOMER-TYPE = "D" GO TO FIND-LOOP.
```

Compare the above with the B 1000 COBOL74 source.

COBOL74 Source:

```
    FIND CUST-SET AT CUSTOMER-TYPE = "D"
         ON EXCEPTION ...

    FIND-LOOP.
        .
        .
        .
        FIND NEXT CUST-SET AT CUSTOMER-TYPE = "D"
             ON EXCEPTION ...

        GO TO FIND-LOOP.
```

In the preceding example, the desired value is specified for the CUSTOMER-TYPE field, and zero is specified for the CUSTOMER-NUMBER field. By doing so, the user guarantees that the FIND AT KEY operation leaves the index pointing either at, or just before, the entry within the index which has the lowest possible value for the CUSTOMER-NUMBER field, as well as CUSTOMER-TYPE = D.

In general, partial keys can be used if a COBOL application program specifies values for the higher-order items within the key. The lower-order items have to be specified as low-values (zeroes for numeric items, @00@ for alpha). The limitations of the partial key are described as follows:

1. It can be used only for index sequential sets. No such capabilities exist for either index random sets or ordered lists.
2. No conditions can be described which ignore the high-order key items but give specific values for the low-order key items.
3. No compound expressions can be easily described. The following example of a generalized selection expression requires two different program loops to find the same record with the Partial Key Search technique:

```
FIND CUST-SET AT
     (CUSTOMER-TYPE = "D" AND CUSTOMER-NUMBER < 1500 ) OR
     (CUSTOMER-TYPE = "E" AND CUSTOMER-NUMBER < 300) .
```

For these reasons, generalized selection expression available with the COBOL74 and RPGII compilers are recommended.

CURRENT RECORD POINTER

Internally, the DMSII system maintains a current record pointer for each path (that is, for every set, subset or for the data set itself) to each data set. The current record pointer points to a data set record and gives the DMSII system a reference point from which to move on subsequent FIND operations (for example, NEXT, PRIOR, NEXT AT KEY). Each invocation of a structure, in addition to providing another record area in the program, provides another current record pointer.

Here are the two typical cases:

- A FIND (or LOCK or MODIFY) of a data set via a path (including the data set itself) causes the current record pointer for that path to be changed to point to the newly found record, and also causes the current record pointer for the data set itself to be changed. Additionally, the data in the newly found record is put into the record area in the program.
- A STORE of a new record into a data set causes the current record pointer for the data set to be changed to point to the newly stored record, but does not update any path current record pointers.

Exceptions to these typical cases can best be understood if some background is gained concerning the internal workings of current record pointers.

Internal States

Internally, in the DMS/ACR (access routines) program, a current record pointer may be in one of three states: undefined, defined, or deleted.

The undefined state is its initial condition, and the condition into which a current record pointer of an embedded structure is placed each time a new record is found or stored in its parent structure. If a FIND NEXT operation is performed when the current record pointer is in this state, an implicit FIND FIRST operation is performed.

The defined state is the normal condition of a current record pointer. In this state, operations such as DELETE may be performed on the current record as well as operations such as FIND NEXT, FIND PRIOR, and the like.

The deleted state is the state into which a current record pointer is moved when the record to which it referred is deleted. (See Deleted Records, later in this section.) When in this state, any operation (for example, DELETE) on the current record returns a NOTFOUND exception, but FIND NEXT, FIND PRIOR, and similar operations are still valid.

Each current record pointer for a data set has a create-flag and a lock-flag. The create-flag is set if the last operation on the data set was CREATE or RECREATE. The lock-flag is set if the last operation on the data set, via any path, was LOCK or MODIFY. Both flags are cleared by any other successful DMSII operation on that data set, via any path, and are left unchanged by unsuccessful DMS operations.

Exceptions on FIND

If the FIND operation results in an exception, then neither the current record pointer for the path nor the one for the data set is altered, with the following exception:

> The FIND operation was a FIND AT KEY operation, and the path was an index sequential set or subset, and the exception was a NOTFOUND.

In this one circumstance, the current record pointer for the path (but not the one for the data set) is updated to "where the record would be if it were there". This condition allows a subsequent FIND NEXT through that path to get the next key higher than the first specified value and enables the COBOL Partial Key Search operation. (See Partial Key Search in the section titled COBOL Programming Notes.) This exception applies only to COBOL and COBOL74. It does not apply to RPGII.

Deleted Records

When a record is deleted from a data set, any current record pointer (both path pointers and data set pointers) pointing to it in any program (including, of course, the one doing the DELETE operation) is changed to the deleted state.

Storing Records

In order to store a data set record, the current record for that data set must be either locked (lock-flag is on) or created (create-flag is on). If it is in neither of these states, the STORE operation terminates with a NOTLOCKED exception. The state of the current record determines the kind of STORE that is done:

> If the create-flag is on, a new record is stored (create-store) and, if the STORE operation is successful, the current record pointer is moved to the newly stored record. That new record is locked and the create-flag is turned off.
>
> If the lock-flag is on, the STORE operation updates the existing current record (update-store), the current record pointer is not moved, and the lock-flag remains on.

Unlocking Records

A data set record that is locked may not be locked (hence, may not be updated) nor deleted by any other program. The record is automatically unlocked when another DMS operation is done on the data set (discussed earlier). Records also may be explicitly unlocked with the FREE verb. In addition, all records except the restart data set record are unlocked at each END-TRANSACTION, and all records are unlocked when a DEADLOCK exception is reported. If a program abort occurs, all records for other programs are not only unlocked but are set to the undefined state.

After an abort, the program may do additional LOCK operations before being notified of the ABORT exception on its next BEGIN-TRANSACTION operation. Therefore, it is possible for the program to have records locked at the time it first learns of the ABORT.

Embedded Datasets

Current record pointers for embedded data sets follow the same rules as those for current record pointers for disjoint data sets except that their state is dependent upon the state of their parent data set. It is not possible to do any operation other than a CREATE on an embedded data set unless the current record pointer for its parent data set is in a defined state. Any such attempt results in a NORECORD exception.

Each time the current record pointer is changed for the parent data set, the current record pointers for all embedded structures are cleared, the lock-flag is cleared, and the state is changed to undefined. The create-flag is not cleared.

SECTION 3
ANSI 68 COBOL LANGUAGE STATEMENTS

The following COBOL verbs are used to manipulate data sets:

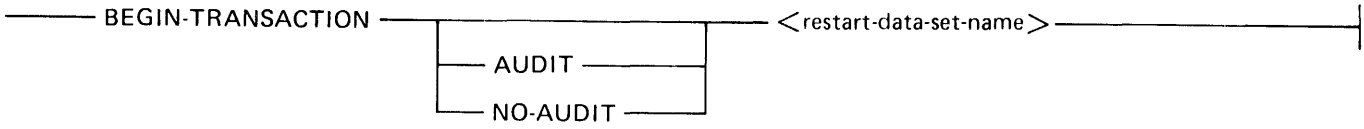
BEGIN-TRANSACTION
CREATE
DELETE
END-TRANSACTION
FIND
FREE
INSERT
MODIFY
RECREATE
REMOVE
STORE

In addition, syntax has been implemented for the OPEN verb and additional semantics for the CLOSE verb.

The COBOL verbs, in alphabetical order, are described next along with the exceptions they can generate. Refer to the descriptions of exceptions in the DMSTATUS Register section in section 2 for explanations of the exceptions.

BEGIN-TRANSACTION

Syntax:



Semantics:

The BEGIN-TRANSACTION verb causes the program to enter transaction state. If an audited data base is in use, a program must be in transaction state before it performs any DMSII operation that changes a record. Examples of such operations are STORE, DELETE, INSERT, REMOVE. Therefore, after the data base is opened or after the program has left transaction state by means of an END-TRANSACTION operation, the BEGIN-TRANSACTION verb must be specified before the first update operation.

1. If a program attempts a BEGIN-TRANSACTION operation while a DMSII system syncpoint or controlpoint operation or a program abort recovery is in process, the program is suspended at the BEGIN-TRANSACTION operation until the in-process operation completes.
2. If the AUDIT clause is specified, the DMSII system stores the current restart record of the program. This requires the user to have established a locked record in the restart data set by the time of the BEGIN-TRANSACTION operation. The user can lock a restart data set record by specifying the CREATE, RECREATE, or MODIFY verb.
3. If the NO-AUDIT clause is specified, the STORE operation on the restart record is suppressed.
4. The AUDIT clause is set TRUE by default.
5. The state of the program is unchanged if any exception condition occurs on a BEGIN-TRANSACTION operation. That is, if an AUDITERROR exception condition occurs because the program was already in transaction state, then the program remains in transaction state after encountering the exception. If any other exception occurs, the program remains out of transaction state after encountering the exception.

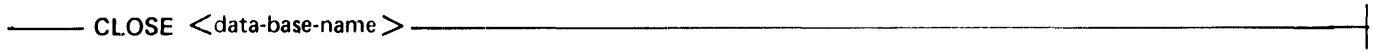
Exception Conditions:

ABORT
AUDITERROR
FATALERROR
INTEGRITYERROR
OPENERROR

If the AUDIT clause was specified, either implicitly or explicitly, any of the exception conditions which are possible on a STORE operation are also possible on a BEGIN-TRANSACTION operation.

CLOSE

Syntax:



Semantics:

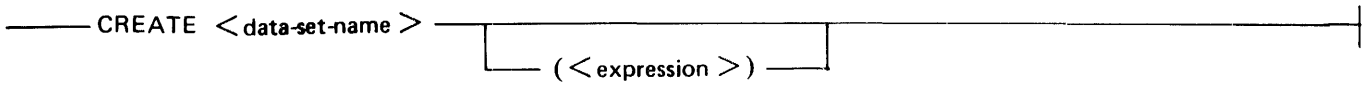
1. The CLOSE verb closes a data base when further access is no longer required.
2. The CLOSE verb is optional since the system closes any open data base when the program terminates. However, an explicit close is recommended so that exception conditions can be returned.
3. An implicit FREE operation is performed on all records locked by the program.
4. If the data base is not open, the close operation terminates with a CLOSERROR exception condition.

Exception Conditions:

ABORT
AUDITERROR
CLOSEERROR
FATALERROR
IOERROR

CREATE

Syntax:



Semantics:

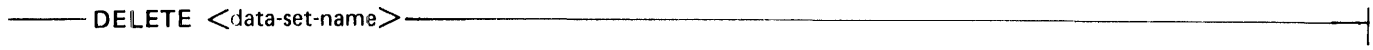
1. The CREATE verb must be performed prior to the addition of a new record in a data set (optionally the RECREATE verb can be used). A CREATE operation does not add the new record to the data base; that is the function of the STORE verb. The main purpose of a CREATE verb is to initialize the entire current record area of the data set according to the value of the INITIALVALUE clause in the data base description. Any data item in the data base description which does not have an INITIALVALUE clause is initialized to null (all bits ON). This initialization is used for validity checking of the record at the time of the STORE operation.
2. An implicit FREE operation is performed on the prior current record of the data set.
3. The current-record pointer goes to the created state.
4. Normally, the CREATE verb is eventually followed by a STORE verb, placing the new record into the data set. However, if a subsequent STORE operation is not desired, the CREATE operation can be nullified by a subsequent FIND, MODIFY, CREATE, RECREATE, DELETE, FREE, or CLOSE operation. A BEGIN-TRANSACTION audit or END-TRANSACTION audit nullifies a CREATE of the restart data set.
5. A CREATE operation initializes only a record area. If the record contains embedded structures, the master record must be stored before storing entries in the embedded structure. If only entries in the embedded structure are added, changed, or deleted, then the master need not be stored a second time.
6. A current owner record must exist if the data set is an embedded data set.
7. <expression> is valid only if the data set description includes a variable-format part.
8. <expression> can be any of a literal, a simple data name, or an arithmetic expression. It cannot be a subscripted or indexed data name.
9. If the data set description referenced by the CREATE verb includes a variable-format part, an <expression> must be included in the CREATE verb of that data set.
10. If the value of <expression> does not match any of the values for the RECORD TYPE field declared to the DMS/DASDL compiler, then a DATAERROR exception condition is returned.

Exception Conditions:

DATAERROR
FATALERROR
OPENERROR

DELETE

Syntax:



Semantics:

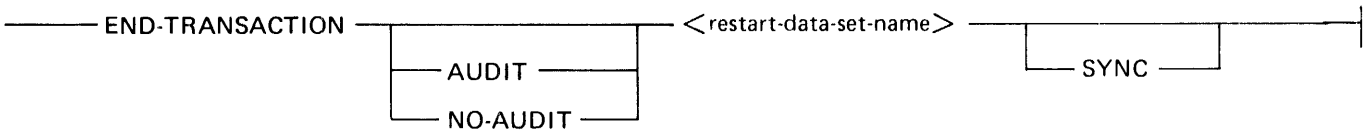
1. The DELETE operation eliminates the current record from a data set.
2. The current record area is reloaded with the contents of the record.
3. If the record contains a non-empty embedded structure, an INUSE exception is returned. The record is not deleted.
4. If the record can be deleted, it is removed from all sets and automatic subsets of which it is a member. The record is then removed from the data set. The current-record pointer goes to the deleted state. The data remains unaltered in the record area.
5. The programmer must remove the record from any manual subset that points to the data set record being deleted before deleting the record. (Refer to the REMOVE verb.)

Exception Conditions:

AUDITERROR
DEADLOCK
FATALERROR
INTEGRITYERROR
INUSE
IOERROR
READONLY
NORECORD
NOTFOUND
OPENERROR

END-TRANSACTION

Syntax:



Semantics:

1. The END-TRANSACTION operation causes the program to leave transaction state. This operation is normally executed at the end of any series of logically related updates to a data base. If a program is in transaction state immediately prior to closing the data base, an END-TRANSACTION operation must be performed before attempting to close the data base.
2. The AUDIT and NO-AUDIT clauses serve the same function as in the BEGIN-TRANSACTION verb.
3. The NO-AUDIT clause is set TRUE by default.
4. The SYNC clause specifies that a syncpoint operation is performed after completing the END-TRANSACTION operation regardless of the actual number of transactions which have occurred since the last syncpoint operation. If a program attempts to perform an END-TRANSACTION with syncpoint operation after a program abort has occurred, then the program is suspended at the END-TRANSACTION verb until the data base has been recovered. After the data base is recovered an ABORT exception condition is returned. When an ABORT exception condition is returned to a program which has attempted END-TRANSACTION with syncpoint operation, that last transaction of the program is backed out, and the syncpoint operation is not performed; however, the program is no longer in transaction state.

   If the END-TRANSACTION is done without a SYNC and if another program aborts, then the last transaction of the program (and, possibly, previous ones) is backed out, but the program is not be notified until the next BEGIN-TRANSACTION or CLOSE.

5. Except for an ABORT exception condition, the transaction state of the program is unchanged if an exception occurs on an END-TRANSACTION operation. If a program encounters an OPENERROR or AUDITERROR exception condition, the program remains out of transaction state. If any other exception condition occurs, the program remains in transaction state. If the program receives a FATALERROR, it is not only out of transaction state but the data base is closed.

Exception Conditions:

ABORT
AUDITERROR
FATALERROR
OPENERROR

If the AUDIT clause was specified, any of the exception conditions which are possible on a STORE operation are also possible on an END-TRANSACTION operation.

FIND

Syntax:

Semantics:

1. The FIND operation performs two functions:

   1) Locates the record satisfying <selection-expression>.
   2) Transfers the data from the data base to the record area so it can be accessed by the program.

2. If a record satisfying <selection-expression> is not found, the operation terminates with a NOTFOUND exception condition. In this case, the record area and current-record pointer retain their original values.
3. If a record is found, the record is transferred to the record area of the program and the current-record pointer is altered to refer to the found record. Also, if a set or automatic subset is involved, its current-path pointer is altered to refer to the found record.
4. When performing a FIND operation by way of an embedded data set or manual subset, the current-record pointer for the owner data set must be in a defined state.

Exception Conditions:

FATALERROR
INTEGRITYERROR
IOERROR
NORECORD
NOTFOUND
OPENERROR
SYSTEMERROR

FREE

Syntax:

Semantics:

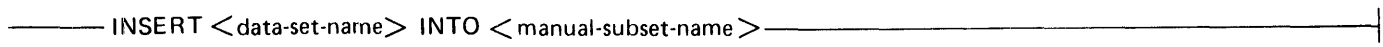
1. A FREE operation unlocks the current record.
2. A FREE operation can occur after any operation. If the current-record pointer is not in the defined state or the current record is not locked, then the FREE operation is ignored.
3. A FREE operation is optional in most situations, since the CREATE, RECREATE, and sometimes the FIND or MODIFY operations perform an implicit FREE operation prior to their other actions. An implicit FREE operation is performed when any DMSII operation that establishes a new current-record pointer succeeds. Also, the END-TRANSACTION operation performs an implicit FREE operation on every record locked by this program, except for the restart data set.
4. The current-record pointer and current-record area are not affected by a FREE operation. If the current-record pointer has just been created by way of the CREATE operation, it is changed back to its state before the previous CREATE operation; otherwise it is not affected.

Exception Conditions:

FATALERROR
OPENERROR

INSERT

Syntax:



Semantics:

1. The INSERT operation places a record into a manual subset.
2. <data-set-name> must be the declared object of records for a manual subset. That is, <manual-subset-name> must be a manual subset of <data-set-name>, as the example below illustrates:

   DMS/DASDL: S1 SUBSET OF D
   COBOL: INSERT D INTO S1

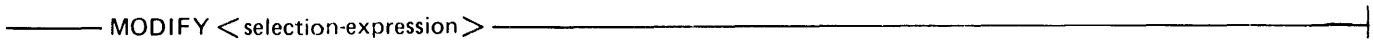
3. The current-record pointer of <data-set-name> must be defined. If it is not, the INSERT operation is terminated with a NOTFOUND exception condition.
4. The data set in which the manual subset is embedded must have the current-record pointer in the defined state. If it is not, the operation is terminated with a NORECORD exception condition.
5. If duplicate keys are not allowed for an ordered manual subset and a record that has a key identical to that of the source record already exists in the manual subset, then a DUPLICATES exception condition occurs.

Exception Conditions:

AUDITERROR
DATAERROR
DEADLOCK
DUPLICATES
FATALERROR
INTEGRITYERROR
IOERROR
LIMITERROR
NORECORD
NOTFOUND
OPENERROR
READONLY

MODIFY

Syntax:



NOTE
The LOCK verb is used in COBOL74 and RPGII programs. The MODIFY verb is used in COBOL programs. The functions of LOCK and MODIFY are identical.

Semantics:

1. The functions of a MODIFY verb are identical to those of the FIND verb with one exception: if the record is found, it is locked, prohibiting other programs from performing a concurrent MODIFY operation on the same record. However, other users can perform FIND operations on locked records.
2. Since a record must be locked before it can be updated, a MODIFY verb should be specified if there is a possibility that the data set record content is to be changed. The MODIFY operation does not physically change the record but allows changes to be performed subsequently without a concurrent update from another program.
3. If the requested record is already locked by another program, a contention analysis is performed by the DMSII system. When performing a contention analysis, the DMSII system must examine the status of the program which has locked the requested record; if that program is itself waiting for another record to be unlocked, the DMSII system must repeat the process by examining the status of the program which has that next record locked. This process continues until one of the following occurs:

   1) A program is encountered which is not waiting for a record to be unlocked. In this case, the program that was originally responsible for the contention analysis being performed is suspended by the DMSII system until either the record is unlocked or MAXWAIT seconds have elapsed. In the former case, the record is returned to the program; in the latter case, the program receives a DEADLOCK exception condition.
   2) A program is encountered which is waiting for a record to be unlocked, and that record is locked by the program originally responsible for the contention analysis. This circular chain of programs is termed a Deadly Embrace. Upon recognizing this condition, the DMSII system returns a DEADLOCK exception condition to the lowest priority program in the chain and reinstates any programs which have been waiting for a record locked by that program.

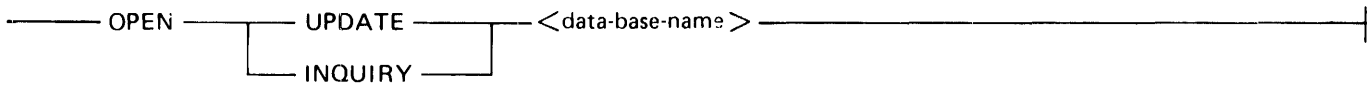
4. Since no other program can lock a record once it is locked, it is important to free the record when it is no longer necessary to keep it locked. Unlocking a record is accomplished by a FREE operation or implicitly by a subsequent LOCK (MODIFY), FIND, CREATE, or RECREATE operation on the same data set. A subsequent STORE operation leaves the record locked. An END-TRANSACTION operation frees all records except restart data set.
5. Locking is maintained on a record level; other records within a block with a locked record are unaffected by the lock operation.
6. If the data set is embedded, or if <selection-expression> involves a manual subset, there must be a valid current owner record.

Exception Conditions:

DEADLOCK
FATALERROR
INTEGRITYERROR
IOERROR
NORECORD
NOTFOUND
OPENERROR
SYSTEMERROR

OPEN

Syntax:



Semantics:

1. The OPEN verb causes an open operation to be performed on a data base for subsequent access.
2. An open operation must be executed prior to the first access to the data base; otherwise, all data base requests terminate with an OPENERROR exception condition.
3. If the data base is already open, the open operation is terminated with an OPENERROR exception condition.
4. The DMSII system attempts to open an existing data base. The data base dictionary is opened at this time. If the data base dictionary is not present, the following message is displayed:

   NO FILE <data-base-name>/DICTIONARY

   In addition, if the access routines (DMS/ACR files) are not present or are of an incompatible version, or if there is insufficient memory to open the data base, an appropriate message is displayed and the program hangs, waiting for an operator to correct the situation.

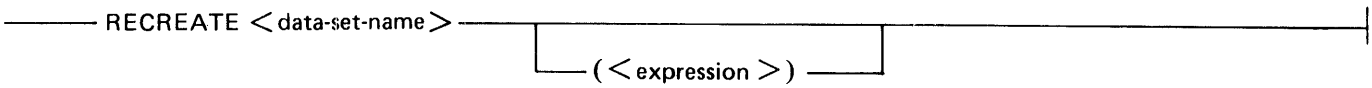
5. The INQUIRY clause specifies that any DMSII operation (STORE, REMOVE, INSERT, and DELETE verbs) which changes the data base is not to be performed. Any such operation attempted on a data base opened with INQUIRY returns a READONLY exception.
6. The UPDATE clause specifies that DMSII operations (STORE, REMOVE, INSERT, and DELETE verbs) which change the data base can be performed.

Exception Conditions:

FATALERROR
OPENERROR
SECURITYERROR
SYSTEMERROR
VERSIONERROR

RECREATE

Syntax:



Semantics:

1. The RECREATE verb is identical to the CREATE verb with one exception: the record area for the data set is not completely initialized. All data items remain unaltered; however, items such as current pointers for manual subsets and embedded data sets are set to the deleted state.
2. When a RECREATE (<expression>) is being performed, the DMSII system does not check to determine if the value of <expression> matches the contents of the RECORD TYPE field. If the values do not match, unpredictable results can occur when the program attempts to access data within the new current variable-format part after the RECREATE operation.

Exception Conditions:

DATAERROR
FATALERROR
OPENERROR

REMOVE

Syntax:

Semantics:

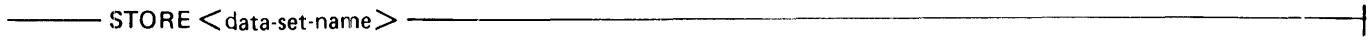
1. The REMOVE verb causes a record to be discarded from a manual subset.
2. The manual subset must have a defined current-path pointer. If it does not, the REMOVE operation is terminated with a NOTFOUND exception condition.
3. The record referenced by the manual subset current-path pointer is removed from the subset but not from the data set.
4. The data set in which the manual subset is embedded must have the current-record pointer in the defined state. If it does not, the REMOVE operation is terminated with a NORECORD exception condition.

Exception Conditions:

AUDITERROR
DEADLOCK
FATALERROR
IOERROR
NORECORD
NOTFOUND
OPENERROR
READONLY

STORE

Syntax:



Semantics:

1. The STORE verb returns a modified record to a data set or places a newly created record into a data set.
2. The data to be stored is in the record area of the data set. Prior to the storing of a record, the data is checked for validity (VERIFY, REQUIRED, non-null keys) as specified by the DMS/DASDL source. A validity failure terminates the STORE operation with a DATAERROR exception condition.
3. If the current-record pointer is in the defined state and the current record is locked, the data replaces the current record in the data set and remains locked. If the current-record pointer is in the defined state but unlocked or in an undefined state or deleted state, then the STORE operation terminates with a NOTLOCKED exception condition.
4. If the current-record pointer is in the created state, the data becomes a new record in the data set and is locked. The current-record pointer is then in the defined state and refers to the new record.
5. Set current-path pointers are not affected by a STORE operation.
6. All fields which are, or form, part of a key or are specified with the REQUIRED clause in the DMS/DASDL source must contain a value other than a null value before a STORE operation can be completed successfully. If any of these fields are null, the STORE operation terminates with a DATAERROR exception condition.

The following additional actions are performed depending on the prior DMSII operation:

STORE Operation after CREATE or RECREATE Operation

1. The condition is evaluated for each automatic subset (subset containing a WHERE condition). The subset is marked for insertion if the condition and validity checks are satisfied.
2. If an exception condition occurs which prevents the data record from being inserted into any of its sets, or into any automatic subset for which the WHERE condition is satisfied, then the STORE operation is terminated and the exception condition is returned to the program. In this case, the record is not inserted into the data set nor into any of the sets or subsets. Exception conditions which can occur during the insertion of a key into a set or automatic subset are the DUPLICATES and LIMITERROR exception conditions.

STORE Operation after MODIFY Operation

1. In this STORE operation, the record already exists in all sets.
2. If any terms involved in an automatic subset condition have changed, the condition must be re-evaluated. The record is removed from the automatic subsets containing the record if a condition is not satisfied. The record is inserted into automatic subsets not already containing the record if the condition is satisfied.
3. If a key used in the ordering of a set is modified, and the record must be moved in that set, then the record is deleted from the set and reinserted in the proper position. A key must not be modified if duplicate records are not allowed or if the set is an embedded data set.

STORE

4. If a field used as a key field of a manual subset is changed, the STORE operation occurs, but no reordering of that manual subset is performed. It is the responsibility of the programmer to maintain manual subsets. On a FIND via a manual subset, if the object record key does not match the key in the manual subset, the object record will not be found. The next record or, possibly, a NOTFOUND exception will be returned.

Exception Conditions:

AUDITERROR
DATAERROR
DEADLOCK
DUPLICATES
FATALERROR
INTEGRITYERROR
IOERROR
KEYCHANGED
LIMITERROR
NORECORD
NOTLOCKED
OPENERROR
READONLY

COBOL COMPILATION PROCEDURES

The COBOL compilation process requires a program written according to the normal COBOL syntactic conventions, incorporating data set INVOKE statements and the appropriate DMSII statement extensions to COBOL as defined in section 2. During each compilation, upon recognition of an INVOKE statement of a data set, the compiler includes (by copy) into the source program the library file generated by the DMS/DASDL compiler. Each library file contains a complete description of the data set, its sets and automatic subsets, and all of its embedded items, including data sets and subsets. The compiler uses this information to establish the record areas necessary for communication between this program and the DMSII system. The library files also provide the information needed to verify for correct syntax the DMSII statements used in the PROCEDURE DIVISION of the COBOL program.

The COBOL compiler expects the DMS/DASDL library files to be on the system disk drive. However, if the DMS/DASDL compile statement directed the data base dictionary and library files to a user disk drive, the following statement must be included in all COBOL compile decks for the compiler to locate the library files:

```
FILE LIBRARY PACK.ID <disk-pack-id>;

        or (WFL)

FILE LIBRARY (FAMILYNAME = <disk-pack-id>;
```

The data base dictionary must always reside on the same disk pack as the DMS/DASDL library files. When the COBOL compiler builds the data base Open Communicate for a user program, the pack-id of the library files is included in the Open Communicate as the pack-id of the data base dictionary. In order for the COBOL compiler to correctly identify that pack-id, the programmer must include the above file-equate in the COBOL compile statement. If the COBOL compile operation is stopped because the data base library files are on a different pack, the IL system command should not be used to override the condition. If it is used to resume the compile, the wrong pack-id will be included in the data base Open Communicate of COBOL programs. The IL system command may be used in COBOL74 compilations to override the no-file condition and go to a different unit.

The COBOL compiler always accesses the library files that have the appropriate identifiers at the time of compilation. If multiple versions of the library files have been produced, it is important that the versions that correspond to the current data base versions are the library files loaded at compile time. The versions are checked at execution time; if the versions are incompatible, the execution of operations against the data base is disallowed, with a VERSIONERROR exception on the open.

The object code produced by the compiler includes a communicate for each of the DMSII statements encountered. Local manipulation of data base items by COBOL statements is handled directly by object code produced by the compiler. The object code produced by the COBOL compiler is ready for execution.

For additional information on COBOL syntax, semantics, options, or compiler operation, refer to the *B 1000 Systems COBOL Language Manual.*

SECTION 4
AUDIT AND RECOVERY RESTART PROCEDURES

The DMSII audit and recovery system consists of (1) code, within the 11.0 operating system and DMS/ACR files, that audits all data base updates to a disk or tape and (2) the DMS/RECOVERDB program that processes this audited information to restore the integrity of a data base that has been compromised by an application programming failure, system error, or hardware malfunction. Additionally, the audit and recovery system is designed to accomplish this task in much less time, and with much less programming or operational effort than user-written recovery procedures. The audit and recovery system is described in the *B 1000 Systems Data Management System II (DMSII) Functional Description Manual.*

NOTE
Throughout this section, the keywords used for operations are those used in COBOL74. In all cases, the equivalent form for COBOL and RPGII is also implied. These equivalents are all listed in appendix B.

There are a few restart procedures that apply to all environments. One set, ordered or retrieval, must be declared for the restart set. For batch programs, the key field for this index might typically be the Program-Id. For data communication programs, the key might identify the station responsible for the input.

Since a STORE operation is performed on the restart data set at either the BEGIN-TRANSACTION or END-TRANSACTION operation, the program should update all of the relevant fields in its restart record immediately before executing that operation. There should be sufficient data stored within the restart record to enable a program to restart itself in each of the areas discussed in each of the paragraphs that follow.

INTERNAL PROCEDURES

Items which are required to maintain consistency and reproducibility of results, such as control totals or preprinted form numbers for checks or invoices, must be accessible through the restart record.

EXTERNAL PROCEDURES RELATED TO THE DMSII SYSTEM

The program must be able to restore any critical record or path pointers to their state at the point of the recovery. This is usually more important for batch programs than data communication programs since successive data communication transactions are typically unrelated, whereas batch programs may process sequentially through an entire structure.

EXTERNAL PROCEDURES NOT RELATED TO THE DMSII SYSTEM

Input and output files and non-DMSII managed files, such as COBOL74 ISAM files, must be present so that they can be repositioned.

GENERAL PROCEDURES

Interaction among the areas previously described must also be taken into consideration. For example, it may be necessary to reprocess the payroll for several employees, repeating the update operations to all of the relevant data sets within the data base and possibly creating or adding to other tape or disk files which are used by another application program; however, if paychecks were physically created prior to the failure, then the program, while in restart mode, must either not produce any new checks or automatically void any duplicate checks. The restart procedures for such an application program must allow for the entry of the last form number physically assigned. By comparing the numbers being assigned to the last number actually issued prior to the failure, the application program determines when to start issuing live checks.

NOTE

This example assumes a stand-alone mix. In designing the procedures required to restart such a program when several programs are updating the data base, the interaction among all programs must be considered in order to guarantee reproducibility of results.

RESTART RECORD HANDLING

Immediately after opening the data base, a program should locate and lock its restart record. If the operation is successful, the program should examine that record to determine if a recovery has occurred, and if so, the restart procedures should be executed. If the LOCK operation is unsuccessful, a CREATE or RECREATE operation must be performed at this time to establish a locked record for this program and prevent the program from getting a NOTLOCKED exception when it attempts its first BEGIN-TRANSACTION or END-TRANSACTION with audit operation.

Just before closing the data base, the following COBOL or COBOL74 code can be performed to delete the restart record of a program, assuming that the one restart record used by the program is still locked. (In the syntax, <exc> refers to exception-handling code.)

```
BEGIN-TRANSACTION NO-AUDIT <restart-data-set-name> <exc>.

DELETE <restart-data-set-name> <exc>.

END-TRANSACTION NO-AUDIT <restart-data-set-name> SYNC <exc>.
```

By deleting its restart record, the program insures that its restart procedures need to be executed after data base open only when the initial LOCK operation on the restart set is successful. Note that AUDIT is suppressed on both BEGIN-TRANSACTION and END-TRANSACTION operations since there is no need to restart this operation. Also, the specification of SYNC insures that, if another program aborts after this END-TRANSACTION operation but before this program can close the data base, the ABORT exception at the close can be ignored.

Another method which can be used, rather than the deletion of the restart record, is to maintain a batch number within the restart record. The current batch number is given to the program either from the ODT or an external file, and compared to the number within the restart record. If the two numbers match, this run is a continuation of an interrupted batch and the program must perform its restart routines. If the two numbers do not match, this is a new batch and no restart is necessary.

BATCH PROGRAMS

Batch programs are much easier to restart than data communications programs, since they usually deal with one or no easily retrievable input source, and it is relatively simple to maintain information concerning the position of that input file as well as any output or secondary input files.

A physical count of the number of input records processed can be used to reposition an input file. Upon restarting, that is the number of records that may be be passed over. For ordered DMSII structures or any other non-DMSII ordered files, a key field accomplishes repositioning. However, output files other than disk cannot be physically repositioned. Therefore, multiple output card or tape files must be merged, and line printer files, especially in the case of preprinted forms, can require operator intervention.

A stand-alone batch program that can be readily restarted or rerun can eliminate overhead by using large transactions. Additionally, the syncpoint and controlpoint values may be raised temporarily with the SM system command. Batch programs which do not run in the stand-alone mode should not use large transactions because all jobs must wait for long transactions to complete when a syncpoint occurs.

DATA COMMUNICATIONS PROGRAMS

Restart procedures for on-line DMS systems are much more complicated to design and to code than those for batch systems. Not only is the input difficult to retrieve but many programs may interact in complex ways and each program may handle a number of users. No general rules can be given for on-line recovery because it is site and application dependent. The generalized message-control system (GEMCOS) provides recovery for on-line environments. (See the section titled Recovery in the *B 1000 Series Generalized Message Control System (GEMCOS) User's Manual.*)

BACKED OUT TRANSACTIONS

All forms of recovery result in some transactions being backed out. Although this loss is seldom critical in a batch environment, it is usually vital in an on-line environment. The syncpoint DMS/DASDL parameter controls the number of transactions that can be lost. Because no program can do a BEGIN-TRANSACTION if the syncpoint count has been reached with the syncpoint not yet done, setting the syncpoint parameter too low may cause programs to await syncpoint too frequently.

One guideline is to set syncpoint to the number of jobs which concurrently update the data base. The syncpoint parameters can be set with the SM system command as well as with a DMS/DASDL update.

The controlpoint parameter controls the amount of time a clearstart recovery takes and is unrelated to the number of lost transactions.

APPENDIX A
COBOL QUALIFICATION OF DMSII IDENTIFIERS

Unique identifiers are required in COBOL programs. If a data set is invoked more than once, separate internal names must be used so that items within the data set can be appropriately qualified.

A variable declaration with the same name as a data base item can be used only if the item is able to be uniquely qualified.

In a selection expression, sets and subsets require qualification if they are not unique identifiers. Data base items in a selection expression need not be qualified.

Example – DASDL:

```
D1 DATA SET(
   A NUMBER (5);
   B NUMBER (3));
S1 SET OF D1 KEY (A), INDEX SEQUENTIAL;
```

Example – COBOL:

```
DB  DBASE.
01  D1 INVOKE D1.
01  DA INVOKE D1.

WORKING-STORAGE SECTION.
77 A PIC 99.       (Invalid because it cannot be uniquely qualified.)
01 Q.
   03 A PIC 99.                  (Valid because it can be qualified.)

PROCEDURE DIVISION.

    MOVE A OF D1 TO L.                                        (Valid.)
    FIND S1 OF D1 AT A = L.                                   (Valid.)
    MOVE A TO L.                  (Insufficient qualification of A.)
    FIND S1 AT A = L.            (Insufficient qualification of S1.)
    FIND S1 OF DA AT A OF DA = L.                             (Valid --
              but A need not be qualified in a selection expression.)
```

APPENDIX B
DMSII OPERATION SUMMARY

This appendix provides summaries of the DMSII verbs and the differences between COBOL and RPGII DMSII.

DMSII VERB SUMMARY

The DMSII verbs are listed in alphabetic order and described in the paragraphs that follow. In most cases, the verb as presented applies to all three languages – RPGII, COBOL, and COBOL74. Where the forms differ, the alternate forms and other differences are noted.

BEGIN-TRANSACTION (COBOL, COBOL74)
TRBEG (RPGII)

The BEGIN-TRANSACTION operation notifies the DMSII system that updates are to be performed on an audited data base. After execution of this operation, the program is in transaction state. All updates to an audited data base must be performed while the program is in transaction state. The BEGIN-TRANSACTION verb is used in COBOL and COBOL74 programs; the TRBEG verb is used in RPGII.

CLOSE (COBOL, COBOL74 only)

The close operation closes a data base. If no close operation is executed by a program, an implicit close operation is performed by the DMSII system when the program goes to end of job (EOJ). The RPGII compiler generates a CLOSE operation for RPGII programs at end of job (EOJ).

CREATE (COBOL, COBOL74 only)

The CREATE operation initializes all data items in a data set record, either to values specified in the DMS/DASDL source, or to nulls (all bits on). A STORE operation after a CREATE operation adds a new record to a data set. RPGII programs perform an implicit CREATE operation prior to any STORE operation code if the letters ADD are specified in the Output-Format Specifications for the data set.

DELETE (COBOL, COBOL74)
DELET (RPGII)

The DELETE operation discards a data set record. The record being deleted could have been located by either a FIND or a LOCK operation.

DMKEY (RPGII only)

The DMKEY option of the FIND and LOCK operation codes in RPGII programs describes the selection criteria to be used to locate a record. The equivalent function in COBOL and COBOL74 programs is performed by syntax contained in the FIND or MODIFY operations.

END-TRANSACTION (COBOL, COBOL74)
TREND (RPGII)

The END-TRANSACTION operation notifies the DMSII system that the current set of updates has completed. After execution of this operation, the program is no longer in transaction state. The data base cannot be closed by a program while in transaction state. The END-TRANSACTION verb is used in COBOL and COBOL74 programs; TREND is used in RPGII.

FIND

A FIND operation locates a record in a data set and the data within that record is transferred into the memory area of the program for processing. A FIND operation is implicitly performed in RPGII programs for all primary and secondary disjoint data sets declared as input-only, indicated by the letter I coded in column 15 of the File Description Specifications for the data set.

FREE

The FREE operation unlocks a record. The FREE operation is implicitly performed whenever another FIND operation is performed on the same data set. Also, a FREE operation is implicitly performed for all locked records except the restart data set whenever a program executes an END-TRANSACTION operation (COBOL or COBOL74) or TREND operation (RPGII), or when a DEADLOCK exception is returned.

INSERT (COBOL, COBOL74)
INSRT (RPGII)

The INSERT operation enters a data set record into a manual subset.

LOCK (COBOL74, RPG)
MODIFY (COBOL)

The LOCK (MODIFY) operation is the same as the FIND operation, but the requested record is to be locked in preparation for subsequent updating. No program can perform a LOCK (MODIFY) operation on a record that is already locked by another program; however, a FIND operation can be performed on a locked record. A record must be locked before it can be updated in the data base. A LOCK operation is implicitly performed in RPGII programs for all primary and secondary disjoint data sets for which updating is allowed, indicated by the letter U coded in column 15 of the File Description Specifications for the data set.

MODIFY (COBOL)

See LOCK.

OPEN (COBOL, COBOL74 only)

The OPEN operation must be performed prior to any attempted access of a data base. No explicit OPEN operation code exists in RPGII programs. The RPGII compiler generates an OPEN operation for the RPGII program at beginning of job (BOJ).

RECREATE (COBOL, COBOL74 only)

The RECREATE operation is similar to the CREATE operation. A subsequent STORE operation adds a record to a data set. The values of the items within the data set record are not initialized as in a CREATE operation; any value contained within an item prior to a RECREATE operation is maintained after the RECREATE operation. No form of this operation exists in RPGII programs.

REMOVE (COBOL, COBOL74)
REMOV (RPGII)

The REMOVE operation discards an entry from a manual subset.

STORE

The STORE operation adds or updates a record in the data base. The STORE operation updates an existing record by specifying the STORE operation after LOCK(MODIFY) operation. The STORE operation adds a record by specifying the CREATE operation in COBOL and COBOL74 programs, or STORE with ADD in RPGII programs. A STORE operation is implicitly performed in RPGII programs for disjoint data sets declared as output, indicated by the letter O in column 15 of the File Description Specifications for the data set.

TRBEG (RPGII only)
See BEGIN-TRANSACTION.

TREND (RPGII only)
See END-TRANSACTION.

DIFFERENCES BETWEEN COBOL AND RPGII DMS

The differences in the implementations of the COBOL-DMS and RPGII-DMS interfaces are described in the following paragraphs. Unless noted, COBOL refers to both the COBOL and COBOL74 compilers.

Data Storage

COBOL
All data items are maintained directly within the record area which the DMSII system uses as its source and destination for STORE and FIND operations. Changes made to an item within this record area are automatically reflected within the data base after a successful STORE operation.

RPGII
The user has no access to the record area used by the DMSII system. The data items referenced within the Input Specifications are filled from the record area by RPGII after a FIND or LOCK operation code. On output, only those items explicitly coded in the Output-Format Specifications are moved back into the record area; thus, an item can be modified in memory, but the data base copy of that item need not be changed.

Data Types

COBOL
All data types allowable in the DMS/DASDL syntax are valid in the COBOL language.

RPGII
The RPGII compiler does not allow unsigned numeric data items. Any numeric item described to the DMS/DASDL compiler as unsigned has a positive sign appended when the item is moved out of the DMSII record area; this sign is removed when the item is moved back into the record area immediately prior to a STORE operation. These operations are performed automatically at the time the data is moved into or out of the DMSII record area, and these operations do not add appreciable overhead to the execution of the program. However, if the value of the item becomes negative during the normal execution of the RPGII program, no error is detected at the time the sign is stripped away from the item. It is the user's responsibility to ensure that RPGII programs which process unsigned numeric data items are not allowed to change the signs of such items.

Subscripting

COBOL
A maximum of three levels of subscripts are allowed. Each subscript must be less than or equal to 1023 (this is a DMS/DASDL restriction, not a COBOL restriction).

RPGII
Only one subscript is allowed. As in the case of COBOL subscripts, the maximum value of a subscript has a DMS/DASDL-enforced limit of 1023. The method for remapping a multiply-subscripted item as an RPGII-compatible, singly-subscripted item is described in section 4 of the *B 1000 Systems DMSII Data and Structure Definition Language (DMS/DASDL) Language Manual.*

Group Items

COBOL
The subitems within a group constitute an implicit redefinition of the group item. Therefore, changes at the group level are reflected within the subitems of the group, and changes to the subitems are similarly reflected within the group item.

RPGII
The concept of a group item does not exist in RPGII programs. If a group item is referenced within an RPGII program, and the individual items within that group are also referenced, then the group item and all of its subitems are maintained separately. Each of the items is filled separately from the DMSII record area after a FIND or LOCK operation. Changes to the group item do not, therefore, affect any of the subitems, nor do changes to the subitems affect the group item. When the record containing the group is stored back into its data set, the order in which the group item and its subitems are coded in the Output-Format Specifications determines the final contents of the data set record.

COBOL
Group items can be subscripted.

RPGII
Group items which are subscripted cannot be used in an RPGII program.

COBOL
Group items can be nested; that is, a subitem within a group can also be a group.

RPGII
Nested group items cannot be used in an RPGII program.

Selection Expressions

COBOL
All key items must be included, and the only relationship which can be specified between a key item and the value supplied is simple equality. The partial-key search function is allowed only on index sequential structures (ordered sets and automatic subsets).

COBOL74
The COBOL74 compiler allows generalized selection expression. The partial-key search function is also available for COBOL74 programs.

RPGII
The generalized selection expression is allowed. The partial key search function is not allowed for RPGII programs.

Library Files

COBOL
In addition to the necessary extensions for the declarations of the structure type, structure number, remap number, and version stamp, the COBOL library files use normal COBOL syntax for the description of the various records and data items. These library files are included in the COBOL source program in a manner which is analogous to the inclusion of user-written library files by way of the COBOL COPY operation.

RPGII

The RPGII library files contain encoded information about each of the items in the disjoint data sets, including sets, subsets, embedded data sets, and data items. These library files are not added to the RPGII program source as COBOL library files are; rather, the RPGII compiler locates these files when a data set is named on a File Description Specification and uses the information contained therein when processing the Input, Calculation, and Output-Format Specifications. The listing of the COBOL-type record description, included by the RPGII compiler at the end of the compile listing, is generated by the RPGII compiler from the encoded information in the RPGII library file.

DMSII Verbs

COBOL

All DMSII operations must be explicitly performed by the user program; the COBOL compiler does not generate any hidden code for the DMSII system.

RPGII

The following operations are implicitly performed by code generated by the RPGII compiler:

Data base open and close.
All FIND/LOCK and STORE operations on cycle-driven data sets.
Any CREATE operation required for storing an added record.
TRBEG and TREND, if a noncycle-driven data set in an audited data base is being updated.

COBOL

When adding records to data sets, either the CREATE or RECREATE operation must be explicitly specified prior to the STORE operation.

RPGII

An implicit CREATE operation is generated by the RPGII compiler immediately prior to every STORE operation of an added record. No explicit CREATE operation code exists in RPGII programs, nor does any RECREATE operation, whether explicit or implicit.

COBOL

The audit operation is performed by default for the BEGIN-TRANSACTION operation; no audit operation is performed by default for the END-TRANSACTION operation. The programmer can override either of these defaults, as well as request a syncpoint with the END-TRANSACTION operation.

RPGII

The default for the TRBEG operation code is no audit, for both implicit and explicit executions of this operation. For explicit executions of the TREND operation code, the default is audit; this can be overridden by the programmer. A syncpoint can be requested with an explicit TREND operation code. For implicit executions of the END-TRANSACTION (TREND) operation, if the LR indicator is ON, then by default no audit and syncpoint are performed by the RPGII compiler-generated code. If the LR indicator is OFF, audit is set by default. Only the defaults for the explicit TREND operation codes can be overridden by the programmer; the defaults for the implicit BEGIN-TRANSACTION (TRBEG) and END-TRANSACTION (TREND) operations cannot be overridden, nor can the defaults for the explicit execution of the TRBEG operation code.

APPENDIX C
NOTATION CONVENTIONS AND SYNTAX SPECIFICATIONS

NOTATION CONVENTIONS

Left and Right Broken Brackets (< >)

Left and right broken bracket characters are used to enclose letters and digits which are supplied by the user. The letters and digits can represent a variable, a number, a file name, or a command.

Example:

<job >AX<command>

At Sign (@)

The at sign (@) character is used to enclose hexadecimal information.

Example:

@F3@ is the hexadecimal representation of the EBCDIC character 3.

The at sign (@) character is also used to enclose binary or hexadecimal information when the initial @ character is followed by a (1) or (4), respectively.

Examples:

@(1)11110011@ is the binary representation of the EBCDIC character 3.

@(4)F3@ is the hexadecimal representation of the EBCDIC character 3.

<identifier>

An identifier is a string of characters used to represent some entity, such as an item name composed of letters, digits, and hyphens. An identifier can vary in length from 1 to 17 characters. The characters must be adjacent, the first character of an identifier must be a letter, and the last character cannot be a hyphen.

<integer>

An integer is specified by a string of adjacent numeric digits representing the decimal value of the integer.

<hexadecimal-number>

A hexadecimal number is specified by a string of numeric digits and/or the characters A through F; this string is enclosed within the at sign (@) characters.

<delimiter>

A delimiter can be any non-alphanumeric character. The hyphen is excluded.

<literal>

A literal is a data item whose value is identical to the characters contained within the item. A literal can be either an alphanumeric (or simply alpha) literal, or a numeric literal. Alpha literals can contain any combination of valid printable characters, or spaces, and must be enclosed by quotation (") characters; a quotation character within an alpha literal is represented by two successive quotation characters within the character string.

Example:

ABC""DEF

The preceding alpha literal could be used to represent the character string ABC"DEF.

Numeric literals can contain only the decimal digits 0 through 9 and are not enclosed within any delimiters.

Percent Sign (DMS/DASDL Only)

The percent sign (%) character designates DMS/DASDL documentation or comments, and its presence terminates the scan of a source record. The example below illustrates the use of a percent sign for in-line coding.

Example:

```
00000100    :%THIS DMS/DASDL PROGRAM GIVES EXAMPLES
00000150    :%OF THE VARIOUS CONSTRUCTS USED IN
00000200    :%DASDL TO DESCRIBE A DATA BASE.
00000300    :PARAMETERS(
00000400    :       SYNCPOINT = 10  );
```

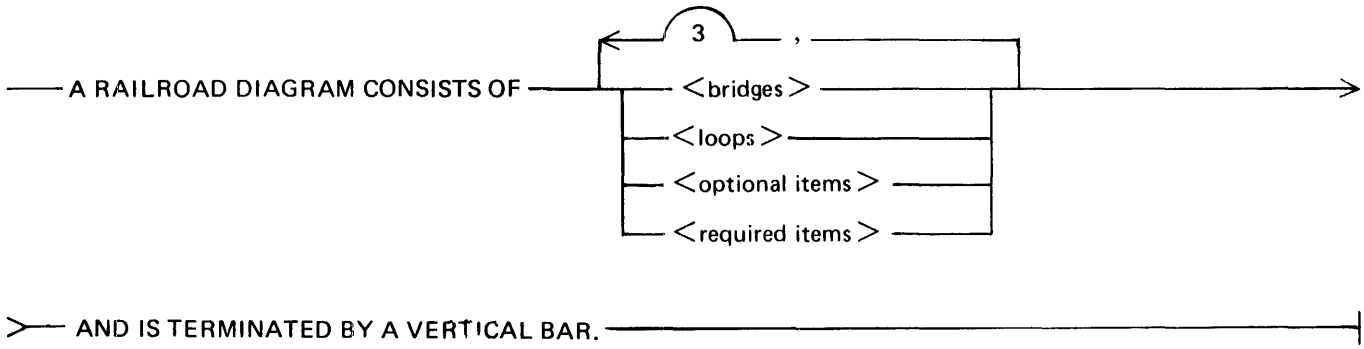
SYNTAX CONVENTIONS

Railroad diagrams show how syntactically valid statements can be constructed.

Traversing a railroad diagram from left to right, or in the direction of the arrowheads, and adhering to the limits illustrated by bridges produces a syntactically valid statement. Continuation from one line of a diagram to another is represented by a right arrow (→) appearing at the end of the current line and the beginning of the next line. The complete syntax diagram is terminated by a vertical bar (|).

Items contained in broken brackets (< >) are syntactic variables which are further defined or require the user to supply the requested information.

Upper-case items must appear literally. Minimum abbreviations of upper-case items are underlined.



G50051

The following syntactically valid statements can be constructed from the preceding diagram:

A RAILROAD DIAGRAM CONSISTS OF <bridges> AND IS TERMINATED BY A VERTICAL BAR.

A RAILROAD DIAGRAM CONSISTS OF <optional items> AND IS TERMINATED BY A VERTICAL BAR.

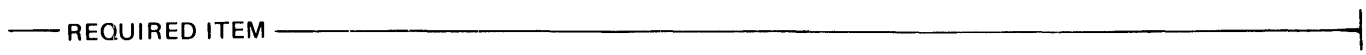
A RAILROAD DIAGRAM CONSISTS OF <bridges>, <loops> AND IS TERMINATED BY A VERTICAL BAR.

A RAILROAD DIAGRAM CONSISTS OF <optional items>, <required items>, <bridges>, <loops> AND IS TERMINATED BY A VERTICAL BAR.

Required Items

No alternate path through the railroad diagram exists for required items or required punctuation.

Example:

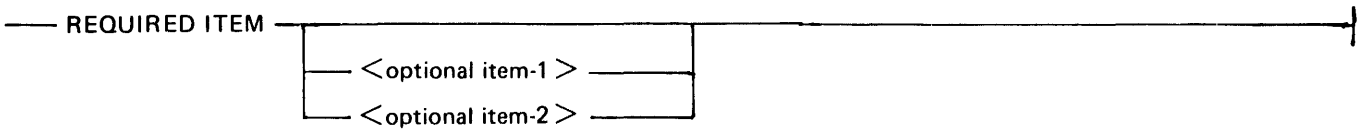


G50052

Optional Items

Items shown as a vertical list indicate that the user must make a choice of the items specified. An empty path through the list allows the optional item to be absent.

Example:



G50053

The following valid statements can be constructed from the preceding diagram:

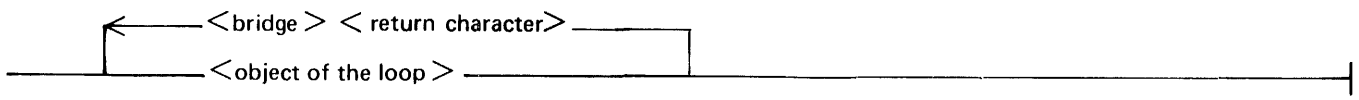
REQUIRED ITEM

REQUIRED ITEM <optional item-1>

REQUIRED ITEM <optional item-2>

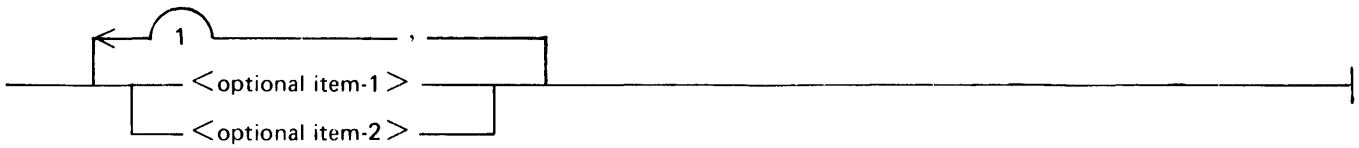
Loops

A loop is a recurrent path through a railroad diagram and has the following general format:



G50054

Example:



G50055

The following statements can be constructed from the railroad diagram in the example:

<optional item-1>

<optional item-2>

<optional item-1>,<optional item-1>

<optional item-1>,<optional item-2>

<optional item-2>,<optional item-1>

<optional item-2>,<optional item-2>

A <loop> must be traversed in the direction of the arrowheads, and the limits specified by bridges cannot be exceeded.

Bridges

A bridge indicates the minimum or maximum number of times a path can be traversed in a railroad diagram.

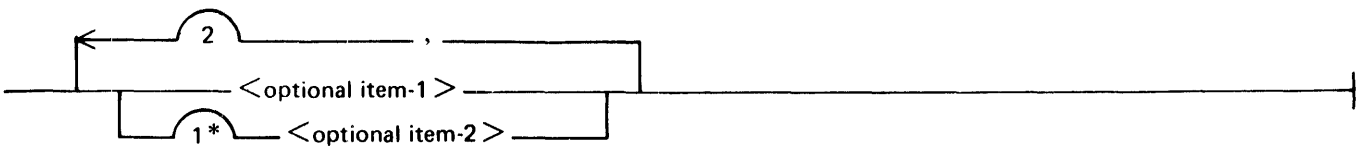
There are two forms of <bridges>.

n is an integer which specifies the maximum number of times the path can be traversed.

n* is an integer which specifies the minimum number of times the path must be traversed.

G50056

Example:



G50057

The loop can be traversed a maximum of two times; however, the path for <optional item-2> must be traversed at least once.

The following statements can be constructed from the railroad diagram in the example:

<optional item-2>

<optional item-1>,<optional item-2>

<optional item-2>,<optional item-2>,<optional item-1>

<optional item-2>,<optional item-2>,<optional item-2>

INDEX

INDEX (Cont)

INDEX (Cont)

INDEX (Cont)

Documentation Evaluation Form

Title: B 1000 Systems Data Management System II (DMSII) Host Language Interface Language Manual

Form No: 1152451

Date: November 1984

Burroughs Corporation is interested in receiving your comments and suggestions regarding this manual. Comments will be utilized in ensuing revisions to improve this manual.

Please check type of Suggestion:

☐ Addition ☐ Deletion ☐ Revision ☐ Error

Comments:

From:

Name _____

Title _____

Company _____

Address _____

_____

Phone Number _____ Date _____

Remove form and mail to:

Burroughs Corporation
Corporate Documentation – West
1300 John Reed Court
City of Industry, CA 91745
U.S.A.