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LOGICAL OPTIMIZATION FOR DATABASE UNIFORMIZATION

Technical Report

Principal Investigator: Dr. John Grant
Department of Computer and
Information Sciences
Towson State University
Towson, MD 21204

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1. Introduction

Database uniformization refers to the building of a common user interface facility to support uniform access to any or all of a collection of distributed heterogeneous databases. Such a system should enable a user, situated anywhere along a set of distributed databases, to access all of the information in the databases without having to learn the various data manipulation languages. Furthermore, such a system should leave intact the component databases, and in particular, their already existing software. A survey of various aspects of the database uniformization problem and a proposed solution can be found in [2].

The proposed solution involves a global data manager. The components are illustrated in Figure 1.1 (the older version is given in Figure 1.2). The global data manager includes a global model which provides a uniform front-end for all users to interact with the databases. The global model is based on database logic and includes the global data manipulation language for user interaction with the global data manager. The global dictionary contains all of the individual databases in the network as well as previously created external views. The user consults the global dictionary to extract the databases of interest.

In our previous report ([1]) we described a portion of the external-to-conceptual translation component of the global data manager. That component translates the user's queries on his/her global view to queries on the underlying view. In general, the translated queries tend to be in a highly complex form. In the old version of the global data manager, logical optimization was one component. In the new version the external-to-conceptual translation component includes logical optimization whose purpose is to simplify logical formulas. We continue to use the sample NASA GSFC databases with typical GSFC applications from the previous report.

In the database literature logical optimization is usually discussed in terms of minimization of tableaux ([4]). A tableau is a tabular representation of a query for a relational database schema. A query is logically optimized by obtaining an equivalent tableau with the minimum possible number of rows. The process involves the deletion of some subformulas in the original query without modifying the answer for any database (which is a model of the appropriate view). This optimization process is also called folding. In our case we need to generalize folding to heterogeneous (i.e. relational, hierarchic, and network) databases via database logic. The logical optimization process also needs to apply the constraints of the view, i.e. the nonlogical axioms. This generalizes the minimization process for chased tableaux.

The outline of this report is as follows. In Section 2 we review the database logic views for the NASA databases ERB-ORAC, ERB-SEED and FCDB, as well as for various external views constructed in [1]. We note that the original definitions for these databases as well as some of the queries we use are taken from [3]. In Section 3 we describe two logical optimization algorithms for interpreted queries over a single conceptual view. The first one can be used for existential conjunctive queries, while the second one allows local disjunctions also. We then apply logical optimization to the interpretation of four queries. In Section 4 we describe the generalization of the logical optimization algorithm for interpreted queries over a distributed conceptual view. We also apply the generalized logical optimization algorithm to an example. We summarize the report in Section 5.

2. Database Views and Interpretations

In this section we review views and interpretations which we constructed and used in [1]. A database view is comprised of a schema which describes the structure of the database, a language which is used for making assertions about the database, and a set of constraints that every instance of the database must obey. In database logic an external view is constructed by formulating an interpretation of the external view into the conceptual view. An interpretation consists of a coding section which indicates the transformation of types, a defining formula section which indicates the transformation of predicates and functions, and a constant transformation section.

Appendix 2.1 contains V(ERB-ORAC), the Earth Radiation Budget database maintained under ORACLE; while Figure 2.1 contains an instance of this database. Appendix 2.2 contains V(ERB-SEED), the Earth Radiation Budget database maintained under SEED; while Figure 2.2 contains an instance. The database view V(PCDB) for the Pilot Climate Data Base which is maintained under ORACLE is given in Appendix 2.3; an instance is given in Figure 2.3.

In [1] we constructed 2 views over a single conceptual view: V(ERB-R), a relational view, over V(ERB-SEED); and V(ERB-N), a network view, over V(ERB-ORAC). We give V(ERB-R) in Appendix 2.4 and V(ERB-N) in Appendix 2.5. The construction of V(ERB-R) as an external view over V(ERB-SEED) is the I(ERB-R;ERB-SEED) of Appendix 2.6. The induced ERB-R database instance for the ERB-SEED instance of Figure 2.2 is given in Figure 2.4. Similarly, we give the construction of V(ERB-N) over V(ERB-ORAC) as I(ERB-N;ERB-ORAC) in Appendix 2.7, and the corresponding induced ERB-N instance for the ERB-ORAC instance of Figure 2.1 in Figure 2.5.

In [1] we also constructed views over distributed databases. The V(GLOBE), given in Appendix 2.8, is the union of V(ERB-ORAC), V(ERB-SEED), and V(PCDB). It is not a true union, however, but is oriented towards ERB-ORAC rather than ERB-SEED. Figure 2.6 contains an instance of GLOBE based on the instances of ERB-ORAC, ERB-SEED, and PCDB from Figures 2.1-2.3. Additionally, we constructed a view, V(GLOBE-R), given in

Appendix 2.9, for a user wishing to see the distributed database as a single relational view. V(GLOBE-R) is given as an external view over V(GLOBE) by the interpretation I(GLOBE-R;GLOBE) of Appendix 2.10. We present the GLOBE-R database instance induced from the GLOBE database instance of Figure 2.6 in Figure 2.7.

3. Logical Optimization of Queries over a Single Conceptual View

Recall that a user writes a query on his/her external view. Such a query is transformed to a query on the conceptual view by the interpretation. Often, such an interpreted query is in a highly complex form whose straightforward evaluation would be very costly. The process of logical optimization is used to generate a query which yields the identical answer as the interpreted query but which is simpler in form and hence less costly to execute.

We first deal with existential conjunctive queries in database logic since they are in the appropriate form for many (interpreted) queries. We can write such a query as

Q(<R;>) = (E)<R'>(P1(<R;>,<c>,<R'>) & ... & Pn(<R;>,<c>,<R'>))

where <R;> are the free (target) variables, <c> are the constants, and <R'> are the existentially quantified variables of the query. Each conjunct Pi is a cluster. We assume that function symbols may appear only in equalities. An interpreted query is initially often not in this form but can be placed into this form by moving the quantifiers to the front.

We logically optimize an existential conjunctive query by getting rid of superfluous conjuncts. The algorithm is given in Appendix 3.1. It consists of three parts. In the first part we delete conjuncts which are superfluous equalities. In the second part we identify objects forced to be equal by functional dependency constraints. In the third part we delete subsumed clusters. Q(i)(<R;>) is the optimized query at the end.

We demonstrate the logical optimization algorithm on some examples. We take two queries on V(ERB-R), interpret them in V(ERB-SEED), and optimize the interpreted queries. The first query is given in [1]; it was originally given in [3] as a sample query on the ERB database maintained by Oracle. We present each query in English first and then in DBL on V(ERB-R). Then we give the interpreted DBL queries on V(ERB-SEED) and show the steps in the optimization. We also present the answers to the queries.

The first query is given in Appendix 3.2. The interpreted query is first placed in prenex conjunctive normal form. In the first three steps the three superfluous equalities are eliminated. In the next three steps the functional dependency

RTAPE:NOTAPE->TAPETYPE,PLAYBACK,RTITLE

is used to identify three pairs of existentially quantified variables. The optimized query is then obtained by deleting a subsumed conjunct. The answer to query 1 on the database of Figure 2.4 is given in Figure 3.1. This is identical to the answer to the interpreted (and optimized) query on the database of Figure 2.2.

The second query is given in Appendix 3.3. The interpreted query is again first placed in prenex conjunctive normal form. In this case the optimization is achieved in one step by renaming existentially quantified variables and deleting a subsumed conjunct. The answer to query 2 on the database of Figure 2.4 is given in Figure 3.2; it is identical to the answer to the interpreted (and optimized) query on the database of Figure 2.2.

Next we consider two queries (the third and fourth) on V(ERB-N), interpret them in V(ERB-ORAC) and optimize the queries. However, in these cases, the interpreted queries are not purely conjunctive as one conjunct contains disjunctions. We write such queries as above but allow a Pi to be a disjunction of clusters. We also modify our algorithm to try to delete some of the disjuncts. This modified algorithm, for an existential query with local disjunctions, is given in Appendix 3.4. We then apply the new algorithm to these two queries.

The third query is given in Appendix 3.5. It is taken from [1]; it was originally given in [3] as a sample query on the ERB database maintained by SEED. The optimization consists of two steps: in each step a disjunct is deleted from the third conjunct. The fourth query is given in Appendix 3.6. The first two steps in the optimization are the same as for the third query. But then an extra step is used to rename some existentially quantified variables and delete the subsumed conjunct. The answers to these two queries on the database of

Figure 2.5 are given in Figures 3.3 and 3.4 respectively. They are identical to the corresponding answers to the interpreted (and optimized) queries on the database of Figure 2.1.

4. Logical Optimization of Queries over a Distributed Conceptual View

In the previous section we gave two algorithms to logically optimize queries. The first algorithm can be applied to purely conjunctive queries; while the second algorithm can be applied to queries with local disjunctions, typically disjunctions in a single conjunct. However, when we deal with queries over a distributed conceptual view, there may be disjunctions in many conjuncts. Recall, for example, I(GLOBE-R;GLOBE), given in Appendix 2.10, where GLOBE is a distributed database. Note that the interpretations for several predicates contain disjunctions in addition to conjunctions. In contrast, I(ERB-R;ERB-SEED), given in Appendix 2.6, contains only conjunctions; while I(ERB-N;ERB-ORAC), given in Appendix 2.7, contains local disjunctions in one conjunct only. Therefore, in dealing with distributed views, we must optimize existential disjunctive queries.

The logical optimization of such an interpreted query consists of several phases. We first place the query in prenex conjunctive normal form. This allows the deletion of superfluous equalities and subsumed local disjuncts as in the logical optimization of a query with local disjunctions. Then we place the query in prenex disjunctive form. We logically optimize each disjunct separately as in the logical optimization of a conjunctive query. Finally we delete subsumed disjuncts. Note that while a subsumed conjunct is a subcluster of another cluster, a subsumed disjunct contains enough clusters to subsume all the clusters of another disjunct. Also, in the case of conjuncts, existentially quantified variables are identified with other objects to obtain subsumptions; while in the case of disjuncts, various objects are identified with existential quantifiers to obtain subsumptions. The algorithm is given in Appendix 4.1.

We end this section by demonstrating the logical optimization algorithm on an example query taken from [1]. We modify the example slightly to remove a function symbol from inside a predicate in order to apply the logical optimization algorithm. The query, which we call query 5, is logically equivalent to the original query. The complete example is given in Appendix 4.2. We present the query in English first and then in DBL for V(GLOBE-R). We also give the interpreted query for V(GLOBE). We place this query in prenex conjunctive normal form. In this case there are no equations or local subsumed disjuncts. Then we place the query in prenex disjunctive normal form. As we go through the conjuncts separately we find that the RECINFO predicate appears twice in the first and fifth conjunct.

The extra appearances are deleted. Finally we find that four of the eight disjuncts are subsumed. We obtain the logically optimized query by deleting the subsumed disjuncts. We present the answer to query 5 on the database of Figure 2.7 in Figure 4.1. This is identical to the answer to the interpreted (and optimized) query on the database of Figure 2.6.

5. Summary

In this report we demonstrated the logical optimization portion of the external-to-conceptual translator component of the data manager for database uniformization. A user of the proposed system will write queries on his/her external view. The external-to-conceptual translator will translate such a query to the conceptual view. After some additional steps the new query will be processed and the answer returned to the user. We gave three logical optimization algorithms: one for existential conjunctive queries, another one for queries with local disjunctions, and a general algorithm for disjunctive queries. The first two algorithms can be used to logically optimize queries over a single conceptual view, while the last one can be used for a distributed conceptual view. To illustrate heterogeneity and to demonstrate NASA applications we used the relational databases ERB-ORAC and PCDB and the network database ERB-SEED for our five examples.

References

1. Grant, J., "External-to-Conceptual Mapping Construction for Database Uniformization", Towson State University, Technical Report, 1983.

2. Jacobs, B. E., "Applications of Database Logic to the Database Uniformization Problem", University of Maryland, Department of Computer Science, Technical Report, 1981.

3. Sylto, Regina, "ERB-6 Data Inventory", NASA Technical Memorandum 82176, 1981.

4. Ullman, J. D., _Principles of Database Systems_, Second Edition, Computer Science Press, Rockville, Maryland, 1982.

Appendix 2.1 V(ERB-ORAC)

```
V(ERB-ORAC): VIEW DEFINITION
  S(ERB-ORAC): SCHEMA DEFINITION
    TABLE  TAPEINFO = (NOTAPE,TAPETYPE,TITLE1,TITLE2,TITLE3)
    TABLE  FILEINFO = (PB,FILE,NOTAPE)
    TABLE  RECINFO = (DATE_TIME,DATE,TIME,LON,LAT,ALT,ZEN,PB,
                     QUALITY,ELECTR,ILLUMIN,CALIB,SCAN)

  L(ERB-ORAC): LANGUAGE DEFINITION
    T(ERB-ORAC): TYPING DEFINITION
      TYPE  NUMBER = (NOTAPE,PB,FILE,DATE_TIME,DATE,TIME,LON,
                     LAT,ALT,ZEN,QUALITY) ASCII NUM(22)
      TYPE  CHAR4 = (TAPETYPE) ASCII CHAR(4)
      TYPE  CHAR115 = (TITLE1,TITLE2,TITLE3) ASCII CHAR(115)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) ASCII CHAR(3)
      TYPE  CHAR8 = (ILLUMIN) ASCII CHAR(8)
    NONLOGICAL SYMBOLS DEFINITION
      PREDICATES
        TAPEINFO:(NUMBER,CHAR4,CHAR115,CHAR115,CHAR115)-PREDICATE
        FILEINFO:(NUMBER,NUMBER,NUMBER)-PREDICATE
        RECINFO:(NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,
                NUMBER,NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)
                -PREDICATE
      FUNCTIONS
        CONC:(NUMBER,NUMBER;NUMBER)-PREDEFINED FUNCTION

  C(ERB-ORAC): CONSTRAINTS DEFINITION
    C(ERB-ORAC,1): CONSTRAINT  TAPEINFO:NOTAPE->TAPETYPE,TITLE1,
                   TITLE2,TITLE3
    C(ERB-ORAC,2): CONSTRAINT  FILEINFO:PB,NOTAPE->FILE
    C(ERB-ORAC,3): CONSTRAINT  RECINFO:DATE_TIME->DATE,TIME,LON,
                   LAT,ALT,ZEN,PB,QUALITY,ELECTR,ILLUMIN,CALIB,
                   SCAN
    C(ERB-ORAC,4): CONSTRAINT  RECINFO:DATE_TIME=CONC(DATE,TIME)
```

Appendix 2.2 V(ERB-SEED)

```
V(ERB-SEED): VIEW DEFINITION
  S(ERB-SEED): SCHEMA DEFINITION
    TABLE  RTAPE = (NOTAPE,TAPETYPE,PLAYBACK,RTITLE)
    TABLE  PLAYBACK = (PB,NOFILE,CATALOG)
    TABLE  RTITLE = (TITLE)
    TABLE  CATALOG = (LON,LAT,ALT,ZEN,TIME1,QUALITY,ELECTR,
                      ILLUMIN,CALIB,SCAN)
    TABLE  RDATES = (DATE1,CATALOG)
    TABLE  RLON = (ILON,CATALOG)
    TABLE  RLAT = (ILAT,CATALOG)
    TABLE  RALT = (IALT,CATALOG)
    TABLE  RZEN = (IZEN,CATALOG)

  L(ERB-SEED): LANGUAGE DEFINITION
    T(ERB-SEED): TYPING DEFINITION
      TYPE  INT4 = (NOTAPE,NOFILE,DATE1,TIME1) EBCDIC INTEGER(4)
      TYPE  CHAR4 = (TAPETYPE) EBCDIC CHAR(4)
      TYPE  CHAR115 = (TITLE) EBCDIC CHAR(115)
      TYPE  REAL4 = (PB,LON,LAT,ALT,ZEN) EBCDIC REAL(4)
      TYPE  INT2 = (ILON,ILAT,IALT,IZEN,QUALITY)
                   EBCDIC INTEGER(2)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) EBCDIC CHAR(3)
      TYPE  CHAR8 = (ILLUMIN) EBCDIC CHAR(8)
    NONLOGICAL SYMBOLS DEFINITION
      PREDICATES
        RDATES-CATALOG:(INT4,CATALOG,REAL4,REAL4,REAL4,
               REAL4,INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL
               CLUSTER PREDICATE
        RLON-CATALOG:(INT2,CATALOG,REAL4,REAL4,REAL4,REAL4,
             INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
             PREDICATE
        RLAT-CATALOG:(INT2,CATALOG,REAL4,REAL4,REAL4,REAL4,
             INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
             PREDICATE
        RALT-CATALOG:(INT2,CATALOG,REAL4,REAL4,REAL4,REAL4,
             INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
             PREDICATE
        RZEN-CATALOG:(INT2,CATALOG,REAL4,REAL4,REAL4,REAL4,
             INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
             PREDICATE
        RTAPE-PLAYBACK-CATALOG-RTITLE:(INT4,CHAR4,PLAYBACK,
              REAL4,INT4,CATALOG,REAL4,REAL4,REAL4,REAL4,INT4,
              INT2,CHAR3,CHAR8,CHAR3,CHAR3,RTITLE,CHAR115)-FULL
              CLUSTER PREDICATE
      FUNCTIONS
        TITLE1:(INT4;CHAR115)-FUNCTION
        TITLE2:(INT4;CHAR115)-FUNCTION
        TITLE3:(INT4;CHAR115)-FUNCTION
        INT:(REAL4;INT2)-PREDEFINED FUNCTION
```

```
C(ERB-SEED):CONSTRAINTS DEFINITION
  C(ERB-SEED,1):  CONSTRAINT  RTAPE:NOTAPE->TAPETYPE,PLAYBACK,
                  RTITLE
  C(ERB-SEED,2):  CONSTRAINT  RTAPE-PLAYBACK:NOTAPE,PB->NOFILE,
                  CATALOG
  C(ERB-SEED,3):  CONSTRAINT  RDATES:DATE1->CATALOG
  C(ERB-SEED,4):  CONSTRAINT  RLON:ILON->CATALOG
  C(ERB-SEED,5):  CONSTRAINT  RLAT:ILAT->CATALOG
  C(ERB-SEED,6):  CONSTRAINT  RALT:IALT->CATALOG
  C(ERB-SEED,7):  CONSTRAINT  RZEN:IZEN->CATALOG
  C(ERB-SEED,8):  CONSTRAINT  RLON-CATALOG:ILON=INT(LON)
  C(ERB-SEED,9):  CONSTRAINT  RLAT-CATALOG:ILAT=INT(LAT)
  C(ERB-SEED,10):CONSTRAINT   RALT-CATALOG:IALT=INT(ALT)
  C(ERB-SEED,11):CONSTRAINT   RZEN-CATALOG:IZEN=INT(ZEN)
```

Appendix 2.3 V(PCDB)

```
V(PCDB): VIEW DEFINITION
  S(PCDB): SCHEMA DEFINITION
    TABLE  TAPE = (TAPEID,MISSION,SENSOR,FORMAT,PROJNUM,GENDATE,
                  INVDATE,ARCHIVER,NUMFILES,TPFIRSTORB,
                  TPLASTORB,TPSTART,TPSTOP,TPALGORITHM,COORDSYS,
                  SYNOPSTART,SYNOPSTOP)
    TABLE  FILE = (TAPEID,FILENUM,FLFIRSTORB,FLLASTORB,FLSTART,
                  FLSTOP,FLALGORITHM,NUMITEMS,FLLEN)
    TABLE  ITEM = (TAPEID,FILENUM,ITEM,ITSTART,ITSTOP,RECNUM,
                  ITALGORITHM,ITLEN)
    TABLE  CAT = (TAPEID,FILENUM,ITEM,CAT,FUNCTION,CATEGORY)
    TABLE  DESCR = (ITEM,NAME)

  L(PCDB): LANGUAGE DEFINITION
    T(PCDB): TYPING DEFINITION
      TYPE  NUMBER = (NUMFILES,TPFIRSTORB,TPLASTORB,FILENUM,
                     FLFIRSTORB,FLLASTORB,NUMITEMS,FLLEN,RECNUM,
                     ITLEN) ASCII NUM(22)
      TYPE  CHAR15 = (TAPEID,MISSION,PROJNUM,COORDSYS) ASCII
                     CHAR(15)
      TYPE  CHAR10 = (SENSOR,FORMAT) ASCII CHAR(10)
      TYPE  CHAR12 = (GENDATE,ARCHIVER,TPSTART,TPSTOP,
                     SYNOPSTART,SYNOPSTOP,FLSTART,FLSTOP,
                     ITSTART,ITSTOP) ASCII CHAR(12)
      TYPE  CHAR8 = (INVDATE) ASCII CHAR(8)
      TYPE  CHAR5 = (TPALGORITHM,FLALGORITHM,ITEM,ITALGORITHM,
                    CAT) ASCII CHAR(5)
      TYPE  CHAR50 = (FUNCTION) ASCII CHAR(50)
      TYPE  CHAR30 = (CATEGORY,NAME) ASCII CHAR(30)
    NONLOGICAL SYMBOLS DEFINITION
      PREDICATES
        TAPE:(CHAR15,CHAR15,CHAR10,CHAR10,CHAR15,CHAR12,CHAR8,
             CHAR12,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
             CHAR15,CHAR12,CHAR12)-PREDICATE
        FILE:(CHAR15,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
             NUMBER,NUMBER)-PREDICATE
        ITEM:(CHAR15,NUMBER,CHAR5,CHAR12,CHAR12,NUMBER,CHAR5,
             NUMBER)-PREDICATE
        CAT:(CHAR15,NUMBER,CHAR5,CHAR5,CHAR50,CHAR30)-PREDICATE
        DESCR:(CHAR5,CHAR30)-PREDICATE
      FUNCTIONS
        NONE
```

```
C(PCDB): CONSTRAINTS DEFINITION
  C(PCDB,1): CONSTRAINT  TAPE:TAPEID->MISSION,SENSOR,FORMAT,
             PROJNUM,GENDATE,INVDATE,ARCHIVER,NUMFILES,
             TPFIRSTORB,TPLASTORB,TPSTART,TPSTOP,TPALGORITHM,
             COORDSYS,SYNOPSTART,SYNOPSTOP
  C(PCDB,2): CONSTRAINT  FILE:TAPEID,FILENUM->FLFIRSTORB,
             FLLASTORB,FLSTART,FLSTOP,FLALGORITHM,NUMITEMS,
             FLLEN
  C(PCDB,3): CONSTRAINT  ITEM:TAPEID,FILENUM,ITEM,RECNUM->
             ITSTART,ITSTOP,ITALGORITHM,ITLEN
  C(PCDB,4): CONSTRAINT  CAT:TAPEID,FILENUM,ITEM->CAT,
             FUNCTION,CATEGORY
  C(PCDB,5): CONSTRAINT  DESCR:ITEM->NAME
```

Appendix 2.4 V(ERB-R)

```
V(ERB-R): VIEW DEFINITION
  S(ERB-R): SCHEMA DEFINITION
    TABLE  TAPEINFO = (NOTAPE,TAPETYPE,TITLE1,TITLE2,TITLE3)
    TABLE  FILEINFO = (PB,FILE,NOTAPE)
    TABLE  RECINFO = (DATE,TIME,LON,LAT,ALT,ZEN,PB,QUALITY,
                     ELECTR,ILLUMIN,CALIB,SCAN)

  L(ERB-R): LANGUAGE DEFINITION
    T(ERB-R): TYPING DEFINITION
      TYPE  INT4 = (NOTAPE,FILE,DATE,TIME) ASCII INTEGER(4)
      TYPE  INT2 = (QUALITY) ASCII INTEGER(2)
      TYPE  REAL4 = (PB,LON,LAT,ALT,ZEN) ASCII REAL(4)
      TYPE  CHAR4 = (TAPETYPE) ASCII CHAR(4)
      TYPE  CHAR115 = (TITLE1,TITLE2,TITLE3) ASCII CHAR(115)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) ASCII CHAR(3)
      TYPE  CHAR8 = (ILLUMIN) ASCII CHAR(8)
    NONLOGICAL SYMBOLS DEFINITION
      PREDICATES
        TAPEINFO:(INT4,CHAR4,CHAR115,CHAR115,CHAR115)-PREDICATE
        FILEINFO:(REAL4,INT4,INT4)-PREDICATE
        RECINFO:(INT4,INT4,REAL4,REAL4,REAL4,REAL4,REAL4,INT2,
                CHAR3,CHAR8,CHAR3,CHAR3)-PREDICATE
      FUNCTIONS
        NONE

  C(ERB-R): CONSTRAINTS DEFINITION
    C(ERB-R,1): CONSTRAINT  TAPEINFO:NOTAPE->TAPETYPE,TITLE1,
                TITLE2,TITLE3
    C(ERB-R,2): CONSTRAINT  FILEINFO:PB,NOTAPE->FILE
```

Appendix 2.5 V(ERB-N)

```
V(ERB-N): VIEW DEFINITION
  S(ERB-N): SCHEMA DEFINITION
    TABLE  RTAPE = (NOTAPE,TAPETYPE,PLAYBACK,RTITLE)
    TABLE  PLAYBACK = (PB,NOFILE,CATALOG)
    TABLE  RTITLE = (TITLE)
    TABLE  CATALOG = (LON,LAT,ALT,ZEN,TIME1,QUALITY,ELECTR,
                      ILLUMIN,CALIB,SCAN)
    TABLE  RDATES = (DATE1,CATALOG)

  L(ERB-N): LANGUAGE DEFINITION
    T(ERB-N): TYPING DEFINITION
      TYPE  INT4 = (NOTAPE,NOFILE,DATE1,TIME1) EBCDIC INTEGER(4)
      TYPE  CHAR4 = (TAPETYPE) EBCDIC CHAR(4)
      TYPE  CHAR115 = (TITLE) EBCDIC CHAR(115)
      TYPE  REAL4 = (PB,LON,LAT,ALT,ZEN) EBCDIC REAL(4)
      TYPE  INT2 = (QUALITY) EBCDIC INTEGER(2)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) EBCDIC CHAR(3)
      TYPE  CHAR8 = (ILLUMIN) EBCDIC CHAR(8)
    NONLOGICAL SYMBOLS DEFINITION
      PREDICATES
        RDATES-CATALOG:(INT4,CATALOG,REAL4,REAL4,REAL4,
               REAL4,INT4,INT2,CHAR3,CHAR8,CHAR3,CHAR3)-FULL
               CLUSTER PREDICATE
        RTAPE-PLAYBACK-CATALOG-RTITLE:(INT4,CHAR4,PLAYBACK,
              REAL4,INT4,CATALOG,REAL4,REAL4,REAL4,REAL4,INT4,
              INT2,CHAR3,CHAR8,CHAR3,CHAR3,RTITLE,CHAR115)-FULL
              CLUSTER PREDICATE
      FUNCTIONS
        TITLE1:(INT4;CHAR115)-FUNCTION
        TITLE2:(INT4;CHAR115)-FUNCTION
        TITLE3:(INT4;CHAR115)-FUNCTION

  C(ERB-N):CONSTRAINTS DEFINITION
    C(ERB-N,1): CONSTRAINT  RTAPE:NOTAPE->TAPETYPE,PLAYBACK,
                RTITLE
    C(ERB-N,2): CONSTRAINT  RTAPE-PLAYBACK:NOTAPE,PB->NOFILE,
                CATALOG
    C(ERB-N,3): CONSTRAINT  RDATES:DATE1->CATALOG
```

Appendix 2.6 I(ERB-R;ERB-SEED)

```
I(ERB-R;ERB-SEED): INTERPRETATION DEFINITION
  EXTERNAL VIEW IS V(ERB-R) = <S(ERB-R),L(ERB-R),C(ERB-R)>
  CONCEPTUAL VIEW IS V(ERB-SEED) = <S(ERB-SEED),L(ERB-SEED),
                                    C(ERB-SEED)>
  CODING SECTION
    CODE FOR INT4 IS INT4;
    CODE FOR INT2 IS INT2;
    CODE FOR REAL4 IS REAL4;
    CODE FOR CHAR4 IS CHAR4;
    CODE FOR CHAR115 IS CHAR115;
    CODE FOR CHAR3 IS CHAR3;
    CODE FOR CHAR8 IS CHAR8;

  DEFINING FORMULA SECTION
    PREDICATE: TAPEINFO
    ARGUMENTS ARE: (NOTAPE:1,TAPETYPE:1,TITLE:1,TITLE:2,TITLE:3)
    IS DEFINED BY
      (E)RTITLE:1(E)PLAYBACK:1
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & TITLE:1 = TITLE1(NOTAPE:1)
      & TITLE:2 = TITLE2(NOTAPE:1)
      & TITLE:3 = TITLE3(NOTAPE:1) )
    PREDICATE: FILEINFO
    ARGUMENTS ARE: (PB:1,NOFILE:1,NOTAPE:1)
    IS DEFINED BY
      (E)TAPETYPE:1(E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:1
      RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
            NOFILE:1,CATALOG:1,RTITLE:1)
    PREDICATE: RECINFO
    ARGUMENTS ARE: (DATE1:1,TIME1:1,LON:1,LAT:1,ALT:1,ZEN:1,PB:1,
                    QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    IS DEFINED BY
      (E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1(E)NOFILE:1
      (E)CATALOG:1(E)RTITLE:1(E)CATALOG:2
      ( RTAPE-PLAYBACK-CATALOG(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,
               PB:1,NOFILE:1,CATALOG:1,LON:1,LAT:1,ALT:1,ZEN:1,
               TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
               SCAN:1,RTITLE:1)
      & RDATES-CATALOG(DATE1:1,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
                TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
                SCAN:1) )

  CONSTANT TRANSFORMATION SECTION
    .
    .
    .
    /*CODE converts from ASCII to EBCDIC;
    DECODE converts from EBCDIC to ASCII.*/
```

Appendix 2.7 I(ERB-N;ERB-ORAC)

```
I(ERB-N;ERB-ORAC): INTERPRETATION DEFINITION
  EXTERNAL VIEW IS V(ERB-N) = <S(ERB-N),L(ERB-N),C(ERB-N)>
  CONCEPTUAL VIEW IS V(ERB-ORAC) = <S(ERB-ORAC),L(ERB-ORAC),
                                    C(ERB-ORAC)>
  CODING SECTION
    CODE FOR INT4 IS NUMBER;
    CODE FOR INT2 IS NUMBER;
    CODE FOR REAL4 IS NUMBER;
    CODE FOR CHAR4 IS CHAR4;
    CODE FOR CHAR115 IS CHAR115,CHAR115,CHAR115;
    CODE FOR CHAR3 IS CHAR3;
    CODE FOR CHAR8 IS CHAR8;
    CODE FOR PLAYBACK IS NUMBER;
    CODE FOR RTITLE IS NUMBER;
    CODE FOR CATALOG IS NUMBER,NUMBER;

  DEFINING FORMULA SECTION
    PREDICATE: RDATES-CATALOG
    ARGUMENTS ARE: (DATE:1,DATE:1,LON:1,LAT:1,ALT:1,ZEN:1,TIME:1,
                    QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    IS DEFINED BY
      (E)DATE_TIME:1(E)PB:1
      RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    PREDICATE: RTAPE-PLAYBACK-CATALOG-RTITLE
    ARGUMENTS ARE: (NOTAPE:1,TAPETYPE:1,NOTAPE:1,PB:1,FILE:1,
                    NOTAPE:1,PB:1,LON:1,LAT:1,ALT:1,ZEN:1,TIME:1,
                    QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1,
                    NOTAPE:1,TITLE1:1,TITLE2:1,TITLE3:1)
    IS DEFINED BY
      (E)DATE_TIME:1(E)DATE:1(E)TITLE2:2(E)TITLE3:2(E)TITLE1:3
      (E)TITLE3:3(E)TITLE1:4(E)TITLE2:4
      ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
               SCAN:1)
      & ( TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,
                  TITLE3:2)
        v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:3,TITLE2:1,
                  TITLE3:3)
        v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:4,TITLE2:4,
                  TITLE3:1) ) )
  FUNCTION: TITLE1
  ARGUMENTS ARE: (NOTAPE:1,TITLE1:1,TITLE2:1,TITLE3:1)
  IS DEFINED BY
    (E)TAPETYPE:2(E)TITLE2:2(E)TITLE3:2
    TAPEINFO(NOTAPE:1,TAPETYPE:2,TITLE1:1,TITLE2:2,TITLE3:2)
  FUNCTION: TITLE2
  ARGUMENTS ARE: (NOTAPE:1,TITLE1:1,TITLE2:1,TITLE3:1)
  IS DEFINED BY
    (E)TAPETYPE:2(E)TITLE1:2(E)TITLE3:2
    TAPEINFO(NOTAPE:1,TAPETYPE:2,TITLE1:2,TITLE2:1,TITLE3:2)
  FUNCTION: TITLE3
  ARGUMENTS ARE: (NOTAPE:1,TITLE1:1,TITLE2:1,TITLE3:1)
  IS DEFINED BY
    (E)TAPETYPE:2(E)TITLE1:2(E)TITLE2:2
    TAPEINFO(NOTAPE:1,TAPETYPE:2,TITLE1:2,TITLE2:2,TITLE3:1)

CONSTANT TRANSFORMATION SECTION
  .
  .
  .
  /*CODE converts from EBCDIC to ASCII -
  Additionally, CODE multiplies LON, LAT, ALT, and
  ZEN entries by 100 and PB entries by 10;
  DECODE converts from ASCII to EBCDIC -
  Additionally, DECODE divides LON, LAT, ALT, and
  ZEN entries by 100 and PB entries by 10.*/
```

Appendix 2.8 V(GLOBE)

```
V(GLOBE): VIEW DEFINITION
  S(GLOBE): SCHEMA DEFINITION
    TABLE  TAPEINFO = (NOTAPE,TAPETYPE,TITLE1,TITLE2,TITLE3)
    TABLE  FILEINFO = (PB,FILE,NOTAPE)
    TABLE  RECINFO = (DATE_TIME,DATE,TIME,LON,LAT,ALT,ZEN,PB,
                     QUALITY,ELECTR,ILLUMIN,CALIB,SCAN)
    TABLE  RTAPE = (NOTAPE,TAPETYPE,PLAYBACK,RTITLE)
    TABLE  PLAYBACK = (PB,FILE,CATALOG)
    TABLE  RTITLE = (TITLE)
    TABLE  CATALOG = (LON,LAT,ALT,ZEN,TIME,QUALITY,ELECTR,
                     ILLUMIN,CALIB,SCAN)
    TABLE  RDATES = (DATE,CATALOG)
    TABLE  RLON = (ILON,CATALOG)
    TABLE  RLAT = (ILAT,CATALOG)
    TABLE  RALT = (IALT,CATALOG)
    TABLE  RZEN = (IZEN,CATALOG)
    TABLE  TAPE = (TAPEID,MISSION,SENSOR,FORMAT,PROJNUM,GENDATE,
                  INVDATE,ARCHIVER,NUMFILES,TPFIRSTORB,
                  TPLASTORB,TPSTART,TPSTOP,TPALGORITHM,COORDSYS,
                  SYNOPSTART,SYNOPSTOP)
    TABLE  FILE = (TAPEID,FILE,FLFIRSTORB,FLLASTORB,FLSTART,
                  FLSTOP,FLALGORITHM,NUMITEMS,FLLEN)
    TABLE  ITEM = (TAPEID,FILE,ITEM,ITSTART,ITSTOP,RECNUM,
                  ITALGORITHM,ITLEN)
    TABLE  CAT = (TAPEID,FILE,ITEM,CAT,FUNCTION,CATEGORY)
    TABLE  DESCR = (ITEM,NAME)

  L(GLOBE): LANGUAGE DEFINITION
    T(GLOBE): TYPING DEFINITION
      TYPE  NUMBER = (NOTAPE,PB,FILE,DATE_TIME,DATE,TIME,LON,
                     LAT,ALT,ZEN,ILON,ILAT,IALT,IZEN,QUALITY,
                     NUMFILES,TPFIRSTORB,TPLASTORB,FLFIRSTORB,
                     FLLASTORB,NUMITEMS,FLLEN,RECNUM,ITLEN)
                     ASCII NUM(22)
      TYPE  CHAR4 = (TAPETYPE) ASCII CHAR(4)
      TYPE  CHAR115 = (TITLE1,TITLE2,TITLE3,TITLE) ASCII
                      CHAR(115)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) ASCII CHAR(3)
      TYPE  CHAR8 = (ILLUMIN,INVDATE) ASCII CHAR(8)
      TYPE  CHAR15 = (TAPEID,MISSION,PROJNUM,COORDSYS) ASCII
                     CHAR(15)
      TYPE  CHAR10 = (SENSOR,FORMAT) ASCII CHAR(10)
      TYPE  CHAR12 = (GENDATE,ARCHIVER,TPSTART,TPSTOP,
                     SYNOPSTART,SYNOPSTOP,FLSTART,FLSTOP,
                     ITSTART,ITSTOP) ASCII CHAR(12)
      TYPE  CHAR5 = (TPALGORITHM,FLALGORITHM,ITEM,ITALGORITHM,
                    CAT) ASCII CHAR(5)
      TYPE  CHAR50 = (FUNCTION) ASCII CHAR(50)
      TYPE  CHAR30 = (CATEGORY,NAME) ASCII CHAR(30)
```

```
NONLOGICAL SYMBOLS DEFINITION
  PREDICATES
    TAPEINFO:(NUMBER,CHAR4,CHAR115,CHAR115,CHAR115)-PREDICATE
    FILEINFO:(NUMBER,NUMBER,NUMBER)-PREDICATE
    RECINFO:(NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,
            NUMBER,NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)
            -PREDICATE
    RDATES-CATALOG:(NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,
           NUMBER,NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-FULL
           CLUSTER PREDICATE
    RLON-CATALOG:(NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,NUMBER,
         NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
         PREDICATE
    RLAT-CATALOG:(NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,NUMBER,
         NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
         PREDICATE
    RALT-CATALOG:(NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,NUMBER,
         NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
         PREDICATE
    RZEN-CATALOG:(NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,NUMBER,
         NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-FULL CLUSTER
         PREDICATE
    RTAPE-PLAYBACK-CATALOG-RTITLE:(NUMBER,CHAR4,PLAYBACK,
          NUMBER,NUMBER,CATALOG,NUMBER,NUMBER,NUMBER,NUMBER,
          NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3,RTITLE,
          CHAR115)-FULL CLUSTER PREDICATE
    TAPE:(CHAR15,CHAR15,CHAR10,CHAR10,CHAR15,CHAR12,CHAR8,
         CHAR12,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
         CHAR15,CHAR12,CHAR12)-PREDICATE
    FILE:(CHAR15,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
         NUMBER,NUMBER)-PREDICATE
    ITEM:(CHAR15,NUMBER,CHAR5,CHAR12,CHAR12,NUMBER,CHAR5,
         NUMBER)-PREDICATE
    CAT:(CHAR15,NUMBER,CHAR5,CHAR5,CHAR50,CHAR30)-PREDICATE
    DESCR:(CHAR5,CHAR30)-PREDICATE
  FUNCTIONS
    CONC:(NUMBER,NUMBER;NUMBER)-PREDEFINED FUNCTION
    TITLE1:(NUMBER;CHAR115)-FUNCTION
    TITLE2:(NUMBER;CHAR115)-FUNCTION
    TITLE3:(NUMBER;CHAR115)-FUNCTION
    NUM:(CHAR15;NUMBER)-PREDEFINED FUNCTION
```

```
C(GLOBE): CONSTRAINTS DEFINITION
   C(GLOBE,1):  CONSTRAINT  TAPEINFO:NOTAPE->TAPETYPE,TITLE1,
                TITLE2,TITLE3
   C(GLOBE,2):  CONSTRAINT  FILEINFO:PB,NOTAPE->FILE
   C(GLOBE,3):  CONSTRAINT  RECINFO:DATE_TIME->DATE,TIME,LON,LAT,
                ALT,ZEN,PB,QUALITY,ELECTR,ILLUMIN,CALIB,SCAN
   C(GLOBE,4):  CONSTRAINT  RECINFO:DATE_TIME=CONC(DATE,TIME)
   C(GLOBE,5):  CONSTRAINT  RTAPE:NOTAPE->TAPETYPE,PLAYBACK,
                            RTITLE
   C(GLOBE,6):  CONSTRAINT  RTAPE-PLAYBACK:NOTAPE,PB->FILE,
                            CATALOG
   C(GLOBE,7):  CONSTRAINT  RDATES:DATE->CATALOG
   C(GLOBE,8):  CONSTRAINT  RLON:ILON->CATALOG
   C(GLOBE,9):  CONSTRAINT  RLAT:ILAT->CATALOG
   C(GLOBE,10):CONSTRAINT  RALT:IALT->CATALOG
   C(GLOBE,11):CONSTRAINT  RZEN:IZEN->CATALOG
   C(GLOBE,12):CONSTRAINT  RLON-CATALOG:ILON=INT(LON)
   C(GLOBE,13):CONSTRAINT  RLAT-CATALOG:ILAT=INT(LAT)
   C(GLOBE,14):CONSTRAINT  RALT-CATALOG:IALT=INT(ALT)
   C(GLOBE,15):CONSTRAINT  RZEN-CATALOG:IZEN=INT(ZEN)
   C(GLOBE,16):CONSTRAINT  NOTAPE IN TAPEINFO -> NOTAPE NOT IN
                RTAPE
   C(GLOBE,17):CONSTRAINT  NOTAPE,PB IN FILEINFO -> NOTAPE,PB
                NOT IN RTAPE-PLAYBACK
   C(GLOBE,18):CONSTRAINT  TAPE:TAPEID->MISSION,SENSOR,FORMAT,
                PROJNUM,GENDATE,INVDATE,ARCHIVER,NUMFILES,
                TPFIRSTORB,TPLASTORB,TPSTART,TPSTOP,TPALGORITHM,
                COORDSYS,SYNOPSTART,SYNOPSTOP
   C(GLOBE,19):CONSTRAINT  FILE:TAPEID,FILE->FLFIRSTORB,
                FLLASTORB,FLSTART,FLSTOP,FLALGORITHM,NUMITEMS,
                FLLEN
   C(GLOBE,20):CONSTRAINT  ITEM:TAPEID,FILE,ITEM,RECNUM->
                ITSTART,ITSTOP,ITALGORITHM,ITLEN
   C(GLOBE,21):CONSTRAINT  CAT:TAPEID,FILE,ITEM->CAT,FUNCTION,
                CATEGORY
   C(GLOBE,22):CONSTRAINT  DESCR:ITEM->NAME
```

Appendix 2.9 V(GLOBE-R)

```
V(GLOBE-R): VIEW DEFINITION
  S(GLOBE-R): SCHEMA DEFINITION
    TABLE  TAPEINFO = (NOTAPE,TAPETYPE,TITLE1,TITLE2,TITLE3)
    TABLE  FILEINFO = (PB,FILE,NOTAPE)
    TABLE  RECINFO = (DATE,TIME,LON,LAT,ALT,ZEN,PB,QUALITY,
                      ELECTR,ILLUMIN,CALIB,SCAN)
    TABLE  TAPE = (TAPEID,MISSION,SENSOR,FORMAT,PROJNUM,GENDATE,
                  INVDATE,ARCHIVER,NUMFILES,TPFIRSTORB,
                  TPLASTORB,TPSTART,TPSTOP,TPALGORITHM,COORDSYS,
                  SYNOPSTART,SYNOPSTOP)
    TABLE  FILE = (TAPEID,FILE,FLFIRSTORB,FLLASTORB,FLSTART,
                  FLSTOP,FLALGORITHM,NUMITEMS,FLLEN)
    TABLE  ITEM = (TAPEID,FILE,ITEM,ITSTART,ITSTOP,RECNUM,
                  ITALGORITHM,ITLEN)
    TABLE  CAT = (TAPEID,FILE,ITEM,CAT,FUNCTION,CATEGORY)
    TABLE  DESCR = (ITEM,NAME)

  L(GLOBE-R): LANGUAGE DEFINITION
    T(GLOBE-R): TYPING DEFINITION
      TYPE  NUMBER = (NOTAPE,PB,FILE,DATE,TIME,LON,LAT,ALT,ZEN,
                     QUALITY,NUMFILES,TPFIRSTORB,TPLASTORB,
                     FLFIRSTORB,FLLASTORB,NUMITEMS,FLLEN,RECNUM,
                     ITLEN) ASCII NUM(22)
      TYPE  CHAR4 = (TAPETYPE) ASCII CHAR(4)
      TYPE  CHAR115 = (TITLE1,TITLE2,TITLE3) ASCII CHAR(115)
      TYPE  CHAR3 = (ELECTR,CALIB,SCAN) ASCII CHAR(3)
      TYPE  CHAR8 = (ILLUMIN,INVDATE) ASCII CHAR(8)
      TYPE  CHAR15 = (TAPEID,MISSION,PROJNUM,COORDSYS) ASCII
                     CHAR(15)
      TYPE  CHAR10 = (SENSOR,FORMAT) ASCII CHAR(10)
      TYPE  CHAR12 = (GENDATE,ARCHIVER,TPSTART,TPSTOP,
                     SYNOPSTART,SYNOPSTOP,FLSTART,FLSTOP,
                     ITSTART,ITSTOP) ASCII CHAR(12)
      TYPE  CHAR5 = (TPALGORITHM,FLALGORITHM,ITEM,ITALGORITHM,
                    CAT) ASCII CHAR(5)
      TYPE  CHAR50 = (FUNCTION) ASCII CHAR(50)
      TYPE  CHAR30 = (CATEGORY,NAME) ASCII CHAR(30)
```

```
NONLOGICAL SYMBOLS DEFINITION
  PREDICATES
    TAPEINFO:(NUMBER,CHAR4,CHAR115,CHAR115,CHAR115)-PREDICATE
    FILEINFO:(NUMBER,NUMBER,NUMBER)-PREDICATE
    RECINFO:(NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,NUMBER,
            NUMBER,NUMBER,CHAR3,CHAR8,CHAR3,CHAR3)-PREDICATE
    TAPE:  (CHAR15,CHAR15,CHAR10,CHAR10,CHAR15,CHAR12,CHAR8,
           CHAR12,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
           CHAR15,CHAR12,CHAR12)-PREDICATE
    FILE:  (CHAR15,NUMBER,NUMBER,NUMBER,CHAR12,CHAR12,CHAR5,
           NUMBER,NUMBER)-PREDICATE
    ITEM:  (CHAR15,NUMBER,CHAR5,CHAR12,CHAR12,NUMBER,CHAR5,
           NUMBER)-PREDICATE
    CAT:  (CHAR15,NUMBER,CHAR5,CHAR5,CHAR50,CHAR30)-PREDICATE
    DESCR:  (CHAR5,CHAR30)-PREDICATE
  FUNCTIONS
    NUM:(CHAR15;NUMBER)-PREDEFINED FUNCTION

C(GLOBE-R): CONSTRAINTS DEFINITION
  C(GLOBE-R,1): CONSTRAINT  TAPEINFO:NOTAPE->TAPETYPE,TITLE1,
                TITLE2,TITLE3
  C(GLOBE-R,2): CONSTRAINT  FILEINFO:PB,NOTAPE->FILE
  C(GLOBE-R,3): CONSTRAINT  TAPE:TAPEID->MISSION,SENSOR,FORMAT,
                PROJNUM,GENDATE,INVDATE,ARCHIVER,NUMFILES,
                TPFIRSTORB,TPLASTORB,TPSTART,TPSTOP,
                TPALGORITHM,COORDSYS,SYNOPSTART,SYNOPSTOP
  C(GLOBE-R,4): CONSTRAINT  FILE:TAPEID,FILE->FLFIRSTORB,
                FLLASTORB,FLSTART,FLSTOP,FLALGORITHM,NUMITEMS,
                FLLEN
  C(GLOBE-R,5): CONSTRAINT  ITEM:TAPEID,FILE,ITEM,RECNUM->
                ITSTART,ITSTOP,ITALGORITHM,ITLEN
  C(GLOBE-R,6): CONSTRAINT  CAT:TAPEID,FILE,ITEM->CAT,FUNCTION,
                CATEGORY
  C(GLOBE-R,7): CONSTRAINT  DESCR:ITEM->NAME
```

Appendix 2.10 I(GLOBE-R;GLOBE)

```
I(GLOBE-R;GLOBE): INTERPRETATION DEFINITION
  EXTERNAL VIEW IS V(GLOBE-R) = <S(GLOBE-R),L(GLOBE-R),
                                 C(GLOBE-R)>
  CONCEPTUAL VIEW IS V(GLOBE) = <S(GLOBE),L(GLOBE),C(GLOBE)>
  CODING SECTION
    CODE FOR NUMBER IS NUMBER;
    CODE FOR CHAR4 IS CHAR4;
    CODE FOR CHAR115 IS CHAR115;
    CODE FOR CHAR3 IS CHAR3;
    CODE FOR CHAR8 IS CHAR8;
    CODE FOR CHAR15 IS CHAR15;
    CODE FOR CHAR10 IS CHAR10;
    CODE FOR CHAR12 IS CHAR12;
    CODE FOR CHAR5 IS CHAR5;
    CODE FOR CHAR50 IS CHAR50;
    CODE FOR CHAR30 IS CHAR30;

  DEFINING FORMULA SECTION
    PREDICATE: TAPEINFO
    ARGUMENTS ARE: (NOTAPE:1,TAPETYPE:1,TITLE:1,TITLE:2,TITLE:3)
    IS DEFINED BY
        TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE:1,TITLE:2,TITLE:3)
      v (E)RTITLE:1(E)PLAYBACK:1
        ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
        & TITLE:1 = TITLE1(NOTAPE:1)
        & TITLE:2 = TITLE2(NOTAPE:1)
        & TITLE:3 = TITLE3(NOTAPE:1) )
    PREDICATE: FILEINFO
    ARGUMENTS ARE: (PB:1,FILE:1,NOTAPE:1)
    IS DEFINED BY
        FILEINFO(PB:1,FILE:1,NOTAPE:1)
      v (E)TAPETYPE:1(E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:1
        RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              FILE:1,CATALOG:1,RTITLE:1)
  PREDICATE: RECINFO
  ARGUMENTS ARE:  (DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,PB:1,
                  QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
  IS DEFINED BY
      (E)DATE_TIME:1
      RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
             ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
             SCAN:1)
    v  (E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1(E)FILE:1
       (E)CATALOG:1(E)RTITLE:1(E)CATALOG:2
       ( RTAPE-PLAYBACK-CATALOG(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,
              PB:1,FILE:1,CATALOG:1,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
              SCAN:1,RTITLE:1)
       & RDATES-CATALOG(DATE:1,CATALOG:2,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ELECTR:1,ILLUMIN:1,
               CALIB:1,SCAN:1) )
 PREDICATE: TAPE
  ARGUMENTS ARE:  (TAPEID:1,MISSION:1,SENSOR:1,FORMAT:1,
                  PROJNUM:1,GENDATE:1,INVDATE:1,ARCHIVER:1,
                  NUMFILES:1,TPFIRSTORB:1,TPLASTORB:1,TPSTART:1,
                  TPSTOP:1,TPALGORITHM:1,COORDSYS:1,
                  SYNOPSTART:1,SYNOPSTOP:1)
  IS DEFINED BY
    TAPE(TAPEID:1,MISSION:1,SENSOR:1,FORMAT:1,PROJNUM:1,
        GENDATE:1,INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
PREDICATE: FILE
ARGUMENTS ARE:  (TAPEID:1,FILE:1,FLFIRSTORB:1,FLLASTORB:1,
                FLSTART:1,FLSTOP:1,FLALGORITHM:1,NUMITEMS:1,
                FLLEN:1)
  IS DEFINED BY
    FILE(TAPEID:1,FILE:1,FLFIRSTORB:1,FLLASTORB:1,FLSTART:1,
        FLSTOP:1,FLALGORITHM:1,NUMITEMS:1,FLLEN:1)
PREDICATE: ITEM
ARGUMENTS ARE:  (TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,
                RECNUM:1,ITALGORITHM:1,ITLEN:1)
  IS DEFINED BY
    ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
    ITALGORITHM:1,ITLEN:1)
PREDICATE: CAT
ARGUMENTS ARE:  (TAPEID:1,FILE:1,ITEM:1,CAT:1,FUNCTION:1,
                CATEGORY:1)
  IS DEFINED BY
    CAT(TAPEID:1,FILE:1,ITEM:1,CAT:1,FUNCTION:1,CATEGORY:1)
PREDICATE: DESCR
ARGUMENTS ARE:  (ITEM:1,NAME:1)
  IS DEFINED BY
    DESCR(ITEM:1,NAME:1)
```

```
FUNCTION: NUM
ARGUMENTS ARE: (TAPEID:1)
  IS DEFINED BY
    NUM(TAPEID:1)

CONSTANT TRANSFORMATION SECTION
   .
   .
   .
  /*CODE and DECODE are the identity maps.*/
```

Appendix 3.1
Logical optimization algorithm for a conjunctive query

```
Begin
  Place the query in prenex conjunctive normal form : Q(0);
  Set  i := 0;
  For  j := 1 to n  Do
    If Pj is an equality that gives the value of a function as an
      existentially quantified variable that does not appear in
      any other conjunct
      Then
        Begin
          Obtain Q(i+1) from Q(i) as follows:
            Begin
              Delete Pj;
              Omit the superfluous quantifiers from the prefix
            End;
          Set i := i+1
        End;
  While a functional dependency constraint may be applied to
    identify different objects in Q(i)  Do
    Begin
      Pick an applicable functional dependency constraint FD;
      Set  S := the set of objects identified by FD;
      Set  a := the total number of target variables in S;
      Set  b := the total number of constants in S;
      If  a+b=0
        Then
          Obtain Q(i+1) from Q(i) as follows:
            Begin
              Pick one object from S;
              Change all objects in S to the chosen object;
              Omit the superfluous quantifiers from the prefix
            End
        Else
          If  a+b=1
            Then
              Obtain Q(i+1) from Q(i) as follows:
                Begin
                  Change all existentially quantified variables
                    in S to the target variable or constant in S;
                  Omit the superfluous quantifiers from the
                    prefix
                End
          Else
            If  b=0
              Then
                Obtain Q(i+1) from Q(i) as follows:
                  Begin
                    Pick one target variable, say X, in S;
                    For every other target variable, say Y, in
                      S, add the conjunct  Y = X;
                    Change all other variables in S to X
                      except in the just added equality
                      conjuncts;
                    Omit the superfluous quantifiers from the
                      prefix
                  End
              Else
                If  b=1
                  Then
                    Obtain Q(i+1) from Q(i) as follows:
                      Begin
                        For every target variable, say Y, in S
                          add the conjunct  Y = c
                          (c is the constant in S);
                        Change all the variables in S to c
                          except in the just added equality
                          conjuncts;
                        Omit the superfluous quantifiers from
                          the prefix
                      End
                   Else Begin
                          Print "The query has no answers";
                          Exit procedure
                        End;
    Set  i := i+1
  End;
Let  P := the set of pairs of conjuncts <C1,C2> where C1 is
            structurally a subcluster of C2;
While  P~=empty  Do
  Begin
    Pick a pair <C1,C2> from P;
    Delete <C1,C2> from P;
    Obtain C1' from C1 as follows:
      Rename all existentially quantified variables in C1 to
        match the corresponding objects in C2 (if possible);
      If C1' is a subcluster of C2 and every existentially
        quantified variable which was renamed to a target
        variable or a constant does not appear in another
        conjunct
        Then
          Begin
            Obtain Q(i+1) from Q(i) as follows:
              Begin
                Delete the conjunct C1;
                Rename all existentially quantified variables
                  according to the formation of C1' from C1;
                Omit the superfluous quantifiers from the prefix
              End;
            Delete every pair from P which includes C1;
            Set  i := i+1
          End
    End
End.
```

Appendix 3.2
Query 1 transformation from ERB-R to ERB-SEED and optimization

Query 1 in English:

What are the tape numbers, the tape types, the playback numbers, and the file numbers in the data inventory?

Query 1 in DBL for ERB-R:

```
GET W(NOTAPE:1,TAPETYPE:1,PB:1,FILE:1):
  (E)TITLE1:1(E)TITLE2:1(E)TITLE3:1
  ( TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:1,TITLE3:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1) )
```

Interpreted query 1 in DBL for ERB-SEED:

```
GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
      DECODE(NOFILE:1)):
  (E)TITLE:1(E)TITLE:2(E)TITLE:3
    (  (E)RTITLE:1(E)PLAYBACK:1
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & TITLE:1 = TITLE1(NOTAPE:1)
      & TITLE:2 = TITLE2(NOTAPE:1)
      & TITLE:3 = TITLE3(NOTAPE:1) )
    & (E)TAPETYPE:2(E)PLAYBACK:2(E)CATALOG:1(E)RTITLE:2
      RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:2,PLAYBACK:2,PB:1,
            NOFILE:1,CATALOG:1,RTITLE:2)  )
```

Place interpreted query 1 in prenex conjunctive normal form -
Obtain Q(0):

```
GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
      DECODE(NOFILE:1)):
  (E)TITLE:1(E)TITLE:2(E)TITLE:3(E)RTITLE:1(E)PLAYBACK:1
  (E)TAPETYPE:2(E)PLAYBACK:2(E)CATALOG:1(E)RTITLE:2
    ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
    & TITLE:1 = TITLE1(NOTAPE:1)
    & TITLE:2 = TITLE2(NOTAPE:1)
    & TITLE:3 = TITLE3(NOTAPE:1)
    & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:2,PLAYBACK:2,PB:1,
            NOFILE:1,CATALOG:1,RTITLE:2)  )
```

Delete the first equality -
Obtain Q(1):

```
GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
      DECODE(NOFILE:1)):
  (E)TITLE:2(E)TITLE:3(E)RTITLE:1(E)PLAYBACK:1(E)TAPETYPE:2
  (E)PLAYBACK:2(E)CATALOG:1(E)RTITLE:2
    ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
    & TITLE:2 = TITLE2(NOTAPE:1)
    & TITLE:3 = TITLE3(NOTAPE:1)
    & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:2,PLAYBACK:2,PB:1,
            NOFILE:1,CATALOG:1,RTITLE:2)  )
```

```
Delete the next equality -
         Obtain Q(2):
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)TITLE:3(E)RTITLE:1(E)PLAYBACK:1(E)TAPETYPE:2(E)PLAYBACK:2
    (E)CATALOG:1(E)RTITLE:2
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & TITLE:3 = TITLE3(NOTAPE:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:2,PLAYBACK:2,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:2) )

Delete the last equality -
         Obtain Q(3):
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)RTITLE:1(E)PLAYBACK:1(E)TAPETYPE:2(E)PLAYBACK:2
    (E)CATALOG:1(E)RTITLE:2
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:2,PLAYBACK:2,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:2) )

Apply C(ERB-SEED,1) to identify TAPETYPE -
         Obtain Q(4):
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)RTITLE:1(E)PLAYBACK:1(E)PLAYBACK:2(E)CATALOG:1(E)RTITLE:2
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:2,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:2) )

Apply C(ERB-SEED,1) to identify PLAYBACK -
         Obtain Q(5):
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)RTITLE:1(E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:2
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:2) )

Apply C(ERB-SEED,1) to identify RTITLE -
         Obtain Q(6):
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)RTITLE:1(E)PLAYBACK:1(E)CATALOG:1
      ( RTAPE(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,RTITLE:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:1) )
```

Delete subsumed conjunct -

Obtain Q(7) (the optimized query):

```
  GET W(DECODE(NOTAPE:1),DECODE(TAPETYPE:1),DECODE(PB:1),
        DECODE(NOFILE:1)):
    (E)RTITLE:1(E)PLAYBACK:1(E)CATALOG:1
      RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              NOFILE:1,CATALOG:1,RTITLE:1)
```

Appendix 3.3
Query 2 transformation from ERB-R to ERB-SEED and optimization

Query 2 in English:

What are the dates, the times, and the illuminations for all the data in the inventory where the playback number is 81261.4 and is associated with some file number?

Query 2 in DBL for ERB-R:

```
  GET W(DATE:1,TIME:1,ILLUMIN:1):
     (E)FILE:1(E)NOTAPE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
     (E)QUALITY:1(E)ELECTR:1(E)CALIB;1(E)SCAN:1
     ( FILEINFO(81261.4,FILE:1,NOTAPE:1)
     & RECINFO(DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,81261.4,
             QUALITY:1,ELECTR;1,ILLUMIN:1,CALIB:1,SCAN:1) )
```

Interpreted query 2 in DBL for ERB-SEED:

```
  GET W(DECODE(DATE1:1),DECODE(TIME1:1),DECODE(ILLUMIN:1)):
     (E)NOFILE;1(E)NOTAPE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
     (E)QUALITY:1(E)ELECTR:1(E)CALIB:1(E)SCAN:1
     (  (E)TAPETYPE:1(E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:1
       RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,81261.4,
             NOFILE:1,CATALOG;1,RTITLE:1)
     &  (E)NOTAPE:2(E)TAPETYPE:2(E)PLAYBACK:2(E)NOFILE:2
       (E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
       ( RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
              81261,4,NOFILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
              SCAN:1,RTITLE:2)
       & RDATES-CATALOG(DATE1:1,CATALOG:3,LON:1,LAT:1,ALT:1,ZEN:1,
               TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
               SCAN:1) ) )
```

Place interpreted query 2 in prenex conjunctive normal form –
Obtain Q(0):

```
  GET W(DECODE(DATE1:1),DECODE(TIME1:1),DECODE(ILLUMIN:1)):
     (E)NOFILE:1(E)NOTAPE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
     (E)QUALITY:1(E)ELECTR:1(E)CALIB:1(E)SCAN:1(E)TAPETYPE:1
     (E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:1(E)NOTAPE:2(E)TAPETYPE:2
     (E)PLAYBACK:2(E)NOFILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
     ( RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,81261.4,
             NOFILE:1,CATALOG:1,RTITLE:1)
     & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             81261.4,NOFILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1,
             RTITLE:2)
     & RDATES-CATALOG(DATE1:1,CATALOG:3,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
              SCAN:1) )
```

```
Rename variables and delete subsumed conjunct -
        Obtain Q(1) (the optimized query):
  GET W(DECODE(DATE1:1),DECODE(TIME1:1),DECODE(ILLUMIN:1)):
    (E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1(E)QUALITY:1(E)ELECTR:1
    (E)CALIB:1(E)SCAN:1(E)NOTAPE:2(E)TAPETYPE:2(E)PLAYBACK:2
    (E)NOFILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    ( RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          81261.4,NOFILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1,
          RTITLE:2)
    & RDATES-CATALOG(DATE1:1,CATALOG:3,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
           SCAN:1) )
```

Appendix 3.4
Logical optimization for a query with local disjunctions

```
Begin
  Place the query in prenex conjunctive normal form : Q(0);
  Set  i := 0;
  For  j := 1 to n  Do
    If Pj is an equality that gives the value of a function as an
      existentially quantified variable that does not appear in
      any other conjunct
      Then
        Begin
          Obtain Q(i+1) from Q(i) as follows:
            Begin
              Delete Pj;
              Omit the superfluous quantifiers from the prefix
            End;
          Set  i := i+1
        End
      Else
        Begin
          Set  Hj := the set of pairs of disjuncts <D1,D2> in Pj
                       such that D1 is structurally a subcluster
                       of D2
          While  Hj~=empty  Do
            Begin
              Pick a pair <D1,D2> from Hj;
              Delete <D1,D2> from Hj;
              Obtain D2' from D2 as follows:
                Rename all objects in D2 to match the
                  corresponding existentially quantified
                  variables in D1 (if possible);
              If D1 is a subcluster of D2'
                Then
                  Begin
                    Obtain Q(i+1) from Q(i) as follows:
                      Begin
                        Delete the disjunct D2 from Pj;
                        Omit the superfluous quantifiers from the
                          prefix
                      End;
                    Delete every pair from Hj which includes D2;
                    Set  i := i+1
                  End
            End
        End;
```

```
While a functional dependency constraint may be applied to
  conjuncts which are clusters to identify different objects in
  Q(i)  Do
  Begin
    Pick an applicable functional dependency constraint FD;
    Set  S := the set of objects identified by FD;
    Set  a := the total number of target variables in S;
    Set  b := the total number of constants in S;
    If  a+b=0
      Then
        Obtain Q(i+1) from Q(i) as follows:
          Begin
            Pick one object from S;
            Change all objects in S to the chosen object;
            Omit the superfluous quantifiers from the prefix
          End
      Else
        If  a+b=1
          Then
            Obtain Q(i+1) from Q(i) as follows:
              Begin
                Change all existentially quantified variables
                  in S to the target variable or constant in S;
                Omit the superfluous quantifiers from the
                  prefix
              End
          Else
            If  b=0
              Then
                Obtain Q(i+1) from Q(i) as follows:
                  Begin
                    Pick one target variable, say X, in S;
                    For every other target variable, say Y, in
                      S, add the conjunct  Y = X;
                    Change all other variables in S to X
                      except in the just added equality
                      conjuncts;
                    Omit the superfluous quantifiers from the
                      prefix
                  End
                Else
                  If  b=1
                    Then
                      Obtain Q(i+1) from Q(i) as follows:
                        Begin
                          For every target variable, say Y, in S
                            add the conjunct  Y = c
                            (c is the constant in S);
                          Change all the variables in S to c
                            except in the just added equality
                            conjuncts;
                          Omit the superfluous quantifiers from
                            the prefix
                        End
                     Else Begin
                            Print "The query has no answers";
                            Exit procedure
                          End;
      Set  i := i+1
    End;
  Let  P := the set of pairs of conjuncts <C1,C2> where C1 is
              structurally a subcluster of C2;
  While  P~=empty  Do
    Begin
      Pick a pair <C1,C2> from P;
      Delete <C1,C2> from P;
      Obtain C1' from C1 as follows:
        Rename all existentially quantified variables in C1 to
          match the corresponding objects in C2 (if possible);
      If C1' is a subcluster of C2 and every existentially
        quantified variable which was renamed to a target
        variable or a constant does not appear in another
        conjunct
        Then
          Begin
            Obtain Q(i+1) from Q(i) as follows:
              Begin
                Delete the conjunct C1;
                Rename all existentially quantified variables
                  according to the formation of C1' from C1;
                Omit the superfluous quantifiers from the prefix
              End;
            Delete every pair from P which includes C1;
            Set  i := i+1
          End
    End
End.
```

Appendix 3.5
Query 3 transformation from ERB-N to ERB-ORAC and optimization

Query:

For tape number = 1003 what are the tape types, the playback numbers and the file numbers?

DBL Query:

```
  GET W(TAPETYPE:1,PB:1,NOFILE:1):
     (E)PLAYBACK:1(E)RTITLE:1(E)CATALOG:1
     RTAPE-PLAYBACK(1003,TAPETYPE:1,PLAYBACK:1,PB:1,NOFILE:1,
           CATALOG:1,RTITLE:1)
```

Interpreted DBL Query (already in normal form) -
         Obtain Q(0):

```
  GET W(DECODE(TAPETYPE:1),DECODE(PB:1),DECODE(FILE:1)):
     (E)DATE_TIME:1(E)DATE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
     (E)TIME:1(E)QUALITY:1(E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1
     (E)SCAN:1(E)TITLE1:1(E)TITLE2:1(E)TITLE3:1(E)TITLE2:2
     (E)TITLE3:2(E)TITLE1:3(E)TITLE3:3(E)TITLE1:4(E)TITLE2:4
       ( FILEINFO(PB:1,FILE:1,1003)
       & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
                SCAN:1)
       & ( TAPEINFO(1003,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
         v TAPEINFO(1003,TAPETYPE:1,TITLE1:3,TITLE2:1,TITLE3:3)
         v TAPEINFO(1003,TAPETYPE:1,TITLE1:4,TITLE2:4,TITLE3:1) )
```

Delete a subsumed disjunct -
         Obtain Q(1):

```
  GET W(DECODE(TAPETYPE:1),DECODE(PB:1),DECODE(FILE:1)):
     (E)DATE_TIME:1(E)DATE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
     (E)TIME:1(E)QUALITY:1(E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1
     (E)SCAN:1(E)TITLE1:1(E)TITLE3:1(E)TITLE2:2(E)TITLE3:2
     (E)TITLE1:4(E)TITLE2:4
       ( FILEINFO(PB:1,FILE:1,1003)
       & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
                SCAN:1)
       & ( TAPEINFO(1003,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
         v TAPEINFO(1003,TAPETYPE:1,TITLE1:4,TITLE2:4,TITLE3:1) )
```

Delete another subsumed disjunct -

Obtain Q(2) (the optimized query):

```
  GET W(DECODE(TAPETYPE:1),DECODE(PB:1),DECODE(FILE:1)):
    (E)DATE_TIME:1(E)DATE:1(E)LON:1(E)LAT:1(E)ALT:1(E)ZEN:1
    (E)TIME:1(E)QUALITY:1(E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1
    (E)SCAN:1(E)TITLE1:1(E)TITLE2:2(E)TITLE3:2
      ( FILEINFO(PB:1,FILE:1,1003)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
               SCAN:1)
      & TAPEINFO(1003,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2) )
```

Appendix 3.6
Query 4 transformation from ERB-N to ERB-ORAC and optimization

Query 4 in English:

What are the tape numbers, dates, and times where longitude < 30 and latitude > 10? Display tape number, longitude, and latitude together with date and time.

Query 4 in DBL for ERB-N:

```
  GET W(NOTAPE:1,DATE1:1,TIME1:1,LON:1,LAT:1):
    (E)TAPETYPE:1(E)PLAYBACK:1(E)PB:1(E)NOFILE:1(E)CATALOG:1
    (E)RTITLE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1(E)ELECTR:1
    (E)ILLUMIN:1(E)CALIB:1(E)SCAN:1(E)CATALOG:2
    ( RTAPE-PLAYBACK-CATALOG(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
            NOFILE:1,CATALOG:1,LON:1,LAT:1,ALT:1,ZEN:1,TIME1:1,
            QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1,RTITLE:1)
    & RDATES-CATALOG(DATE1:1,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME1:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & LON:1 < 30
    & LAT:1 > 10 )
```

Interpreted query 4 in DBL for ERB-ORAC:

```
  GET W(DECODE(NOTAPE:1),DECODE(DATE:1),DECODE(TIME:1),
        DECODE(LON:1),DECODE(LAT:1)):
    (E)TAPETYPE:1(E)PB:1(E)FILE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1
    (E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1(E)SCAN:1
    ( (E)DATE_TIME:1(E)DATE:2(E)TITLE2:2(E)TITLE3:2(E)TITLE1:3
      (E)TITLE3:3(E)TITLE1:4(E)TITLE2:4(E)TITLE1:1(E)TITLE2:1
      (E)TITLE3:1
      ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:2,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,
               SCAN:1)
      & ( TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,
                  TITLE3:2)
        v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:3,TITLE2:1,
                  TITLE3:3)
        v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:4,TITLE2:4,
                  TITLE3:1) ) )
    & (E)DATE_TIME:2(E)PB:2
      RECINFO(DATE_TIME:2,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:2,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & LON:1 < 3000
    & LAT:1 > 1000 )
```

Place interpreted query 4 in prenex conjunctive normal form -
Obtain Q(0):

```
GET W(DECODE(NOTAPE:1),DECODE(DATE:1),DECODE(TIME:1),
      DECODE(LON:1),DECODE(LAT:1)):
    (E)TAPETYPE:1(E)PB:1(E)FILE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1
    (E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1(E)SCAN:1(E)DATE_TIME:1
    (E)DATE:2(E)TITLE2:2(E)TITLE3:2(E)TITLE1:3(E)TITLE3:3
    (E)TITLE1:4(E)TITLE2:4(E)TITLE1:1(E)TITLE2:1(E)TITLE3:1
    (E)DATE_TIME:2(E)PB:2
    ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
    & RECINFO(DATE_TIME:1,DATE:2,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & ( TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
      v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:3,TITLE2:1,TITLE3:3)
      v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:4,TITLE2:4,
                TITLE3:1) )
    & RECINFO(DATE_TIME:2,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:2,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & LON:1 < 3000
    & LAT:1 > 1000 )
```

Delete a subsumed disjunct from the third conjunct -
Obtain Q(1):

```
GET W(DECODE(NOTAPE:1),DECODE(DATE:1),DECODE(TIME:1),
      DECODE(LON:1),DECODE(LAT:1)):
    (E)TAPETYPE:1(E)PB:1(E)FILE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1
    (E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1(E)SCAN:1(E)DATE_TIME:1
    (E)DATE:2(E)TITLE2:2(E)TITLE3:2(E)TITLE1:4(E)TITLE2:4
    (E)TITLE1:1(E)TITLE3:1(E)DATE_TIME:2(E)PB:2
    ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
    & RECINFO(DATE_TIME:1,DATE:2,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & ( TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
      v TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:4,TITLE2:4,
                TITLE3:1) )
    & RECINFO(DATE_TIME:2,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:2,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
    & LON:1 < 3000
    & LAT:1 > 1000 )
```

Delete the subsumed disjunct from the third conjunct -
Obtain Q(2):

```
GET W(DECODE(NOTAPE:1),DECODE(DATE:1),DECODE(TIME:1),
      DECODE(LON:1),DECODE(LAT:1)):
   (E)TAPETYPE:1(E)PB:1(E)FILE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1
   (E)ELECTR:1(E)ILLUMIN:1(E)CALIB:1(E)SCAN:1(E)DATE_TIME:1
   (E)DATE:2(E)TITLE2:2(E)TITLE3:2(E)TITLE1:1(E)DATE_TIME:2
   (E)PB:2
   ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
   & RECINFO(DATE_TIME:1,DATE:2,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:1,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
   & TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
   & RECINFO(DATE_TIME:2,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:2,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
   & LON:1 < 3000
   & LAT:1 > 1000 )
```

Rename variables and delete subsumed conjunct -
Obtain Q(3) (the optimized query):

```
GET W(DECODE(NOTAPE:1),DECODE(DATE:1),DECODE(TIME:1),
      DECODE(LON:1),DECODE(LAT:1)):
   (E)TAPETYPE:1(E)FILE:1(E)ALT:1(E)ZEN:1(E)QUALITY:1(E)ELECTR:1
   (E)ILLUMIN:1(E)CALIB:1(E)SCAN:1(E)DATE_TIME:1(E)TITLE2:2
   (E)TITLE3:2(E)TITLE1:1(E)DATE_TIME:2(E)PB:2
   ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
   & TAPEINFO(NOTAPE:1,TAPETYPE:1,TITLE1:1,TITLE2:2,TITLE3:2)
   & RECINFO(DATE_TIME:2,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,
             PB:2,QUALITY:1,ELECTR:1,ILLUMIN:1,CALIB:1,SCAN:1)
   & LON:1 < 3000
   & LAT:1 > 1000 )
```

Appendix 4.1
Logical optimization algorithm for a disjunctive query

```
Begin
  Place the query in prenex conjunctive normal form : Q(0);
  Set  i := 0;
  For  j := 1 to n  Do
    If Pj is an equality that gives the value of a function as an
      existentially quantified variable that does not appear in
      any other conjunct
      Then
        Begin
          Obtain Q(i+1) from Q(i) as follows:
            Begin
              Delete Pj;
              Omit the superfluous quantifiers from the
                prefix
            End;
          Set i := i+1
        End
      Else
        Begin
          Set  Hj := the set of pairs of disjuncts <D1,D2> in Pj
                       such that D1 is structurally a subcluster
                       of D2
          While  Hj~=empty  Do
            Begin
              Pick a pair <D1,D2> from Hj;
              Delete <D1,D2> from Hj;
              Obtain D2' from D2 as follows:
                Rename all objects in D2 to match the
                  corresponding existentially quantified
                  variables in D1 (if possible);
              If D1 is a subcluster of D2'
                Then
                  Begin
                    Obtain Q(i+1) from Q(i) as follows:
                      Begin
                        Delete the disjunct D2 from Pj;
                        Omit the superfluous quantifiers from the
                          prefix
                      End;
                    Delete every pair from Hj which includes D2;
                    Set  i := i+1
                  End
            End
        End;
  Obtain Q(i+1) from Q(i) as follows:
    Place in prenex disjunctive normal form;
```

```
Set  i := i+1;
For  j := 1 to k Do  (D1,...,Dk are the disjuncts in Q(i))
  Begin
    While a functional dependency constraint may be applied to
      identify different objects in Dj  Do
      Begin
        Pick an applicable functional dependency constraint FD;
        Set  Sj := the set of objects identified by FD in Dj;
        Set  aj := the total number of target variables in Sj;
        Set  bj := the total number of constants in Sj;
        If  aj+bj=0
          Then
            Obtain Q(i+1) from Q(i) as follows:
              Begin
                Pick one object from Sj;
                Change all objects in Sj to the chosen object
                  for Dj;
                Omit the superfluous quantifiers from the
                  prefix
              End
          Else
            If  a+b=1
              Then
                Obtain Q(i+1) from Q(i) as follows:
                  Begin
                    Change all existentially quantified
                      variables in Sj for Dj to the target
                      variable or constant in Sj;
                    Omit the superfluous quantifiers from the
                      prefix
                  End
              Else
                If  b=0
                  Then
                    Obtain Q(i+1) from Q(i) as follows:
                      Begin
                        Pick one target variable, say X, in Sj;
                        For every other target variable, say Y,
                          in Sj, add the conjunct  Y = X to Dj;
                        Change all other variables in Sj to X
                          for Dj except in the just added
                          equality conjuncts;
                        Omit the superfluous quantifiers from
                          the prefix
                      End
                Else
                  If  b=1
                    Then
                      Obtain Q(i+1) from Q(i) as follows:
                        Begin
                          For every target variable, say Y,
                            in Sj, add the conjunct  Y = c to
                            Dj (c is the constant in Sj);
                          Change all the variables in Sj to c
                            in Dj except in the just added
                            equality conjuncts;
                          Omit the superfluous quantifiers
                            from the prefix
                        End
                    Else
                      Obtain Q(i+1) from Q(i) as follows:
                        Delete Dj;
      Set  i := i+1
    End;
  Let  Pj := the set of pairs of conjuncts <C1,C2> where C1
                is structurally a subcluster of C2;
  While  Pj~=empty  Do
    Begin
      Pick a pair <C1,C2> from Pj;
      Delete <C1,C2> from Pj;
      Obtain C1' from C1 as follows:
        Rename all existentially quantified variables in C1
          to match the corresponding objects in C2 (if
          possible);
      If C1' is a subcluster of C2 and every existentially
        quantified variable which was renamed to a target
        variable or a constant does not appear in another
        conjunct of Dj
        Then
          Begin
            Obtain Q(i+1) from Q(i) as follows:
              Begin
                Delete the conjunct C1;
                Rename all existentially quantified variables
                  in Dj according to the formation of C1'
                  from C1;
                Omit the superfluous quantifiers from the
                  prefix
              End;
            Delete every pair from Pj which includes C1;
            Set  i := i+1
          End
    End
End;
```

```
  Let  P := the set of pairs of disjuncts <D1,D2> where every
              cluster of D1 is structurally a subcluster of D2;
  While  P~=empty  Do
    Begin
      Pick a pair <D1,D2> from P;
      Delete <D1,D2> from P;
      Obtain D2' from D2 as follows:
        Rename all objects in D2 to match the corresponding
          existentially quantified variables in D1 (if possible);
        If every cluster of D1 is a subcluster of D2'
          Then
            Begin
              Obtain Q(i+1) from Q(i) as follows:
                Begin
                  Delete the disjunct D2;
                  Omit the superfluous quantifiers from the
                    prefix
                End;
              Delete every pair from P which includes D2;
              Set  i := i+1
            End
        End
End.
```

Appendix 4.2
Query 5 transformation from GLOBE-R to GLOBE and optimization

Query 5 in English:

What are the project numbers, the description names and the altitudes for all ERB files that represent information corresponding to the electronic status being ON and the scanning mode being OFF?

Query 5 in DBL for GLOBE-R:

```
GET W(PROJNUM:1,NAME:1,ALT:1):
   (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
   (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
   (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
   (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
   (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
   (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
   (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1
   ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
   & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
   & DESCR(ITEM:1,NAME:1)
   & FILEINFO(PB:1,FILE:1,NOTAPE:1)
   & RECINFO(DATE:1,TIME:1,LON:1,LAT:1,ALT:1,ZEN:1,PB:1,
            QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
   & NOTAPE:1 = NUM(TAPEID:1) )
```

Interpreted query 5 in DBL for GLOBE:

```
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1
    ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
          INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
          TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
          COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
    & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
          ITALGORITHM:1,ITLEN:1)
    & DESCR(ITEM:1,NAME:1)
    & ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
      v (E)TAPETYPE:1(E)PLAYBACK:1(E)CATALOG:1(E)RTITLE:1
        RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              FILE:1,CATALOG:1,RTITLE:1) )
    & ( (E)DATE_TIME:1
        RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
              ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      v (E)NOTAPE:2(E)TAPETYPE:2(E)PLAYBACK:2(E)FILE:2
        (E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
        ( RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
               PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
               TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
               RTITLE:2)
        & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
                ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
                OFF) )
    & NOTAPE:1 = NUM(TAPEID:1) )
```

```
Place interpreted query 5 in prenex conjunctive normal form -
         Obtain Q(0):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
    (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
    (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
          INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
          TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
          COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
    & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
          ITALGORITHM:1,ITLEN:1)
    & DESCR(ITEM:1,NAME:1)
    & ( FILEINFO(PB:1,FILE:1,NOTAPE:1)
      v RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              FILE:1,CATALOG:1,RTITLE:1) )
    & ( RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      v RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
              PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
              RTITLE:2) )
    & ( RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      v RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF) )
    & NOTAPE:1 = NUM(TAPEID:1) )
```

```
Place in prenex disjunctive normal form -
         Obtain Q(1):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
    (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
    (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    (  ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1)  )
    v  ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
      & NOTAPE:1 = NUM(TAPEID:1)  )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
             RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
             RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
             FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
           ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
           ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
           OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
           ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
           ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
           OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

```
Delete subsumed conjunct in first disjunct -
        Obtain Q(2):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
     (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
     (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
     (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
     (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
     (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
     (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
     (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
     (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
     (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
     ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
              INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
              TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
              COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
       & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
              ITALGORITHM:1,ITLEN:1)
       & DESCR(ITEM:1,NAME:1)
       & FILEINFO(PB:1,FILE:1,NOTAPE:1)
       & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                 ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
       & NOTAPE:1 = NUM(TAPEID:1) )
     v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
              INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
              TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
              COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
       & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
              ITALGORITHM:1,ITLEN:1)
       & DESCR(ITEM:1,NAME:1)
       & FILEINFO(PB:1,FILE:1,NOTAPE:1)
       & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                 ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
       & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
                 ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
                 OFF)
       & NOTAPE:1 = NUM(TAPEID:1) )
     v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
              INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
              TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
              COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
       & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
              ITALGORITHM:1,ITLEN:1)
       & DESCR(ITEM:1,NAME:1)
       & FILEINFO(PB:1,FILE:1,NOTAPE:1)
       & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
                PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
                TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
                RTITLE:2)
       & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                 ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
       & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
             RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
             FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
             FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
             FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
             RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
             FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
             PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
             TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
             RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

```
Delete subsumed conjunct in fifth disjunct -
        Obtain Q(3):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
    (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
    (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
    v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
           ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
           ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
           OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
           ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
             ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
             ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
             OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
             ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
             ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
             OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

```
Delete subsumed second disjunct -
         Obtain Q(4):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
    (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
    (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
    v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
              PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
              RTITLE:2)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
          INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
          TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
          COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
          ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & FILEINFO(PB:1,FILE:1,NOTAPE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
            PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
            TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
            RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
             ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
             OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
          INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
          TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
          COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
          ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
            FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
             ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
          INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
          TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
          COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
          ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
            FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
             ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
             ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
             OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
            ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
         INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
         TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
         COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
         ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
            ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
            OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

```
Delete subsumed second disjunct -
         Obtain Q(5):
  GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
    (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
    (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
    (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
    (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
    (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
    (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
    (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
    (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
    (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
    ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
              ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
    v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & FILEINFO(PB:1,FILE:1,NOTAPE:1)
      & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
              PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
              RTITLE:2)
      & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
              ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
              OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
    v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
      & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
      & DESCR(ITEM:1,NAME:1)
      & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              FILE:1,CATALOG:1,RTITLE:1)
      & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
              ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
      & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
            ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
            ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
            OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
            ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
           FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
           PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
           TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
           RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
            ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
            OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

Delete subsumed fourth disjunct -
Obtain Q(6):

```
   GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
      (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
      (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
      (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
      (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
      (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
      (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
      (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
      (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
      (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
      ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
                INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
                TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
                COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
        & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
                ITALGORITHM:1,ITLEN:1)
        & DESCR(ITEM:1,NAME:1)
        & FILEINFO(PB:1,FILE:1,NOTAPE:1)
        & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                   ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
        & NOTAPE:1 = NUM(TAPEID:1) )
      v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
                INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
                TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
                COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
        & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
                ITALGORITHM:1,ITLEN:1)
        & DESCR(ITEM:1,NAME:1)
        & FILEINFO(PB:1,FILE:1,NOTAPE:1)
        & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
                  PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
                  TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
                  RTITLE:2)
        & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
                   ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
                   OFF)
        & NOTAPE:1 = NUM(TAPEID:1) )
      v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
                INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
                TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
                COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
        & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
                ITALGORITHM:1,ITLEN:1)
        & DESCR(ITEM:1,NAME:1)
        & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
                  FILE:1,CATALOG:1,RTITLE:1)
        & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
                   ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
        & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
           ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
  & NOTAPE:1 = NUM(TAPEID:1) )
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
           ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
           OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

Delete subsumed fourth disjunct -
Obtain Q(7) (the optimized query):

```
 GET W(DECODE(PROJNUM:1),DECODE(NAME:1),DECODE(ALT:1)):
   (E)TAPEID:1(E)MISSION:1(E)FORMAT:1(E)GENDATE:1(E)INVDATE:1
   (E)ARCHIVER:1(E)NUMFILES:1(E)TPFIRSTORB:1(E)TPLASTORB:1
   (E)TPSTART:1(E)TPSTOP:1(E)TPALGORITHM:1(E)COORDSYS:1
   (E)SYNOPSTART:1(E)SYNOPSTOP:1(E)FILE:1(E)ITEM:1(E)ITSTART:1
   (E)ITSTOP:1(E)RECNUM:1(E)ITALGORITHM:1(E)ITLEN:1(E)PB:1
   (E)DATE:1(E)TIME:1(E)LON:1(E)LAT:1(E)ZEN:1(E)QUALITY:1
   (E)ILLUMIN:1(E)CALIB:1(E)NOTAPE:1(E)TAPETYPE:1(E)PLAYBACK:1
   (E)CATALOG:1(E)RTITLE:1(E)DATE_TIME:1(E)NOTAPE:2(E)TAPETYPE:2
   (E)PLAYBACK:2(E)FILE:2(E)CATALOG:2(E)RTITLE:2(E)CATALOG:3
   ( ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
     & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
     & DESCR(ITEM:1,NAME:1)
     & FILEINFO(PB:1,FILE:1,NOTAPE:1)
     & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
     & NOTAPE:1 = NUM(TAPEID:1) )
   v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
     & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
     & DESCR(ITEM:1,NAME:1)
     & FILEINFO(PB:1,FILE:1,NOTAPE:1)
     & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
              PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
              TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
              RTITLE:2)
     & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
               ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
               OFF)
     & NOTAPE:1 = NUM(TAPEID:1) )
   v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
            INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
            TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
            COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
     & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
            ITALGORITHM:1,ITLEN:1)
     & DESCR(ITEM:1,NAME:1)
     & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
              FILE:1,CATALOG:1,RTITLE:1)
     & RECINFO(DATE_TIME:1,DATE:1,TIME:1,LON:1,LAT:1,ALT:1,
               ZEN:1,PB:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF)
     & NOTAPE:1 = NUM(TAPEID:1) )
```

```
v ( TAPE(TAPEID:1,MISSION:1,ERB,FORMAT:1,PROJNUM:1,GENDATE:1,
        INVDATE:1,ARCHIVER:1,NUMFILES:1,TPFIRSTORB:1,
        TPLASTORB:1,TPSTART:1,TPSTOP:1,TPALGORITHM:1,
        COORDSYS:1,SYNOPSTART:1,SYNOPSTOP:1)
  & ITEM(TAPEID:1,FILE:1,ITEM:1,ITSTART:1,ITSTOP:1,RECNUM:1,
        ITALGORITHM:1,ITLEN:1)
  & DESCR(ITEM:1,NAME:1)
  & RTAPE-PLAYBACK(NOTAPE:1,TAPETYPE:1,PLAYBACK:1,PB:1,
          FILE:1,CATALOG:1,RTITLE:1)
  & RTAPE-PLAYBACK-CATALOG(NOTAPE:2,TAPETYPE:2,PLAYBACK:2,
          PB:1,FILE:2,CATALOG:2,LON:1,LAT:1,ALT:1,ZEN:1,
          TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,OFF,
          RTITLE:2)
  & RDATES-CATALOG(DATE:1,CATALOG:3,LON:1,LAT:1,ALT:1,
           ZEN:1,TIME:1,QUALITY:1,ON,ILLUMIN:1,CALIB:1,
           OFF)
  & NOTAPE:1 = NUM(TAPEID:1) ) )
```

Figure 1.1 The global data manager - new version

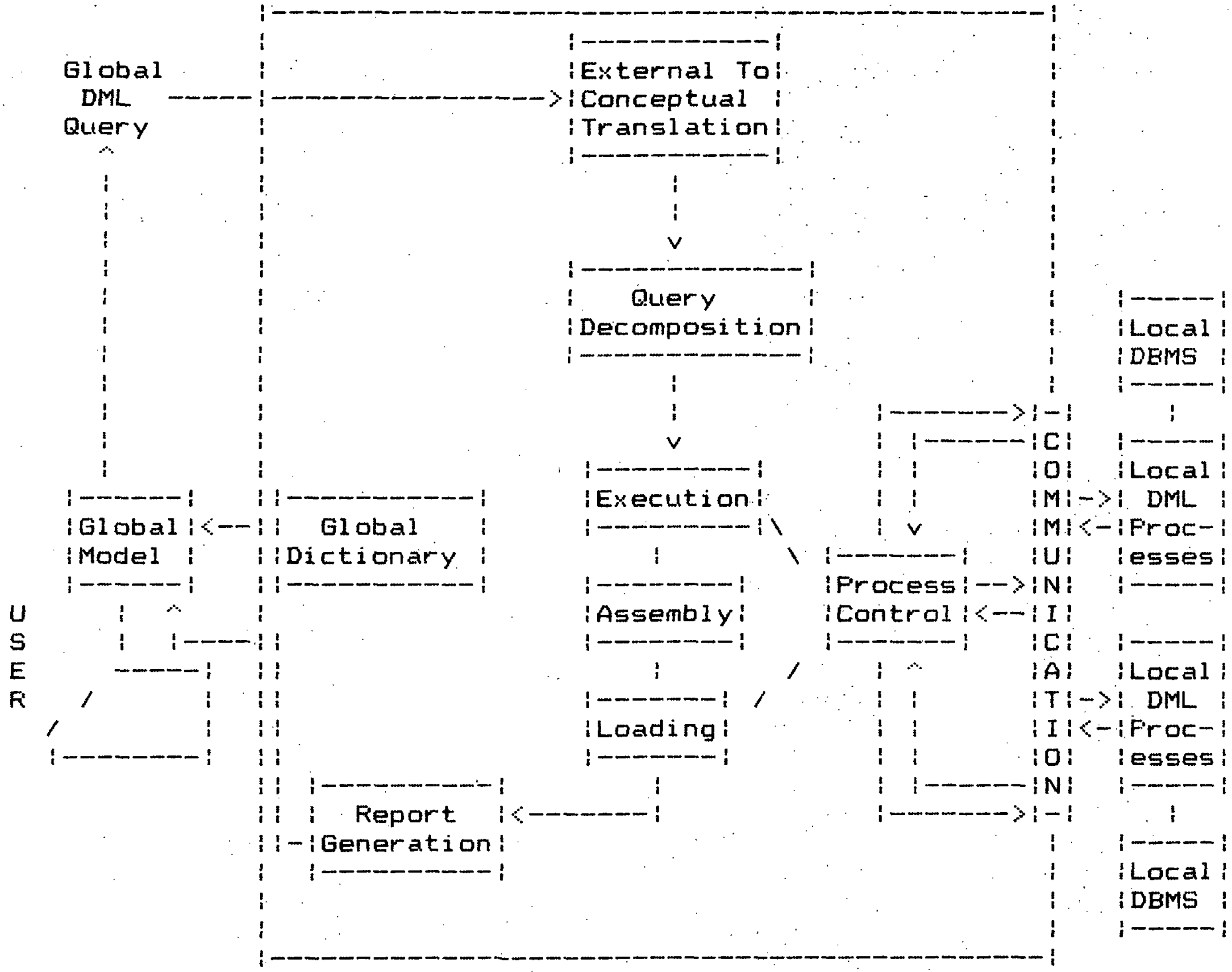

Figure 1.2 The global data manager - old version

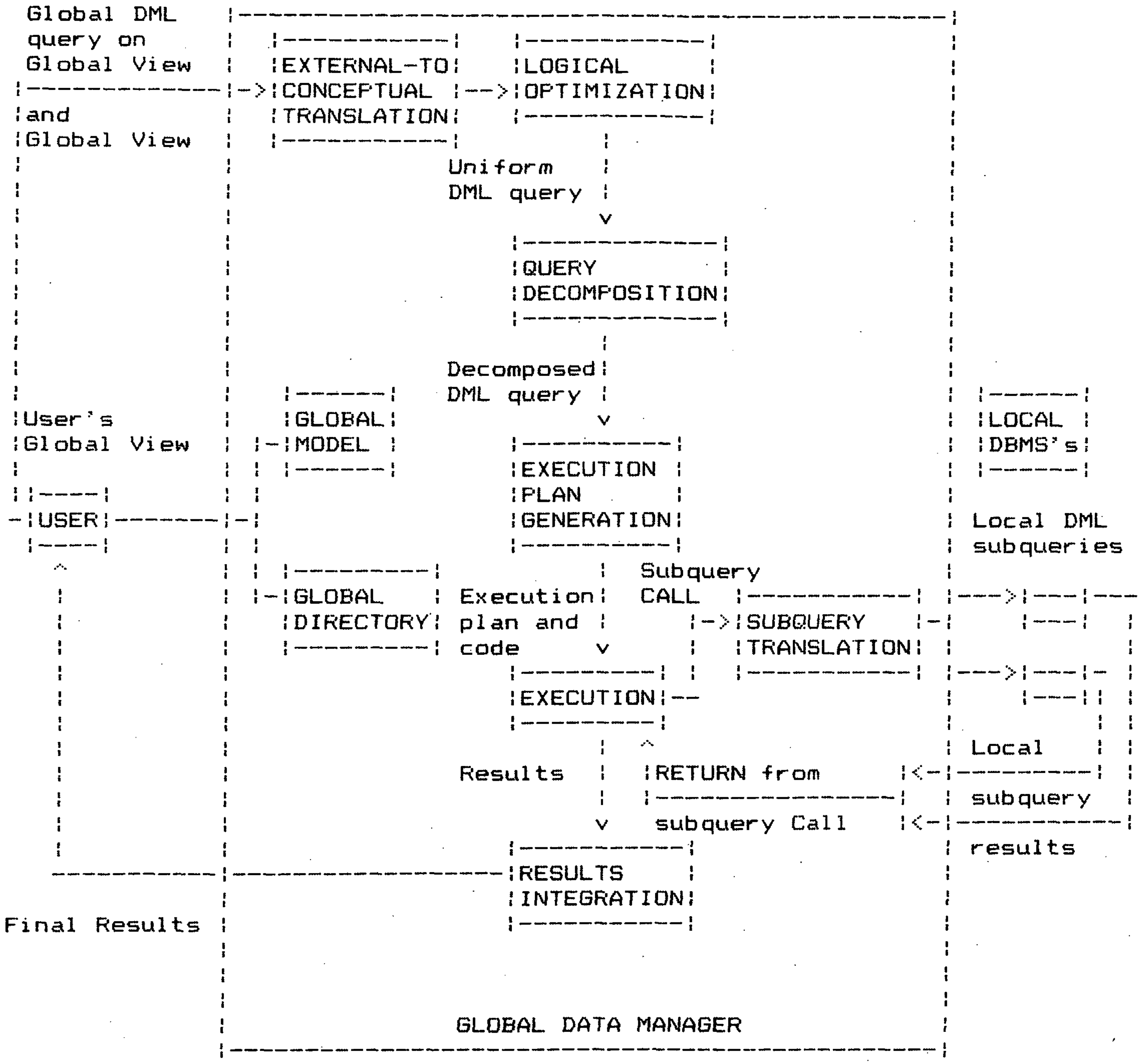

Figure 2.1 An instance of the ERB-ORAC database

TAPEINFO				
NOTAPE	TAPETYPE	TITLE1	TITLE2	TITLE3
1003	SDT	NIMBUS6...	BY...	DATA...
1004	SDT	NIMBUS6...	BY...	DATA...

FILEINFO		
PB	FILE	NOTAPE
174000	2	1003
174010	3	1003
174570	2	1004
174590	3	1004

RECINFO							
DATE_TIME	DATE	TIME	LON	LAT	ALT	ZEN	PB
	QUALITY	ELECTR	ILLUMIN	CALIB	SCAN		
790103124549	790103	124549	15857	-100	111250	15363	174000
	0	ON	NIGHT	NO	OFF		
790105145629	790105	145629	2590	-96	111230	15397	174590
	0	ON	NIGHT	NO	OFF		
790117110204	790117	110204	275	1043	110500	3411	174570
	0	ON	NIGHT	NO	OFF		
790107105349	790107	105349	482	1084	110300	3559	174010
	8	OFF	DAY	YES	ON		

Figure 2.2 An instance of the ERB-SEED database

```
¦---------------------------------------------------------------¦
¦                           RTAPE                               ¦
¦---------------------------------------------------¦-----------¦
¦NO  ¦TAPE¦                PLAYBACK                 ¦  RTITLE   ¦
¦TAPE¦TYPE¦-----------------------------------------¦-----------¦
¦    ¦    ¦  FB   ¦NO  ¦         CATALOG            ¦   TITLE   ¦
¦    ¦    ¦       ¦FILE¦----------------------------¦           ¦
¦    ¦    ¦       ¦    ¦ LON   ¦ LAT  ¦  ALT   ¦ ZEN ¦           ¦
¦    ¦    ¦       ¦    ¦  ¦TIME1 ¦QUALITY¦ELECTR¦   ¦           ¦
¦    ¦    ¦       ¦    ¦   ¦ILLUMIN ¦CALIB¦SCAN¦    ¦           ¦
¦---------------------------------------------------------------¦
¦1010¦SDT ¦           e(PLAYBACK):1                 ¦e(RTITLE):1¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦81261.4¦ 4  ¦     e(CATALOG):1           ¦NIMBUS6... ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦    ¦    ¦       ¦    ¦-133.69¦-55.62¦1123.70¦98.71¦BY...      ¦
¦    ¦    ¦       ¦    ¦  ¦012076¦   1   ¦  ON  ¦   ¦-----------¦
¦    ¦    ¦       ¦    ¦   ¦TWILIGHT¦ NO  ¦OFF ¦    ¦DATA...    ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦    ¦    ¦       ¦    ¦-134.25¦-56.47¦1123.90¦97.82¦           ¦
¦    ¦    ¦       ¦    ¦  ¦012109 ¦  1   ¦  ON  ¦   ¦           ¦
¦    ¦    ¦       ¦    ¦   ¦TWILIGHT¦ NO  ¦OFF ¦    ¦           ¦
¦---------------------------------------------------------------¦
¦2010¦SDT ¦           e(PLAYBACK):2                 ¦e(RTITLE):2¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦81261.0¦ 3  ¦     e(CATALOG):2           ¦NIMBUS7... ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦    ¦    ¦       ¦    ¦155.04 ¦-80.07¦1126.80¦66.65¦BY...      ¦
¦    ¦    ¦       ¦    ¦  ¦021349¦   0   ¦  ON  ¦   ¦-----------¦
¦    ¦    ¦       ¦    ¦   ¦DAY     ¦ NO  ¦OFF ¦    ¦DATA...    ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦---------------------------------------------------------------¦
```

```
¦----------------------------------------------------------------------¦
¦                               RDATES                                  ¦
¦----------------------------------------------------------------------¦
¦DATE1 ¦                          CATALOG                               ¦
¦      ¦---------------------------------------------------------------¦
¦      ¦  LON   ¦ LAT   ¦  ALT   ¦ ZEN ¦TIME1  ¦QUALITY¦ELECTR¦
¦      ¦                ¦ILLUMIN ¦CALIB¦SCAN¦                           ¦
¦----------------------------------------------------------------------¦
¦790101¦                     e(CATALOG):1                               ¦
¦      ¦---------------------------------------------------------------¦
¦      ¦-133.69¦-55.62¦1123.70¦98.71¦012076¦   1    ¦  ON  ¦
¦      ¦               ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦      ¦---------------------------------------------------------------¦
¦      ¦-134.25¦-56.47¦1123.90¦97.82¦012109¦   1    ¦  ON  ¦
¦      ¦               ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790201¦                     e(CATALOG):2                               ¦
¦      ¦---------------------------------------------------------------¦
¦      ¦155.04 ¦-80.07¦1126.80¦66.65¦021349¦   0    ¦  ON  ¦
¦      ¦               ¦DAY     ¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦


¦--------------------------------------------------------------------¦
¦                               RLON                                  ¦
¦--------------------------------------------------------------------¦
¦ILON¦                          CATALOG                               ¦
¦    ¦---------------------------------------------------------------¦
¦    ¦  LON   ¦ LAT   ¦  ALT   ¦ ZEN ¦TIME1  ¦QUALITY¦ELECTR¦
¦    ¦                ¦ILLUMIN ¦CALIB¦SCAN¦                           ¦
¦--------------------------------------------------------------------¦
¦-133¦                     e(CATALOG):3                               ¦
¦    ¦---------------------------------------------------------------¦
¦    ¦-133.69¦-55.62¦1123.70¦98.71¦012076¦   1    ¦  ON  ¦
¦    ¦               ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦--------------------------------------------------------------------¦
¦-134¦                     e(CATALOG):4                               ¦
¦    ¦---------------------------------------------------------------¦
¦    ¦-134.25¦-56.47¦1123.90¦97.82¦012109¦   1    ¦  ON  ¦
¦    ¦               ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦--------------------------------------------------------------------¦
¦155 ¦                     e(CATALOG):2                               ¦
¦    ¦---------------------------------------------------------------¦
¦    ¦155.04 ¦-80.07¦1126.80¦66.65¦021349¦   0    ¦  ON  ¦
¦    ¦               ¦DAY     ¦ NO  ¦OFF ¦                            ¦
¦--------------------------------------------------------------------¦
```

```
|-------------------------------------------------------------|
|                           RLAT                              |
|-------------------------------------------------------------|
|ILAT|                      CATALOG                           |
|    |--------------------------------------------------------|
|    |  LON   | LAT   |   ALT   | ZEN |TIME1  |QUALITY|ELECTR|
|    |                |ILLUMIN |CALIB|SCAN|                    |
|-------------------------------------------------------------|
|-55 |                 e(CATALOG):3                           |
|    |--------------------------------------------------------|
|    |-133.69|-55.62|1123.70|98.71|012076|    1    |  ON      |
|    |              |TWILIGHT| NO   |OFF |                     |
|-------------------------------------------------------------|
|-56 |                 e(CATALOG):4                           |
|    |--------------------------------------------------------|
|    |-134.25|-56.47|1123.90|97.82|012109|    1    |  ON      |
|    |              |TWILIGHT| NO   |OFF |                     |
|-------------------------------------------------------------|
|-80 |                 e(CATALOG):2                           |
|    |--------------------------------------------------------|
|    |155.04 |-80.07|1126.80|66.65|021349|    0    |  ON      |
|    |              |DAY     | NO   |OFF |                     |
|-------------------------------------------------------------|
```

```
|-------------------------------------------------------------|
|                           RALT                              |
|-------------------------------------------------------------|
|IALT|                      CATALOG                           |
|    |--------------------------------------------------------|
|    |  LON   | LAT   |   ALT   | ZEN |TIME1  |QUALITY|ELECTR|
|    |                |ILLUMIN |CALIB|SCAN|                    |
|-------------------------------------------------------------|
|1123|                 e(CATALOG):1                           |
|    |--------------------------------------------------------|
|    |-133.69|-55.62|1123.70|98.71|012076|    1    |  ON      |
|    |              |TWILIGHT| NO   |OFF |                     |
|    |--------------------------------------------------------|
|    |-134.25|-56.47|1123.90|97.82|012109|    1    |  ON      |
|    |              |TWILIGHT| NO   |OFF |                     |
|-------------------------------------------------------------|
|1126|                 e(CATALOG):2                           |
|    |--------------------------------------------------------|
|    |155.04 |-80.07|1126.80|66.65|021349|    0    |  ON      |
|    |              |DAY     | NO   |OFF |                     |
|-------------------------------------------------------------|
¦-------------------------------------------------------¦
¦                           RZEN                        ¦
¦-------------------------------------------------------¦
¦IZEN¦                      CATALOG                     ¦
¦    ¦--------------------------------------------------¦
¦    ¦ LON   ¦ LAT  ¦  ALT  ¦ ZEN ¦TIME1 ¦QUALITY¦ELECTR¦
¦    ¦            ¦ILLUMIN ¦CALIB¦SCAN¦                 ¦
¦-------------------------------------------------------¦
¦ 98 ¦                 e(CATALOG):3                     ¦
¦    ¦--------------------------------------------------¦
¦    ¦-133.69¦-55.62¦1123.70¦98.71¦012076¦   1   ¦ ON   ¦
¦    ¦            ¦TWILIGHT¦ NO  ¦OFF ¦                 ¦
¦-------------------------------------------------------¦
¦ 97 ¦                 e(CATALOG):4                     ¦
¦    ¦--------------------------------------------------¦
¦    ¦-134.25¦-56.47¦1123.90¦97.82¦012109¦   1   ¦ ON   ¦
¦    ¦            ¦TWILIGHT¦ NO  ¦OFF ¦                 ¦
¦-------------------------------------------------------¦
¦ 66 ¦                 e(CATALOG):2                     ¦
¦    ¦--------------------------------------------------¦
¦    ¦155.04 ¦-80.07¦1126.80¦66.65¦021349¦   0   ¦ ON   ¦
¦    ¦            ¦DAY     ¦ NO  ¦OFF ¦                 ¦
¦-------------------------------------------------------¦
```

FUNCTIONS TITLE1, TITLE2, TITLE3

```
¦------¦----------¦---------¦---------¦
¦NOTAPE¦  TITLE1  ¦ TITLE2  ¦ TITLE3  ¦
¦------¦----------¦---------¦---------¦
¦1010  ¦NIMBUS6...¦BY...    ¦DATA...  ¦
¦------¦----------¦---------¦---------¦
¦2010  ¦NIMBUS7...¦BY...    ¦DATA...  ¦
¦------¦----------¦---------¦---------¦
```

Figure 2.3 An instance of the PCDB database

TAPE

TAPEID	MISSION	SENSOR	FORMAT	PROJNUM	GENDATE	INVDATE	ARCHIVER	NUMFILES	TPFIRSTORB	TPLASTORB	TPSTART	TPSTOP	TPALGORITHM	COORDSYS	SYNOPSTART	SYNOPSTOP
1003	NIMBUS6	ERB	PARM-SS	00080	198208130000	19830406	SMITH	9	10000	12000	197812020000	197905310000	1	GEOMAC	197841500000	197841500000
1010	NIMBUS6	ERB	PARM-LD	00082	198002100000	19830406	SMITH	10	8000	9000	197812042100	197812082100	2	GEODETIC	197851600000	197851600000

FILE

TAPEID	FILENUM	FLFIRSTORB	FLLASTORB	FLSTART	FLSTOP	FLALGORITHM	NUMITEMS	FLLEN
1003	2	35	38	197711500000	197711800000	1	10	104800
1010	4	36	39	197812000000	197812200000	3	12	106800

ITEM

TAPEID	FILE NUM	ITEM	ITSTART	ITSTOP	REC NUM	ITAL GORITHM	ITLEN
1003	2	WGMON	197711500000	197711800000	43	1	3000
1010	4	MAP	197812000000	197812200000	31	3	2000

```
¦---------------------------------------------------------¦
¦                         CAT                             ¦
¦---------------------------------------------------------¦
¦TAPEID¦FILENUM¦ITEM ¦CAT¦ FUNCTION   ¦     CATEGORY      ¦
¦---------------------------------------------------------¦
¦ 1003 ¦   2   ¦WGMON¦SST¦YOU MAY... ¦SEA SURFACE TEMP... ¦
¦---------------------------------------------------------¦
¦ 1010 ¦   4   ¦MAP  ¦SST¦YOU MAY... ¦SEA SURFACE TEMP... ¦
¦---------------------------------------------------------¦
```

```
¦-----------------¦
¦      DESCR      ¦
¦-----------------¦
¦ITEM ¦    NAME   ¦
¦-----------------¦
¦WGMON¦WORLD GRID ¦
¦-----------------¦
¦MAP  ¦MONTHLY MAP¦
¦-----------------¦
```

Figure 2.4 The induced ERB-R database instance

TAPEINFO

NOTAPE	TAPETYPE	TITLE1	TITLE2	TITLE3
1010	SDT	NIMBUS6...	BY...	DATA...
2010	SDT	NIMBUS7...	BY...	DATA...

FILEINFO

PB	FILE	NOTAPE
81261.4	4	1010
81261.0	3	2010

RECINFO

DATE	TIME	LON	LAT	ALT	ZEN	PB	QUALITY
		ELECTR	ILLUMIN	CALIB	SCAN		
790101	012076	-133.69	-55.62	1123.70	98.71	81261.4	1
		ON	TWILIGHT	NO	OFF		
790101	012109	-134.25	-56.47	1123.90	97.82	81261.4	1
		ON	TWILIGHT	NO	OFF		
790201	021349	155.04	-80.07	1126.80	66.65	81261.0	0
		ON	DAY	NO	OFF		

Figure 2.5 The induced ERB-N database instance

```
¦---------------------------------------------------------------¦
¦                          RTAPE                                ¦
¦---------------------------------------------------¦-----------¦
¦NO  ¦TAPE¦               PLAYBACK                  ¦  RTITLE   ¦
¦TAPE¦TYPE¦-----------------------------------------¦-----------¦
¦    ¦    ¦  PB   ¦NO  ¦        CATALOG             ¦   TITLE   ¦
¦    ¦    ¦       ¦FILE¦----------------------------¦           ¦
¦    ¦    ¦       ¦    ¦ LON  ¦ LAT ¦  ALT  ¦ ZEN   ¦           ¦
¦    ¦    ¦       ¦    ¦  ¦TIME1 ¦QUALITY¦ELECTR¦   ¦           ¦
¦    ¦    ¦       ¦    ¦   ¦ILLUMIN ¦CALIB¦SCAN¦    ¦           ¦
¦---------------------------------------------------------------¦
¦1003¦SDT ¦            e(PLAYBACK):3                ¦e(RTITLE):1¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦17400.0¦ 2  ¦        e(CATALOG):5        ¦NIMBUS6... ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦    ¦    ¦       ¦    ¦158.57¦-1.00¦1112.50¦153.63 ¦BY...      ¦
¦    ¦    ¦       ¦    ¦  ¦124549¦   0   ¦  ON  ¦   ¦-----------¦
¦    ¦    ¦       ¦    ¦   ¦ NIGHT  ¦ NO  ¦OFF ¦     ¦DATA...    ¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦17401.0¦ 3  ¦        e(CATALOG):6        ¦           ¦
¦    ¦    ¦       ¦    ¦----------------------------¦           ¦
¦    ¦    ¦       ¦    ¦4.82  ¦10.84¦1103.00¦35.59  ¦           ¦
¦    ¦    ¦       ¦    ¦  ¦105349¦   8   ¦  OFF ¦   ¦           ¦
¦    ¦    ¦       ¦    ¦   ¦ DAY    ¦ YES ¦ON  ¦     ¦           ¦
¦---------------------------------------------------------------¦
¦1004¦SDT ¦            e(PLAYBACK):4                ¦e(RTITLE):2¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦17457.0¦ 2  ¦        e(CATALOG):7        ¦NIMBUS6... ¦
¦    ¦    ¦       ¦    ¦----------------------------¦-----------¦
¦    ¦    ¦       ¦    ¦2.75  ¦10.43¦1105.00¦34.11  ¦BY...      ¦
¦    ¦    ¦       ¦    ¦  ¦110204¦   0   ¦  ON  ¦   ¦-----------¦
¦    ¦    ¦       ¦    ¦   ¦ NIGHT  ¦ NO  ¦OFF ¦     ¦DATA...    ¦
¦    ¦    ¦-----------------------------------------¦-----------¦
¦    ¦    ¦17459.0¦ 3  ¦        e(CATALOG):8        ¦           ¦
¦    ¦    ¦       ¦    ¦----------------------------¦           ¦
¦    ¦    ¦       ¦    ¦25.90 ¦-0.96¦1112.30¦153.97 ¦           ¦
¦    ¦    ¦       ¦    ¦  ¦145629¦   0   ¦  ON  ¦   ¦           ¦
¦    ¦    ¦       ¦    ¦   ¦ NIGHT  ¦ NO  ¦OFF ¦     ¦           ¦
¦---------------------------------------------------------------¦
```

```
|----------------------------------------------------------|
|                         RDATES                           |
|----------------------------------------------------------|
|DATE1 |                    CATALOG                        |
|      |---------------------------------------------------|
|      |  LON  | LAT  |  ALT  | ZEN  |TIME1 |QUALITY|ELECTR|
|      |            |ILLUMIN|CALIB|SCAN|                   |
|----------------------------------------------------------|
|790103|                  e(CATALOG):5                     |
|      |---------------------------------------------------|
|      |158.57 |-1.00 |1112.50|153.63|124549|   0   |  ON  |
|      |            | NIGHT | NO  |OFF |                   |
|------|---------------------------------------------------|
|790105|                  e(CATALOG):8                     |
|      |---------------------------------------------------|
|      |25.90  |-0.96 |1112.30|153.97|145629|   0   |  ON  |
|      |            | NIGHT | NO  |OFF |                   |
|------|---------------------------------------------------|
|790117|                  e(CATALOG):7                     |
|      |---------------------------------------------------|
|      |2.75   |10.43 |1105.00|34.11 |110204|   0   |  ON  |
|      |            | NIGHT | NO  |OFF |                   |
|------|---------------------------------------------------|
|790107|                  e(CATALOG):6                     |
|      |---------------------------------------------------|
|      |4.82   |10.84 |1103.00|35.59 |105349|   8   |  OFF |
|      |            | DAY   | YES |ON  |                   |
|------|---------------------------------------------------|
```

FUNCTIONS TITLE1, TITLE2, TITLE3

```
|------|----------|--------|--------|
|NOTAPE|  TITLE1  | TITLE2 | TITLE3 |
|------|----------|--------|--------|
|1003  |NIMBUS6...|BY...   |DATA... |
|------|----------|--------|--------|
|1004  |NIMBUS6...|BY...   |DATA... |
|------|----------|--------|--------|
```

Figure 2.6 An instance of the GLOBE database

TAPEINFO

NOTAPE	TAPETYPE	TITLE1	TITLE2	TITLE3
1003	SDT	NIMBUS6...	BY...	DATA...
1004	SDT	NIMBUS6...	BY...	DATA...

FILEINFO

PB	FILE	NOTAPE
174000	2	1003
174010	3	1003
174570	2	1004
174590	3	1004

RECINFO

DATE_TIME	DATE	TIME	LON	LAT	ALT	ZEN	PB
	QUALITY	ELECTR	ILLUMIN	CALIB	SCAN		
790103124549	790103	124549	15857	-100	111250	15363	174000
	0	ON	NIGHT	NO	OFF		
790105145629	790105	145629	2590	-96	111230	15397	174590
	0	ON	NIGHT	NO	OFF		
790117110204	790117	110204	275	1043	110500	3411	174570
	0	ON	NIGHT	NO	OFF		
790107105349	790107	105349	482	1084	110300	3559	174010
	8	OFF	DAY	YES	ON		

```
|----------------------------------------------------------------------|
|                            RTAPE                                     |
|----------------------------------------------------------------------|
|NO  |TAPE|                    PLAYBACK                    |RTITLE     |
|TAPE|TYPE|------------------------------------------------|-----------|
|    |    |  PB   |FILE|            CATALOG                | TITLE     |
|    |    |       |    |-----------------------------------|           |
|    |    |       |    | LON  | LAT  | ALT    |ZEN  |TIME  |           |
|    |    |       |    |QUA  |ELECTR|ILLUMIN |CALIB|SCAN|           |
|    |    |       |    |LITY|       |         |     |      |           |
|----------------------------------------------------------------------|
|1010|SDT |              e(PLAYBACK):1                     |e(RTITLE)  |
|    |    |------------------------------------------------|   :1      |
|    |    |812614|  4 |      e(CATALOG):1                  |-----------|
|    |    |       |    |-----------------------------------|NIMBUS6    |
|    |    |       |    |-13369|-5562|112370|9871|012076|...        |
|    |    |       |    | 1   |   ON   |TWILIGHT|  NO  |OFF   |-----------|
|    |    |       |    |-----------------------------------|BY...      |
|    |    |       |    |-13425|-5647|112390|9782|012109|-----------|
|    |    |       |    | 1   |   ON   |TWILIGHT|  NO  |OFF   |DATA...    |
|----------------------------------------------------------------------|
|2010|SDT |              e(PLAYBACK):2                     |e(RTITLE)  |
|    |    |------------------------------------------------|   :2      |
|    |    |812610|  3 |      e(CATALOG):2                  |-----------|
|    |    |       |    |-----------------------------------|NIMBUS7    |
|    |    |       |    |15504 |-8007|112680|6665|021349|...        |
|    |    |       |    | 0   |   ON   |DAY      |  NO  |OFF   |-----------|
|    |    |       |    |-----------------------------------|BY...      |
|    |    |       |    |                                   |-----------|
|    |    |       |    |                                   |DATA...    |
|----------------------------------------------------------------------|
¦---------------------------------------------------------¦
¦                         RDATES                          ¦
¦---------------------------------------------------------¦
¦DATE    ¦                  CATALOG                       ¦
¦        ¦------------------------------------------------¦
¦        ¦ LON    ¦ LAT ¦ ALT    ¦ZEN ¦TIME   ¦QUALITY¦ELECTR¦
¦        ¦           ¦ILLUMIN   ¦CALIB ¦SCAN¦             ¦
¦---------------------------------------------------------¦
¦790101  ¦              e(CATALOG):1                      ¦
¦        ¦------------------------------------------------¦
¦        ¦-13369¦-5562¦112370¦9871¦012076¦   1    ¦  ON   ¦
¦        ¦           ¦TWILIGHT ¦  NO  ¦OFF ¦              ¦
¦        ¦------------------------------------------------¦
¦        ¦-13425¦-5647¦112390¦9782¦012109¦   1    ¦  ON   ¦
¦        ¦           ¦TWILIGHT ¦  NO  ¦OFF ¦              ¦
¦---------------------------------------------------------¦
¦790201  ¦              e(CATALOG):2                      ¦
¦        ¦------------------------------------------------¦
¦        ¦15504  ¦-8007¦112680¦6665¦021349¦  0    ¦  ON   ¦
¦        ¦           ¦DAY      ¦  NO  ¦OFF ¦              ¦
¦---------------------------------------------------------¦


¦------------------------------------------------------¦
¦                        RLON                          ¦
¦------------------------------------------------------¦
¦ILON¦                    CATALOG                      ¦
¦    ¦-------------------------------------------------¦
¦    ¦ LON    ¦ LAT ¦ ALT    ¦ZEN ¦TIME   ¦QUALITY¦ELECTR¦
¦    ¦           ¦ILLUMIN   ¦CALIB¦SCAN¦               ¦
¦------------------------------------------------------¦
¦-133¦              e(CATALOG):3                       ¦
¦    ¦-------------------------------------------------¦
¦    ¦-13369¦-5562¦112370¦9871¦012076¦   1    ¦  ON    ¦
¦    ¦           ¦TWILIGHT ¦ NO  ¦OFF ¦                ¦
¦------------------------------------------------------¦
¦-134¦              e(CATALOG):4                       ¦
¦    ¦-------------------------------------------------¦
¦    ¦-13425¦-5647¦112390¦9782¦012109¦   1    ¦  ON    ¦
¦    ¦           ¦TWILIGHT ¦ NO  ¦OFF ¦                ¦
¦------------------------------------------------------¦
¦155 ¦              e(CATALOG):2                       ¦
¦    ¦-------------------------------------------------¦
¦    ¦15504  ¦-8007¦112680¦6665¦021349¦   0    ¦  ON   ¦
¦    ¦           ¦DAY      ¦ NO  ¦OFF ¦                ¦
¦------------------------------------------------------¦
```

```
|---------------------------------------------------------|
|                          RLAT                           |
|---------------------------------------------------------|
|ILAT|                       CATALOG                      |
|    |----------------------------------------------------|
|    | LON   | LAT | ALT    |ZEN |TIME    |QUALITY|ELECTR|
|    |             |ILLUMIN  |CALIB|SCAN|                 |
|---------------------------------------------------------|
|-55 |                   e(CATALOG):3                     |
|    |----------------------------------------------------|
|    |-13369|-5562|112370|9871|012076|    1    |   ON    |
|    |             |TWILIGHT | NO   |OFF |                 |
|---------------------------------------------------------|
|-56 |                   e(CATALOG):4                     |
|    |----------------------------------------------------|
|    |-13425|-5647|112390|9782|012109|    1    |   ON    |
|    |             |TWILIGHT | NO   |OFF |                 |
|---------------------------------------------------------|
|-80 |                   e(CATALOG):2                     |
|    |----------------------------------------------------|
|    |15504 |-8007|112680|6665|021349|    0    |   ON    |
|    |             |DAY      | NO   |OFF |                 |
|---------------------------------------------------------|


|---------------------------------------------------------|
|                          RALT                           |
|---------------------------------------------------------|
|IALT|                       CATALOG                      |
|    |----------------------------------------------------|
|    | LON   | LAT | ALT    |ZEN |TIME    |QUALITY|ELECTR|
|    |             |ILLUMIN  |CALIB|SCAN|                 |
|---------------------------------------------------------|
|1123|                   e(CATALOG):1                     |
|    |----------------------------------------------------|
|    |-13369|-5562|112370|9871|012076|    1    |   ON    |
|    |             |TWILIGHT | NO   |OFF |                 |
|    |----------------------------------------------------|
|    |-13425|-5647|112390|9782|012109|    1    |   ON    |
|    |             |TWILIGHT | NO   |OFF |                 |
|---------------------------------------------------------|
|1126|                   e(CATALOG):2                     |
|    |----------------------------------------------------|
|    |15504 |-8007|112680|6665|021349|    0    |   ON    |
|    |             |DAY      | NO   |OFF |                 |
|---------------------------------------------------------|
¦----------------------------------------------------------------¦
¦                            RZEN                                ¦
¦----------------------------------------------------------------¦
¦IZEN¦                        CATALOG                            ¦
¦    ¦-----------------------------------------------------------¦
¦    ¦ LON    ¦ LAT ¦ ALT   ¦ZEN ¦TIME   ¦QUALITY¦ELECTR¦
¦    ¦             ¦ILLUMIN   ¦CALIB¦SCAN¦                       ¦
¦----------------------------------------------------------------¦
¦ 98 ¦                    e(CATALOG):3                           ¦
¦    ¦-----------------------------------------------------------¦
¦    ¦-13369¦-5562¦112370¦9871¦012076¦   1    ¦  ON   ¦
¦    ¦             ¦TWILIGHT ¦ NO  ¦OFF ¦                        ¦
¦----------------------------------------------------------------¦
¦ 97 ¦                    e(CATALOG):4                           ¦
¦    ¦-----------------------------------------------------------¦
¦    ¦-13425¦-5647¦112390¦9782¦012109¦   1    ¦  ON   ¦
¦    ¦             ¦TWILIGHT ¦ NO  ¦OFF ¦                        ¦
¦----------------------------------------------------------------¦
¦ 66 ¦                    e(CATALOG):2                           ¦
¦    ¦-----------------------------------------------------------¦
¦    ¦15504 ¦-8007¦112680¦6665¦021349¦   0    ¦  ON   ¦
¦    ¦             ¦DAY      ¦ NO  ¦OFF ¦                        ¦
¦----------------------------------------------------------------¦

¦--------------------------------------------------------------------------¦
¦                                  TAPE                                    ¦
¦--------------------------------------------------------------------------¦
¦TAPEID¦MISSION¦SENSOR¦FORMAT  ¦PROJNUM¦  GENDATE    ¦INVDATE  ¦
¦ARCHIVER¦NUMFILES¦TPFIRSTORB¦TPLASTORB¦  TPSTART    ¦         ¦
¦   TPSTOP    ¦TPALGORITHM¦COORDSYS¦ SYNOPSTART  ¦ SYNOPSTOP   ¦
¦--------------------------------------------------------------------------¦
¦ 1003 ¦NIMBUS6¦ ERB  ¦PARM-SS¦ 00080 ¦198208130000¦19830406¦
¦SMITH   ¦   9    ¦  10000    ¦  12000   ¦197812020000¦        ¦
¦197905310000¦     1      ¦GEOMAC  ¦197841500000¦197841500000¦
¦--------------------------------------------------------------------------¦
¦ 1010 ¦NIMBUS6¦ ERB  ¦PARM-LD¦ 00082 ¦198002100000¦19830406¦
¦SMITH   ¦   10   ¦  8000     ¦  9000    ¦197812042100¦        ¦
¦197812082100¦     2      ¦GEODETIC¦197851600000¦197851600000¦
¦--------------------------------------------------------------------------¦
```

```
¦-----------------------------------------------------------¦
¦                        FILE                               ¦
¦-----------------------------------------------------------¦
¦TAPEID¦FILE¦FLFIRSTORB¦FLLASTORB¦  FLSTART    ¦  FLSTOP    ¦
¦              ¦FLALGORITHM¦NUMITEMS¦FLLEN  ¦               ¦
¦-----------------------------------------------------------¦
¦ 1003 ¦ 2  ¦    35    ¦    38   ¦197711500000¦197711800000¦
¦              ¦     1     ¦   10   ¦104800¦                ¦
¦-----------------------------------------------------------¦
¦ 1010 ¦ 4  ¦    36    ¦    39   ¦197812000000¦197812200000¦
¦              ¦     3     ¦   12   ¦106800¦                ¦
¦-----------------------------------------------------------¦


¦--------------------------------------------------------------¦
¦                            ITEM                              ¦
¦--------------------------------------------------------------¦
¦TAPEID¦FILE¦ITEM ¦  ITSTART   ¦   ITSTOP    ¦REC¦ITAL    ¦ITLEN¦
¦      ¦    ¦     ¦            ¦             ¦NUM¦GORITHM ¦     ¦
¦--------------------------------------------------------------¦
¦ 1003 ¦ 2  ¦WGMON¦197711500000¦197711800000¦43 ¦   1    ¦3000 ¦
¦--------------------------------------------------------------¦
¦ 1010 ¦ 4  ¦MAP  ¦197812000000¦197812200000¦31 ¦   3    ¦2000 ¦
¦--------------------------------------------------------------¦


¦-------------------------------------------------------¦
¦                      CAT                              ¦
¦-------------------------------------------------------¦
¦TAPEID¦FILE¦ITEM ¦CAT¦ FUNCTION  ¦     CATEGORY        ¦
¦-------------------------------------------------------¦
¦ 1003 ¦ 2  ¦WGMON¦SST¦YOU MAY... ¦SEA SURFACE TEMP...  ¦
¦-------------------------------------------------------¦
¦ 1010 ¦ 4  ¦MAP  ¦SST¦YOU MAY... ¦SEA SURFACE TEMP...  ¦
¦-------------------------------------------------------¦


¦-----------------¦
¦      DESCR      ¦
¦-----------------¦
¦ITEM ¦   NAME    ¦
¦-----------------¦
¦WGMON¦WORLD GRID ¦
¦-----------------¦
¦MAP  ¦MONTHLY MAP¦
¦-----------------¦
```

FUNCTIONS TITLE1, TITLE2, TITLE3

NOTAPE	TITLE1	TITLE2	TITLE3
1003	NIMBUS6...	BY...	DATA...
1004	NIMBUS6...	BY...	DATA...
1010	NIMBUS6...	BY...	DATA...
2010	NIMBUS7...	BY...	DATA...

Figure 2.7 The induced GLOBE-R database instance

TAPEINFO

NOTAPE	TAPETYPE	TITLE1	TITLE2	TITLE3
1003	SDT	NIMBUS6...	BY...	DATA...
1004	SDT	NIMBUS6...	BY...	DATA...
1010	SDT	NIMBUS6...	BY...	DATA...
2010	SDT	NIMBUS7...	BY...	DATA...

FILEINFO

PB	FILE	NOTAPE
174000	2	1003
174010	3	1003
174570	2	1004
174590	3	1004
812614	4	1010
812610	3	2010

```
¦----------------------------------------------------------------------¦
¦                              RECINFO                                 ¦
¦----------------------------------------------------------------------¦
¦ DATE ¦ TIME ¦ LON   ¦ LAT ¦ ALT   ¦ ZEN ¦  PB  ¦QUALITY¦ELECTR¦
¦                     ¦ILLUMIN ¦CALIB¦SCAN¦                            ¦
¦----------------------------------------------------------------------¦
¦790103¦124549¦15857 ¦-100 ¦111250¦15363¦174000¦   0   ¦  ON  ¦
¦                     ¦NIGHT   ¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790105¦145629¦2590  ¦-96  ¦111230¦15397¦174590¦   0   ¦  ON  ¦
¦                     ¦NIGHT   ¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790117¦110204¦275   ¦1043 ¦110500¦3411 ¦174570¦   0   ¦  ON  ¦
¦                     ¦NIGHT   ¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790107¦105349¦482   ¦1084 ¦110300¦3559 ¦174010¦   8   ¦  OFF ¦
¦                     ¦ DAY    ¦ YES ¦ON  ¦                            ¦
¦----------------------------------------------------------------------¦
¦790101¦012076¦-13369¦-5562¦112370¦9871 ¦812614¦   1   ¦  ON  ¦
¦                     ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790101¦012109¦-13425¦-5647¦112390¦9782 ¦812614¦   1   ¦  ON  ¦
¦                     ¦TWILIGHT¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
¦790201¦021349¦15504 ¦-8007¦112680¦6665 ¦812610¦   0   ¦  ON  ¦
¦                     ¦DAY     ¦ NO  ¦OFF ¦                            ¦
¦----------------------------------------------------------------------¦
```

```
¦-------------------------------------------------------------------¦
¦                               TAPE                                ¦
¦-------------------------------------------------------------------¦
¦TAPEID¦MISSION¦SENSOR¦FORMAT ¦PROJNUM¦   GENDATE    ¦INVDATE ¦
¦ARCHIVER¦NUMFILES¦TPFIRSTORB¦TPLASTORB¦  TPSTART     ¦        ¦
¦   TPSTOP    ¦TPALGORITHM¦COORDSYS¦ SYNOPSTART ¦ SYNOPSTOP  ¦
¦-------------------------------------------------------------------¦
¦ 1003 ¦NIMBUS6¦ ERB  ¦PARM-SS¦ 00080 ¦198208130000¦19830406¦
¦SMITH   ¦   9    ¦  10000   ¦  12000   ¦197812020000¦        ¦
¦197905310000¦     1      ¦GEOMAC  ¦197841500000¦197841500000¦
¦-------------------------------------------------------------------¦
¦ 1010 ¦NIMBUS6¦ ERB  ¦PARM-LD¦ 00082 ¦198002100000¦19830406¦
¦SMITH   ¦   10   ¦  8000    ¦  9000    ¦197812042100¦        ¦
¦197812082100¦     2      ¦GEODETIC¦197851600000¦197851600000¦
¦-------------------------------------------------------------------¦
```

FILE

TAPEID	FILE	FLFIRSTORB	FLLASTORB	FLSTART	FLSTOP	FLALGORITHM	NUMITEMS	FLLEN
1003	2	35	38	197711500000	197711800000	1	10	104800
1010	4	36	39	197812000000	197812200000	3	12	106800

ITEM

TAPEID	FILE	ITEM	ITSTART	ITSTOP	RECNUM	ITALGORITHM	ITLEN
1003	2	WGMON	197711500000	197711800000	43	1	3000
1010	4	MAP	197812000000	197812200000	31	3	2000

CAT

TAPEID	FILE	ITEM	CAT	FUNCTION	CATEGORY
1003	2	WGMON	SST	YOU MAY...	SEA SURFACE TEMP...
1010	4	MAP	SST	YOU MAY...	SEA SURFACE TEMP...

DESCR

ITEM	NAME
WGMON	WORLD GRID
MAP	MONTHLY MAP

Figure 3.1 Answer to query 1 on the database of Figure 2.4

```
|-----------------------------|
|NOTAPE|TAPETYPE|   PB   |FILE|
|-----------------------------|
| 1010 |  SDT   |81261.4| 4   |
|-----------------------------|
| 2010 |  SDT   |81261.0| 3   |
|-----------------------------|
```

Figure 3.2 Answer to query 2 on the database of Figure 2.4

```
|----------------------|
| DATE | TIME |ILLUMIN |
|----------------------|
|790101|012076|TWILIGHT|
|----------------------|
|790101|012109|TWILIGHT|
|----------------------|
```

Figure 3.3 Answer to query 3 on the database of Figure 2.5

TAPETYPE	PB	NOFILE
SDT	17400.0	2
SDT	17401.0	3

Figure 3.4 Answer to query 4 on the database of Figure 2.5

```
|---------------------------------|
|NOTAPE|DATE1 |TIME1 | LON  | LAT |
|---------------------------------|
| 1003 |790107|105349|4.82  |10.84|
|---------------------------------|
| 1004 |790117|110204|2.75  |10.43|
|---------------------------------|
```

Figure 4.1 Answer to query 5 on the database of Figure 2.7

```
|----------------------------|
|PROJNUM|   NAME     | ALT   |
|----------------------------|
| 00080 |WORLD GRID |111250|
|-------|-----------|------|
| 00082 |MONTHLY MAP|112370|
|-------|-----------|------|
| 00082 |MONTHLY MAP|112390|
|----------------------------|
```