FUSEDATA – A Fusion Systems Data Base

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FUSION TECHNOLOGY INSTITUTE

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1. INTRODUCTION

This document describes the Fusion Systems Data Base. The intention of this work is to aid in systematic collection, storage and dissemination of relevant data in fusion plant design work, with emphasis on data useful in availability analysis. The motivation for this study comes from the lack of data for analyzing availability of fusion plants, one of the most important performance and economic indicators of any system. By putting together a framework where data could be systematically accumulated, we have made it substantially easier to install the proper data when it becomes available (at first from the experimental facilities now operating). We do not claim that this framework is perfect or complete; some revisions will undoubtedly be necessary in the future to account for experience with this data base. More "modules", i.e. tables may be added that pertain to some other important aspects of designing a fusion plant; ideally, a fusion systems data base would contain all the information needed to design and analyze such a plant. At this stage, such a task would have been unmanageable for the group that undertook the project in the time given.

The data base consists of different tables that contain information which defines the system, its operating and environmental conditions as well as the necessary performance data (reliability, maintenance, economic, etc.). Refer to chapter 2 to learn in more detail about the organization of the data base. A detailed description of records in the tables contained in this framework is given in Chapter 3. Chapter 4 describes the menu driven program that interfaces the user to the data base and tells the user what to expect when he signs on the computer. Detailed listing and flowcharts of the menu driven program are presented in Appendix A. As of now, the data base is implemented

on the IBM-PC utilizing the data manager called Knowledgemanager (KMAN), which is flexible enough to suit our present purposes. Some groups must be charged with periodically updating and maintaining the data base. As of now, there are no accessibility restrictions applied in the program (i.e., passwords) because at first only very few sites will be contributing to and using the data base.

In the final version of this report, we will also have a procedure for generating a unique and acceptable ID number for each subsystem or component. We also anticipate having a module that automatically converts the data from the data base into the format suitable for input into the availability program AVSYS.

2. ORGANIZATION OF THE DATA BASE

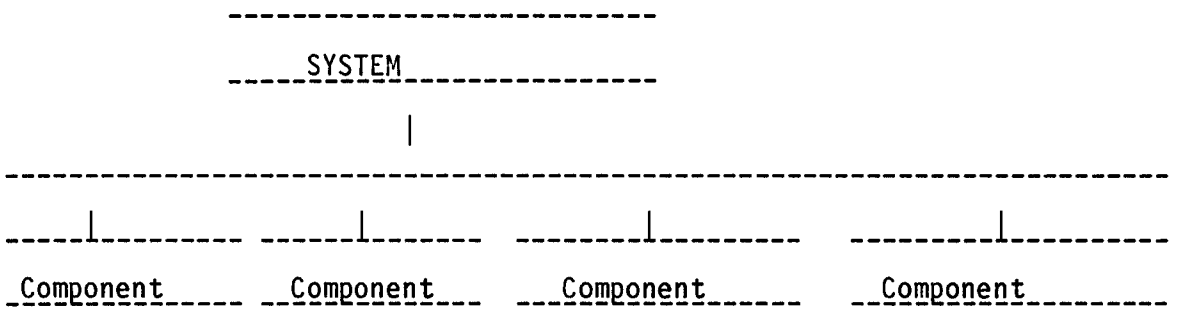
This data base is set up as a number of simple tables which contain basic information about a system or a component. The tables are arranged in nine basic categories as follows:

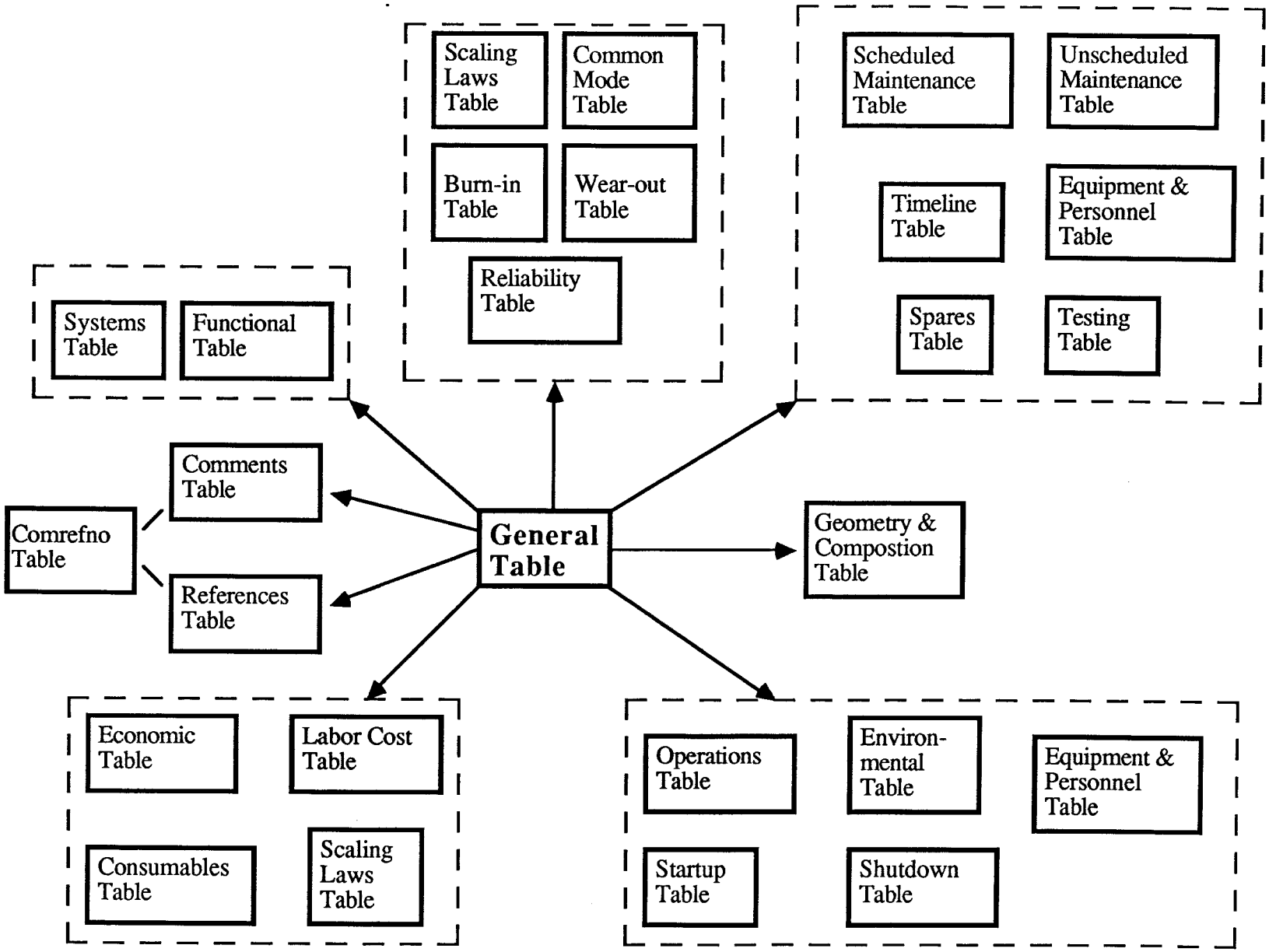
1. General
2. Geometry and Composition
3. System's
4. Reliability
5. Maintenance
6. Operations
7. Economic
8. Comments
9. References

Each of these categories has from one to six associated tables. Figure 2-1 shows the tables and how they are associated.

2.1 Definition of Systems and Components

The data base is arranged in a modular fashion such that components are independent "building block" units which can be put together to form a system as shown below.





FUSEDATA LAYOUT

Figure 2-1. Fusion systems data base layout.

A component is defined as a unit which (for purposes of the data base) is broken down or analyzed as far as needed or as far as availability of data permits. For example, a motor can be considered as a component if it is treated as a black box with input and output rather than broken down into armature, winding, etc. A system is defined as a coherent set of components. For example, a motor can be identified as a system if it is composed of an armature, winding, etc. which are defined as components in the data base. The meaning of the terms "system" and "component" is therefore dynamic and dependent upon the modeler's purpose in using them. Components of a system are identified in the systems table. If the motor were a system, its components would be listed as armature, winding, etc. However, the armature and winding would not identify themselves as part of a particular system of the motor. In this way, connections between systems and components can be considered to be defined in the downward but not the "upward" direction, preserving the building block nature of the components.

2.2 Tables

This is a relational data base consisting of 26 tables. Figure 2-2 shows the format of a typical table in the data base. Refer to Fig. 2-1 for the basic grouping of the tables. The organization of the tables can best be described using an employment application as an analogy. This organization has to be looked at from two different points of view -- the applicant's and the company's.

Say the applicant wants to apply for 19 different jobs in one company. After he fills out a general application, he must fill out one for each of the jobs he is applying for. Each application requires some information that uniquely identifies the applicant, some information specific to the job or the

Equipment and Personnel Table

1. System ID# _____
2. System name _____
3. Type of maintenance _
4. Maintenance mode ID# ___
5. Procedure number ___
6. Type of equipment used ID# _____
7. Number needed ___
8. Comments _____
9. References _____
10. Date of Last Update __/__/__

Figure 2-2. Typical Table Format

class of job he is applying for and some background information such as references. This is analogous to filling in all of the tables for a particular component.

From the company's point of view, all of the applications that come in have to be filed and reviewed as needed. There may be 100 applications for one job and only 5 for another. The company may want to consider only those applicants with certain qualifications listed on their applications. They may decide they want some statistics on the ages of the applicants or may want to pick out some other information. In this way, the company is analogous to the modeller using the data base.

This is about as far as the applicant-company analogy can be taken. It serves to illustrate the basic organization of the data tables except for the few tables that are not keyed off the system/component ID number, and therefore don't have separate data records for each system/component. These are the consumable materials table, and the reference and the comments tables. For example, the reference table is a list of references in the order they are entered into the data base and any reference can be cited in any table.

3. DETAILED DESCRIPTION OF TABLES

3.1 Introduction

Twenty six tables have been set up. These are categorized into nine groups according to their contents. The table structure is illustrated in Fig. 2-1. An exact listing of the fields in each table of the FSDB is contained in Appendix E; since each field name has a maximum length, the fields listed in Appendix E for each table are descriptive and are not the actual names used in the FSDB I/O processor.

As has already been discussed in the preceding chapter, a table consists of a number of records and each record contains several fields. The data formats of fields have been defined. The format will be specified by "STR N" or "NUM N", where N is an integer. "STR N" indicates that the format is a string of N characters, and "NUM N" indicates a string of N digits.

Everything in a reactor plant can be a system. A subsystem of a system is a unit at one level below the system, when a hierarchical structure of the system is taken into account.

Most records contain common fields: a system identification number, a comment ID# field, a reference ID# field, and the last update date of the record.

In the following section the contents of each table will be described. Field names and their formats will be defined. In the last section, identification number systems to be used throughout the present data base will be proposed.

3.2 Table Description

GROUP 1

This group consists of only one table, the General Table. This table gives a brief description of a system such as physical size and weight, primary input and output names and their typical values, and environmental conditions for normal operation. Whenever data for a new system is added to the data base, a new record for the system must be created in the General Table. For a user who tries to retrieve data from the data base, this table is likely the first table to be consulted. See Table 1, Appendix E.

GROUP 2

This group consists of two tables: Systems and Functional. The Systems Table details the system definition in terms of its subsystems and also indicates the interconnections among its subsystems. A record contains input and output connections for one of the subsystems. Each system ID # field has a duplicate subsystem identifier field in the case that one system has two or more identical subsystems. In this case it is necessary to distinguish between these identical subsystems. Also, the subsystem names of a system can be found in the General Table.

The Functional Table contains all the inputs and outputs of each system. A record includes the system id#, the duplicate subsystem distinguishing field, an input or output id# and name and a quantitative description of the I/O.

See Tables 2 and 3, Appendix E.

GROUP 3

This group consists of only one table, the Geometry and Composition Table. This table includes information on geometrical structure and material

composition of a system. The geometry itself is not included in this table. Instead only ID numbers of references where detailed mechanical drawings can be found are listed. In the near future, graphics files, which may be created by means of a computer aided design (CAD) system, can be associated with this table.

See Table 4, Appendix E.

GROUP 4

This group consists of five tables: Reliability, Common Mode Failure, Burnin, Wearout, and Reliability Scaling Law.

The system failure rate, $\lambda(t)$, is in general a function of time. We assume that $\lambda(t)$ is represented by the Bathtub curve as illustrated in Fig. 3-1. The curve is characterized by a relatively high early failure rate (the burn-in period) followed by a fairly constant prime-of-life period where failures occur randomly, and then a final wearout or burn-out phase [3-1].

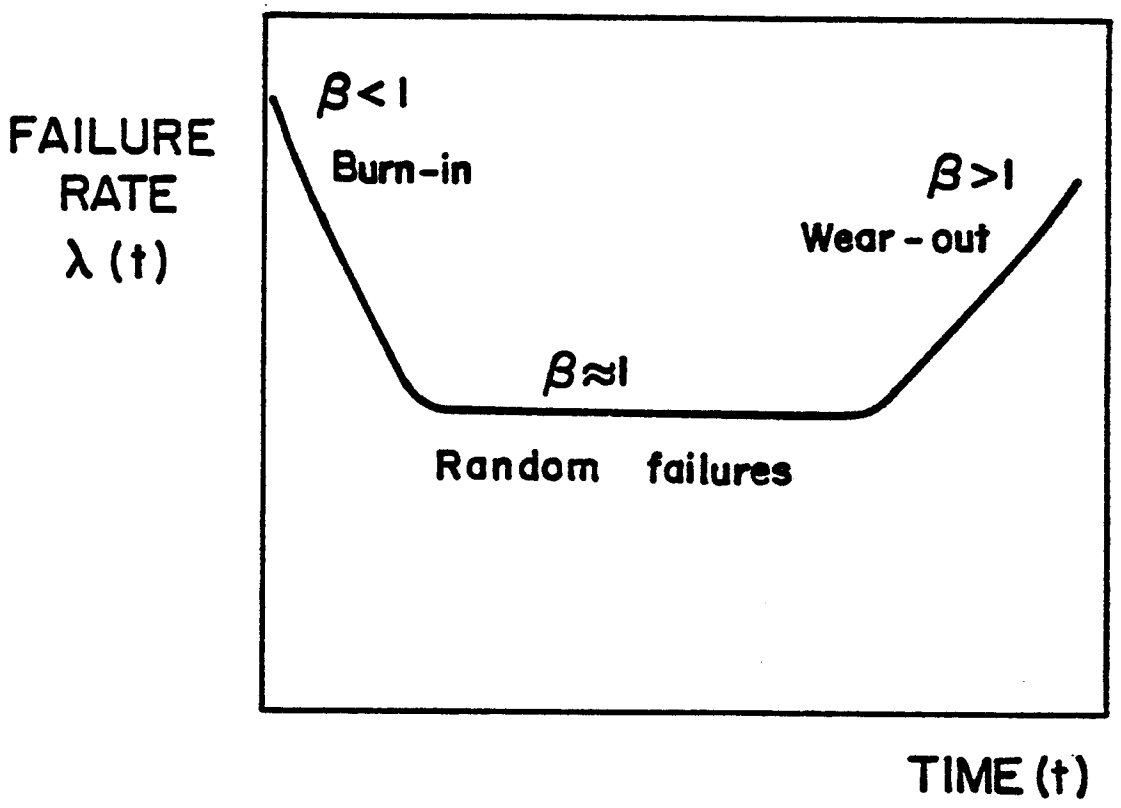
$\lambda(t)$ can be represented as [3-1]

$$\lambda(t) = \lambda_c a t^{\beta-1} \tag{3.1}$$

In the present work, we use three distinct periods:

(I) burnin period	$0 < t < T_1$,
(II) random failure period	$T_1 < t < T_2$
(III) wearout period	$T_2 < t$,

where T_1 and T_2 are called the maturity age and the lifetime, respectively. In each period, it is assumed that λ_c and β are constant and these parameters have normal statistical distributions. The standard deviations of these para-



Weibull distribution: $\lambda(t) = \lambda_c \beta t^{\beta-1}$, λ_c = constant, β = constant

Fig. 3-1. The bathtub curve.

meters are listed in the tables. λ_c and β for periods I, II, and III are stored in the Burnin, Reliability, and Wearout Tables, respectively.

Common mode failures are system failures, which take place due to some other specific system failure(s). This failure data is accumulated in the Common Mode Failure Table.

The Reliability Scaling Law Table contains scaling laws used to obtain the constant failure rates, λ_c, for period II ($\beta = 1$) of systems that are similar to a given system but either have different ratings or operating environments. The failure rate is scaled with respect to operational environment, size and weight of the system, and so on. At present, no expression for the scaling is available. Hence we propose tentative formulas as follows:

$$Ax^C + By^D \tag{3.2}$$

$$Ax^C y^D \tag{3.3}$$

where A, B, C, and D are constants, and x and y are variables for which the failure rate is scaled (e.g., mass, power rating, etc.).

See Tables 10-14, Appendix E.

GROUP 5

This group consists of six tables: Scheduled Maintenance, Unscheduled Maintenance, Maintenance Timeline, Testing, Equipment & Personnel, and Spare Parts Tables.

The Spare Parts Table details which systems and how many subsystems of each system should have spares available to maximize the system availability.

The Scheduled Maintenance Table provides types of preventive maintenance, their frequency, the state of the system during the maintenance, and the aver-

age total maintenance time along with distribution of this time. If necessary, the Maintenance Timeline and Equipment & Personnel Tables may be referred to.

The Unscheduled Maintenance Table contains system repair information. Since a repair is specific to a failure mode, a system failure mode ID defined in the Reliability Table is listed along with a maintenance mode ID, average total repair time, and its distribution.

The Maintenance Timeline Table provides maintenance timeline information: procedure numbers, procedure start time, and procedure duration. If a specific testing of the system is needed at the beginning or end of a procedure, the Testing Table is referred to.

The Testing Table contains system testing information. All probable testing types and their procedures are included. Since a repair is required for positive results of testing, if a failure is detected during the testing, appropriate unscheduled maintenance should be performed.

Equipment & Personnel Table - see the description in group 6 below.

See Tables 9, 15-19, Appendix E.

GROUP 6

This group consists of five tables: Operations, Startup, Shutdown, Environmental, and Equipment & Personnel Tables.

The Operations Table provides data on procedures for normal operation of a system.

The Startup and Shutdown Tables contain procedure data of system startup and shutdown. A startup or shutdown operation is divided into a sequence of procedures, and the start time and average duration of each procedure are listed.

The Environmental Table contains environmental conditions under which a system is normally operated and other non-optimal conditions. Environmental parameter names such as ambient temperature and pressure are provided along with their ranges.

The Equipment & Personnel Table contains equipment/personnel ID numbers and the number of the equipment/personnel for each procedure. Each of these procedures has a corresponding entry in the startup, shutdown, operations or maintenance timeline tables. The equipment ID numbers are defined in the General Table.

See Tables 5-9, Appendix E.

GROUP 7

This group consists of four tables: Economic, Consumable Material, Labor Cost, and Cost Scaling Law Tables.

The Economic Table contains capital cost (off-shelf cost and installation cost). There is a flag which tells if a scaling law is available for the particular system cost.

The system cost varies for three reasons: inflation, resource depletion and technological advance. By inflation, we mean that the absolute value of the dollar is changing in time. To take into account this effect, the year which dollar is used to calculate the cost is listed in the Reference Dollar Year field. Technological improvement lessens the absolute value of a system; for example, the price of a personal computer is decreasing every year; however, this effect is difficult to adequately quantify.

The Cost Scaling Law Table contains scaling laws used to compute the capital cost of systems which differ in the value of some parameter from others. Cost is scaled for size, weight, and other parameters. In the

present data base, we use the following generalized formula [3-3]:

$$Ax^C + By^D \tag{3.4}$$

$$Ax^C\ y^D \tag{3.5}$$

where A, B, C, and D are constants, and x and y are variables for which the cost is scaled.

The Consumable Materials and Labor Cost Tables are different from other tables in terms of record specification. A record begins with the material ID number in the Consumable Material Table, and a personnel type ID number in the Labor Cost Table. In other words, these attributes are not associated with particular hardware.

See Tables 20-23, Appendix E.

GROUP 8

This group consists of only one table, the Reference Table. This table provides the author names, title, and site and date of publication of reports, which are referred to in other tables.

See Table 24, Appendix E.

GROUP 9

This group consists of only the Comments Table which is used to hold descriptive information about data records in other tables. See Table 25, Appendix E.

UTILITY TABLE

The Comrefno table is used to hold the next available comment and reference ID numbers (for processing purposes only).

See Table 26, Appendix E.

3.3 Identification Number System

SYSTEM ID NUMBERS

System identification numbers play the following roles:

* If it is designed in a clever manner, the number itself can tell a user about some characteristics of a system.
* Knowing ID numbers in advance makes data search much more efficient.
* In the present data base, the ID numbers play a role as a key, which relates records relevant to a system over the entire set of tables.

There is an ID number system widely used in the fusion community [3-4]. This ID system, which will be called the PNL system, was designed for fusion reactor cost accounting, and has been used in several conceptual fusion reactor design studies. This ID system employs five or more sets of two digit numbers to make an ID number. By clarifying the hierarchical structure of an entire plant, in other words, arranging systems in a plant in a tree structure, this categorizes the systems into groups from the top of the tree to bottom downward. That is, the first two digits of an ID number represent the second level subsystems such as land, reactor plant, turbine plant, electric plant, and so on. Then the second two digits represent subsystems of these systems; for example, first wall/blanket in a reactor plant. The PNL system satisfies the three requirements mentioned above. However, there are two drawbacks of the PNL system for our database. First, this specifies where a system must be in a plant. This lessens the flexibility of new designs. Second, a system might be associated with several ID numbers because one system can be a subsystem of several different systems.

Taking into account these considerations, we propose a different ID number system: use two sets of two digit numbers followed by two sets of

three digit numbers. In our ID system, all systems are categorized into large groups according to their functions. The function is specified by the first two digits. The second two digits are used to partition the function into more specific functions or types. The third set is a serial number, and there is no systematic numbering for this. The fourth is preserved for later use. This ID number system is shown in Table 3-1. It is worth noting that the present list of functions is far from exhaustive. Hence in the not-to-distant future this may be largely revised.

MATERIAL AND PERSONNEL ID NUMBERS

These are defined as parts of the system ID numbers described above.

REFERENCE AND COMMENT ID NUMBERS

The reference and comment ID numbers should be uniquely defined in order to be able to distinguish between the comments and references of different records in each of the tables. These numbers are automatically generated by the FSDB I/O processor with the aid of the only utility table (the COMREFNO table).

REFERENCES FOR CHAPTER 3

[3.1] Henley, E.J. and H. Kumamoto, Reliability Engineering and Risk Assessment, Prentice-Hall, Englewood Cliffs, NJ, 1981.

[3.2] Musicki, Z. and C.W. Maynard, "A Preliminary Fusion Availability Data Base," University of Wisconsin-Madison Fusion Technology Institute Report UWFDM-532, Feb. 1984.

[3.3] Bathke, G.G., et al., "ELMO Bumpy Torus Reactor and Power Plant: Conceptual Design Study," Appendix F, Los Alamos National Laboratory, CA, LA-8882-MS, Aug. 1981.

[3.4] S.C. Schulte, T.L. Willke and J.R. Young, "Fusion Reactor Design Studies - Standard Account For Cost Estimates," Pacific Northwest Laboratory, Richland, WA, PNL-2648, Jan. 1981.

TABLE 3-1. IDENTIFICATION NUMBERS FOR THE FSDB

00.00.000

A B C

A: function id
B: type/subfunction
C: serial number

	FUNCTION	TYPE/SUBFUNCTION
10	Plant	11=Tokamak, 12=Tandem mirror, 13=Field reversal, 14=Stellarator, 51=Laser ICF, 52=Electron beam ICF, 53=Light ion beam ICF, 54=Heavy ion beam ICF
11	Fueling	01=plasma gun, 02=pellet injector, 03=gas puffing, 04=gas blanket
12	Plasma heating	01=ICRH, 02=ECRH, 03=NBI, 04=electron beam, 05=laser
13	Impurity/exhaust	01=vacuum pumping, 02=limiter, 03=divertor
14	Blanket	01=self-cooled liquid metal, 02=helium-cooled, 03=water-cooled, 04=molten-salt-cooled
15	Magnets	01=superconductor, 02=normal conductor
16	Heat/mass transport	01=steam generator, 02=heat exchanger, 03=pumps

	FUNCTION	TYPE/SUBFUNCTION
17	Energy conversion	01=Turbine, 02=Direct convertor, 03=Electric generator
18	Fuel management	00=tritium handling system 01=extraction/recovery, 02=storage, 03=purification, 04=liquification
19	Cryogenic	00=cryogenic system, 01=liquification/refrigeration, 02=recovery, 03=purification, 04=storage, 05=distribution, 06=auxiliary
20	Electric	01=power supply 02=switching 03=energy storage
21	Instrumentation/control	00=I/C system 01=temperature 02=pressure 03=mass flow 04=electromagnetic (voltage, current, ...) 05=heat 06=stress/strain 07=radiation 08=chemical
22	Shielding/protection	01=Radiation shielding
23	Structure/building facilities	01=support structure 02=building structure 03=building service (air cond., ...)
24	Maintenance equipment	01=maintenance equipment
25	Transportation	01=transportation system
26	Waste management	01=radioactive 02=chemical 03=heat
27	Personnel	01=operator 02=maintenance 03=construction

	FUNCTION	TYPE/SUBFUNCTION
30	Material/fuel	01=fuel 02=structural material 03=coolant 04=radiation shielding 05=nuclear material (multiplier, breeder, ..) 06=insulator (electric) 07=lubricant
90	Basic components	01=components
99	Supplement	00=anything

4. THE FUSION SYSTEMS DATABASE (FSDB) INPUT/OUTPUT PROCESSOR

4.1 Getting Started

The FSDB I/O processor can be entered from DOS by typing "KMAN FSDB". It can also be entered from within KMAN by entering "Perform FSDB". Of course it is advisable that you make sure that all the required files are in the default directory. A list of the required files can be found in Appendix A.

4.2 Menu Structure

4.2.1 Description

There are three major menu levels. In the first the user is asked to choose the table group in which he wishes to work. The table groups are described in Chapter 3 and are numbered 1-9; a complete definition of each table in terms of its fields may be found in Appendix E. Then, if the table group has more than one table (groups 2, 4, 5, 6 and 7) the user is asked to select the table he/she is interested in. Finally, the user may choose the function to perform (add, change, delete, view or quit). Also, after the user performs the desired function he/she may choose to repeat the function for the same table. If the user decides not to, he/she is returned to the table-within-the group menu and permitted to choose another table.

4.2.2 Suggested Method of Performing Functions

Due to memory limitations of the present version of KMAN the user is recommended to perform all the functions for a particular table in consecutive order. In other words, minimize skipping around from one table to another and one group to another. Sometimes substantial delays will occur (< 30 seconds) when changing from one table to another within a group or when changing from one table group to another. This delay is due to the loading of I/O forms for the groups and tables.

4.2.3 About Ending the Session With the FSDB I/O Processor

After the user selects the quit option from the group selection menu there will be a delay before the system comes up in DOS. This is caused by the need to compress all those tables which have had records marked for deletion in this processing session; in order to avoid excessive delays in processing during a session the tables are not "compressed" until the end of the session. Therefore, one should not turn off the computer until the system comes up in DOS.

4.3 Purpose/Description

The I/O processor for the FSDB was written to ensure that duplication of data records does not occur. Each record in a table is distinguished from all the others by the value of one or more key fields. Two records with the same key field values cannot be added (or caused to occur through a change operation) to the same table. The I/O processor also allows the addition, changing, deletion of records in an expedient and convenient form. The menu driven system is easy to follow and takes care of the bookkeeping tasks. The best way to see what it can do is to give it a try. A detailed description of the various tables and the fields within each table is in Chapter 3 and Appendix E of this document.

There are 26 tables in the FSDB. Due to the logical similarities of some of these, they have been split up into 6 different classes in terms of the different change, delete and view options available. Note: these classifications are not the same as the breakdown of the tables into groups as in Chapter 3 (according to type of information stored in the tables). This logical classification is depicted in Table 4-1.

TABLE 4-1. LOGICAL CLASSIFICATION OF TABLES BY FUNCTION OPTIONS AVAILABLE (NOT BY TYPE OF INFORMATION STORED)

Class	Table No.	Table Name	Description of Logic Class
1	11	General	Contains a record for every system in the FSDB. See the explanation which follows.
2	21	Systems	Every table in this Class has at least two key fields; of these, at least two key fields which correspond to separate system ID# records in the general table.
	42	Common Mode	
	54	Spares	
	56	Spec. Equip	
3	31	Geom. & Compos.	Each of these tables has only one key field and it corresponds to a system ID# record in the general table.
	43	Burnin	
	44	Wear out	
	72	Economics	
4	22	Functional	These tables have one system ID# key field and at least one other non-system ID# key field.
	41	Reliability	
	45	Relscale	
	51	Sched. Mainten.	
	52	Unsched. Mainten.	
	53	Timeline	
	55	Testing	
	74	Ecoscale	
5	71	Labor cost	Tables with one non-system ID# key field.
	73	Consum. Matl's	
6	81	Comments	These tables are for documentation purposes.
	91	References	

4.4 Description of Basic Functions and Special Functions for Table Classes 1-5

There are four basic functions (add, change, delete and view) described below. Others (such as creation of disk output files) will be added as deemed necessary. Unfortunately, the present version of KMAN does not support host language query language calls. Also, there are some special options available for the different logic classes depicted below.

4.4.1 Adding Records to a Table

The user is allowed to create new records in a table, one at a time. He cannot create any records which have the same key field values of a record already in the table. If this is attempted the user is informed of the condition and given the chance to add another record to the table. There are no special add options available for any of the six logical classes of tables.

4.4.2 Changing Records in a Table

The data fields of a record which has already been added to a table may be altered by choosing this selection from the function menu. Again if one attempts to create a record with key field values that are the same as another record in the table, the change is not permitted and the user is informed of the condition. There is a special case of this function for changes in the General table (see explanation below).

4.4.3 Deleting Records from a Table

One or more records can be deleted from a table or all the records for a particular system ID# can be removed from the FSDB. See the explanation for deletion under Class 1 tables (General) below.

4.4.4 Viewing Records

Several view options are available to the user of the FSDB. A comprehensive listing of the records of a table may be obtained; however, only the key fields are listed due to lack of space on the screen. Therefore, we allow the viewing of all the fields of an individual record in a table. Also there are special functions available for different tables as described below.

4.5 Special Function Options

4.5.1 Class 1 (General Table) Special Functions

4.5.1.1 Change General Option

All the records in the FSDB which contain a system ID# key field may be altered to contain a new system ID# in its place by using the change function selected through the General table. This is a powerful function which should be used carefully. Also, as before, if changing a record from an old system ID# to a new system ID# would create duplicate records in a table, then the old system ID# record is left unaltered. No duplicate records can be created in this process.

4.5.1.2 Delete General Option

This function will completely remove all the records for a particular system ID# from the FSDB and therefore must be used with care. It is an irreversible step; it should be noted that this function can only be performed by selecting the delete function after choosing the general table in the group menu selection.

4.5.1.3 View Option

There are two view choices available under the General table (Class 1) menu selection in addition to the view all records and view one record in detail possibilities. These are:

1) Display all the tables and the number of records in each that have data for a certain system. If a table has no records for a system then nothing will be output from that table. Tables in class 2 may be listed twice since there are two system ID# key fields. Tables in class three, if displayed will indicate "Y" next to their names since they have only one record per system. Tables in class 4 will be denoted by a number indicating the number of records for that system contained within.
2) Printout (only, since there is not enough room on the screen) a list of all systems in the FSDB and the number of records in each table for each system. The same comments on the type of output for each table class holds as in (1) above.

4.5.2 Class 2 Tables

4.5.2.1 Special View Options

There are two view options available in class two tables besides the view all records option which is possible for all directly accessible tables. These are:

1) View all the records for a certain first system ID# key field. In these tables there are two system ID# key fields. The first and second system ID# key fields are listed below in Table 4-2.
2) View all the records for a particular second system ID#. This is in effect the opposite of (1) above. For instance instead of viewing all the subsystems or a particular system (as in (1)), we want to view all the systems which have a particular subsystem.

TABLE 4-2

Table Name	Table No.	First System ID#	Second System ID#
Systems	21	system ID#	subsystem ID#
Common mode	42	system ID#	causing system ID#
Spares	54	system ID#	spare ID#
Spec. equipment	56	system ID#	equipment ID#

4.5.3 Class 4 Tables

4.5.3.1 Special View Option

There is one special view option for class 4 tables other than viewing one particular record in detail or viewing all the records in the table. This is basically the same as special view option (1) for class 2 tables described above. Simply, it is viewing all the records for a particular system ID# in the table.

4.5.4 Table Classes 3 and 5 Special Options

Classes 3 and 5 have the basic set of options described previously (Sections 4.4.1-4.4.4).

4.6 Programming Guide

4.6.1 Special Features of the General Table

The General table is a master list of all the systems which exist in the FSDB. Any time an attempt is made to add a record to any table with a system ID# that does not have a corresponding record in the General table, one is automatically added and the user is "forced" to enter related data. In addition, there are 22 status variable fields in the General table which keep track of the number of records in each table for each system in the FSDB. Tables in classes 5 and 6 do not have system ID# key fields and therefore do not have corresponding status variable fields in the General table. Furthermore, tables of class 2 have two corresponding status variable fields in the General table because they have two system ID# key fields (referred to hereafter as the first system ID# key field and the second system ID# key field). For a description of the different table logic classes see Section 4.1.

The status variable fields are used to speed up processing. Instead of searching in a table for records that do not exist, the status variable is

first checked. Likewise, any time a new record is added to a table or a record is changed in a table (except class 5 and 6 tables) the corresponding status field variables are updated in the General table for the systems involved. This is why it is important not to add, delete or change any records in the FSDB outside of the FSDB I/O processor.

4.6.2 Brief Description of the I/O Routines

There are 26 main processing routines in the FSDB. See Appendix page A-1 for a listing of the file names. Also, Appendix C contains flow charts of the more complicated routines. The function of each procedure is outlined below.

4.6.2.1 FSDB

This procedure oversees the performance of the basic set-up steps needed to get ready for the main processing tasks. It opens the General table (which is used quite frequently), defines the FSDB control arrays by calling the FUSIONDB routine, loads the main processing routines into KMAN memory by a call to the setfdb procedure, loads the most frequently used I/O forms by performing the NOGROPFM file, and then branches to the MAINCOMM main processing program. Finally, when the user decides to quit, program control comes back from the MAINCOMM routine and FSDB calls the CMPSTBLE procedure to compress those tables which have had records marked in the preceding processing session. Then, of course, an exit to DOS occurs. The overall program flow is illustrated on page C-1 (Appendix C, page 1).

4.6.2.2 FUSIONDB Procedure

As described above, the FUSIONDB procedure defines the arrays which are used to define the FSDB for programming purposes. A list of the variables and arrays so defined can be found in the comments section of the FUSIONDB routine (see Appendix D).

4.6.2.3 SETFDB Procedure

This routine loads the main processing routines into KMAN memory using the load perform command. See the SETFDB routine for a list of those procedures which are loaded. The current date is also obtained from the user. It is important to enter the date accurately because each record of the FSDB has a last-date-of-update field which is automatically changed whenever the record is altered. Also, the user may specify a RAM-drive. This is used to store forms so that time will be saved when loading and releasing them as needed.

4.6.2.4 MAINCOMM Procedure

The menu structure, loading and unloading of I/O and description forms and the branching between the main processing routines is taken care of by this routine. Due to memory limitations, forms must be loaded and released in reverse order as needed. These forms depict the different groups that the user can select (group selection form), the tables within each group and the fields in each (group description forms) and the I/O forms for data entry and viewing.

4.6.2.5 MAKCNDTS Procedure

Each time an individual record is obtained from a table in the FSDB, the key field(s) of the desired record must be specified. The obtain command is used to get the desired record. A condition must be specified in KMAN syntax using the obtain command. Each table has its own set of key fields (one or more) which allows distinguishing one record from another. The MAKCNDTS routine builds a condition string for use with the obtain command to get the desired data record. It does this with the use of the arrays defined in the FUSIONDB routine.

4.6.2.6 MKSELCOM Procedure

As with the OBTAIN command, the use of the select command requires the specification of a list of fields and conditions. This routine puts together a command string for the select command to get the proper data out of the table depending on the view-option selected by the user, and the table of interest. There is no flowchart for this routine but the fields put into the command string are enumerated in Appendix D.

4.6.2.7 FORMLOAD Procedure

The MAINCOMM routine uses this procedure to load forms into KMAN memory space. This routine checks both the default drive and the RAM-drive (if one is specified) and uses the perform command to load the form file.

4.6.2.8 CMPSTBLE Procedure

When the user decides to quit the FSDB (using the main menu), the FSDB routine branches to this procedure. This procedure checks the compress flags of all the tables and compresses those tables with non-zero values.

4.6.2.9 ADDTABV2, CHGTAB, DELTABV2, VUTAB Procedures

These procedures perform the main processing functions as described in Section 4.1.

4.6.2.10 ADDGENRL, CHNGENRL, DELGENRL, VUGENERL Procedures

These procedures perform the add, change, delete and view-options for the general table menu selection. The general table function options have several special functions (see Section 4.1).

4.6.2.11 INSERTCOM, CHNGCOM, DELETCOM, INCOM, VIEWCOMM, DOCMASTR, ADDDOCSEP, INITCOM, INCOMMAN and UPDATCOM

These procedures allow addition, deletion, changing and viewing of comments for a particular record.

Acknowledgment

Support for this work has been provided by the U.S. Department of Energy.

APPENDIX A

LISTING OF ALL THE PROCEDURE, FORM AND TABLE FILES
WHICH MUST BE ON THE DEFAULT DIRECTORY IN ORDER
FOR THE FSDB I/O PROCESSOR TO FUNCTION PROPERLY

A.1. PROCEDURES WHICH MUST BE ON THE DEFAULT DIRECTORY*

1. FSDB
2. SETFDB
3. MAINCOMM
4. FORMLOAD
5. FUSIONDB
6. MKSELCOM
7. MAKCNDTS
8. CMPSTBLE
9. ADDTABV2
10. CHGTAB
11. DELTABV2
12. VUTAB
13. ADDGENRL
14. CHNGENRL
15. DELGENRL
16. VUGENERL
17. UPDATCOM
18. INCOMMAN
19. INCOM
20. INSERTCOM
21. DELETCOM
22. CHNGCOM
23. VIEWCOMM
24. ADDDOCSEP
25. DOCMASTR
26. INITCOM

* ALL THESE FILES HAVE .IPF EXTENSIONS

A.2. FORM FILES WHICH MUST BE IN THE DEFAULT DIRECTORY

1. NOGROPFM
2. TABGRP1
3. GENTAB
4. SYSTAB
5. GECOTAB
6. RELTAB
7. MANTAB1
8. OPETAB
9. ECOTAB
10. INSYSSUB
11. SYS1NKFM
12. INIONFM
13. IONUNKFM
14. IOCNNKFM
15. INIOCNCT
16. GEOMNKFM
17. RELNKFM
18. FALTYPFM
19. COMNKFM
20. COMDIDFM
21. WERNKFM
22. WNONKFM
23. RELSNKFM
24. INRELSFM
25. SCHDNKFM
26. INMNMDFM
27. USCMNKFM
28. INFLUNFM
29. TIMLINFM
30. INTMLNFM
31. INEQPFM
32. TESTNGFM
33. INTESFM
34. SPECEQFM
35. SPARNKFM
36. SPARIDFM
37. OPERNKFM
38. INPROCFM
39. STRTNKFM
40. SHUTNKFM
41. INENVRFM
42. ENVIRFM
43. LBRCSTFM
44. LABORCFM
45. ECONKFM
46. CONSUMFM
47. MATERIFM
48. ECOSNKFM
49. INECOSFM
50. VIEWSYST
51. VIEWINOT
52. VIEWCOMD
53. VIEWSPEC
54. VIEWSPAR

* ALL THESE FILES HAVE .IPF EXTENSIONS

A.3. THE TABLE FILES (ALL HAVE .ITB EXTENSIONS)

(THESE ARE ACRONYMS OF THE DESCRIPTIVE TABLE TITLES

BECAUSE FILE NAMES MUST HAVE < 8 CHARACTERS)

1. GENERAL	2. SYSTEMS	3. FUNCTION
4. GEOMCOMP	5. RELIABIL	6. COMNMODE
7. BURNIN	8. WEAROUT	9. RELSCALE
10. SCHEDMAN	11. UNSCHMAN	12. TIMELINE
13. SPECEQPT	14. TESTING	15. SYSSPARE
16. OPERATIN	17. STARTUP	18. SHUTDOWN
19. ENVIRONM	20. LABRCOST	21. ECONOMIC
22. MATECOST	23. ECOSCALE	24. REFERENC
25. COMMENTS	26. COMREFNO	

APPENDIX B

LISTING OF ALL THE KEY FIELDS OF EACH TABLE

B.1. COMPREHENSIVE LIST OF TABLE KEY FIELDS

		KEY FIELDS *				
TABLE NAME	NO.	#1	#2	#3	#4	#5
GENERAL	11	SYSID#[1]				
SYSTEMS	21	SYSID#	SUBSYSID			
FUNCTIONAL	22	SYSID#	INOUTID#			
GEOM & COMP	31	SYSID#				
RELIABILITY	41	SYSID#	FAILMODE			
COMMON MODE	42	SYSID#	ID#CAUSY	FMOD#CAU	COMMODID	
BURNIN	43	SYSID#				
WEAROUT	44	SYSID#				
RELIAB. SCA	45	SYSID#	SCALTYPE			
SCHED. MAN.	51	SYSID#	MAINMOD#			
UNSCH. MAN.	52	SYSID#	FALMOD#			
TIMELINE	53	SYSID#	MAINMOD#	PROCID#	MANTYPE	
SPECIAL EQP	54	SYSID#	EQPMNTID	MODE#	PROCID#	MANTYPE
TESTING	55	SYSID#	TESTID#	TPROCID#		
SPARES	56	SYSID#	SPARID#			
OPERATIONS	61	SYSID#	PROCID#			
STARTUP	62	SYSID#	PROCID#			
SHUTDOWN	63	SYSID#	PROCID#			
ENVIRONMENTAL	64	SYSID#	ENVIRID#			
LABOR COST	71	PERSID#				
ECONOMICS	72	SYSID#				
CONSUMABLE	73	MATERID#				
ECONOM. SCAL.	74	SYSID#	SCALTYPE			
COMMENTS	81	COMENTID	COMEN#			
REFERENCES	91	REFRENID	REFEREN#			

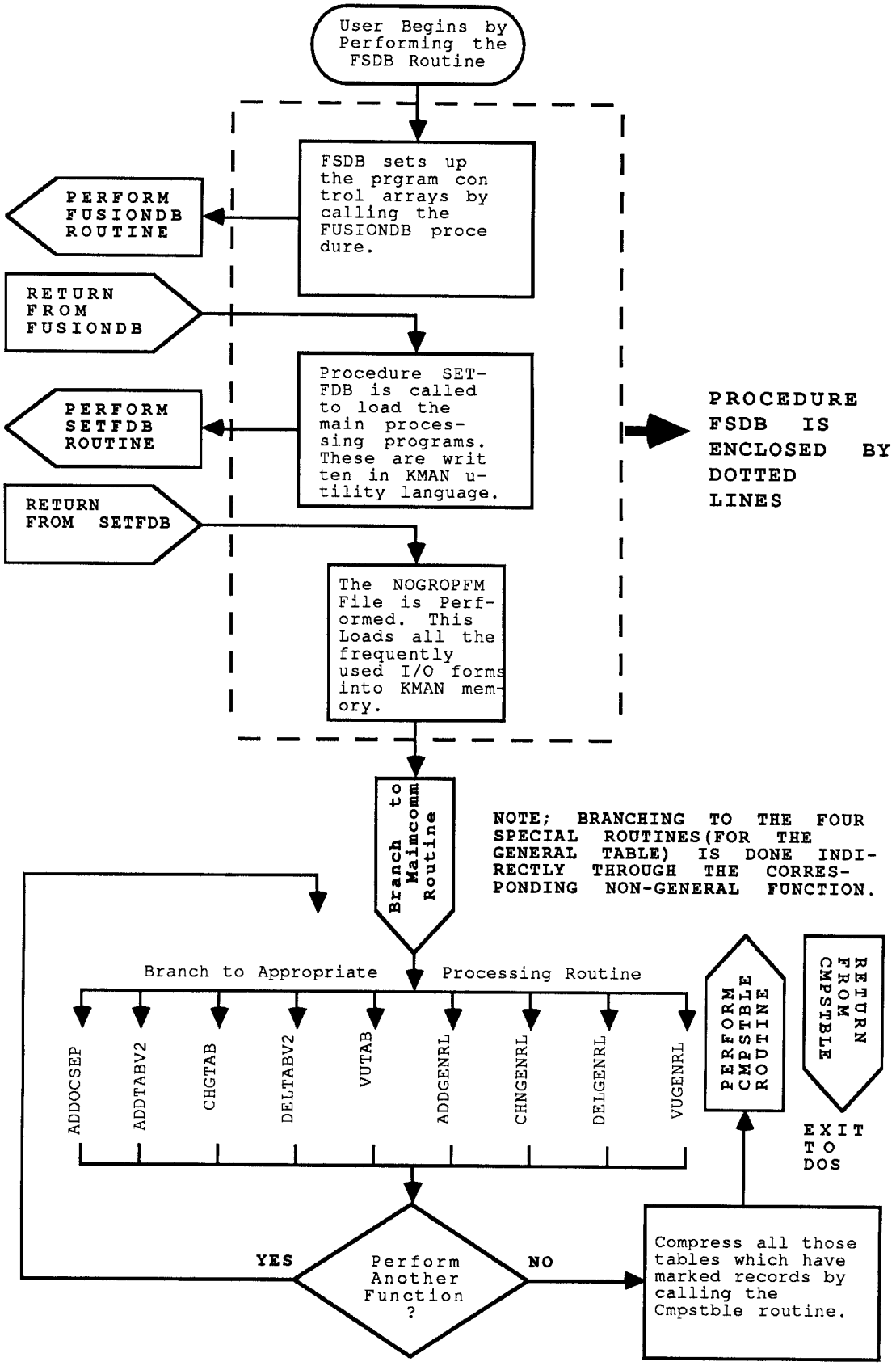
(1) - SYSID# - indicates SYSTEM ID# (FIRST) KEY FIELD.

* IF THERE IS NO ENTRY FOR A KEY FIELD THEN NO OTHERS EXIST.

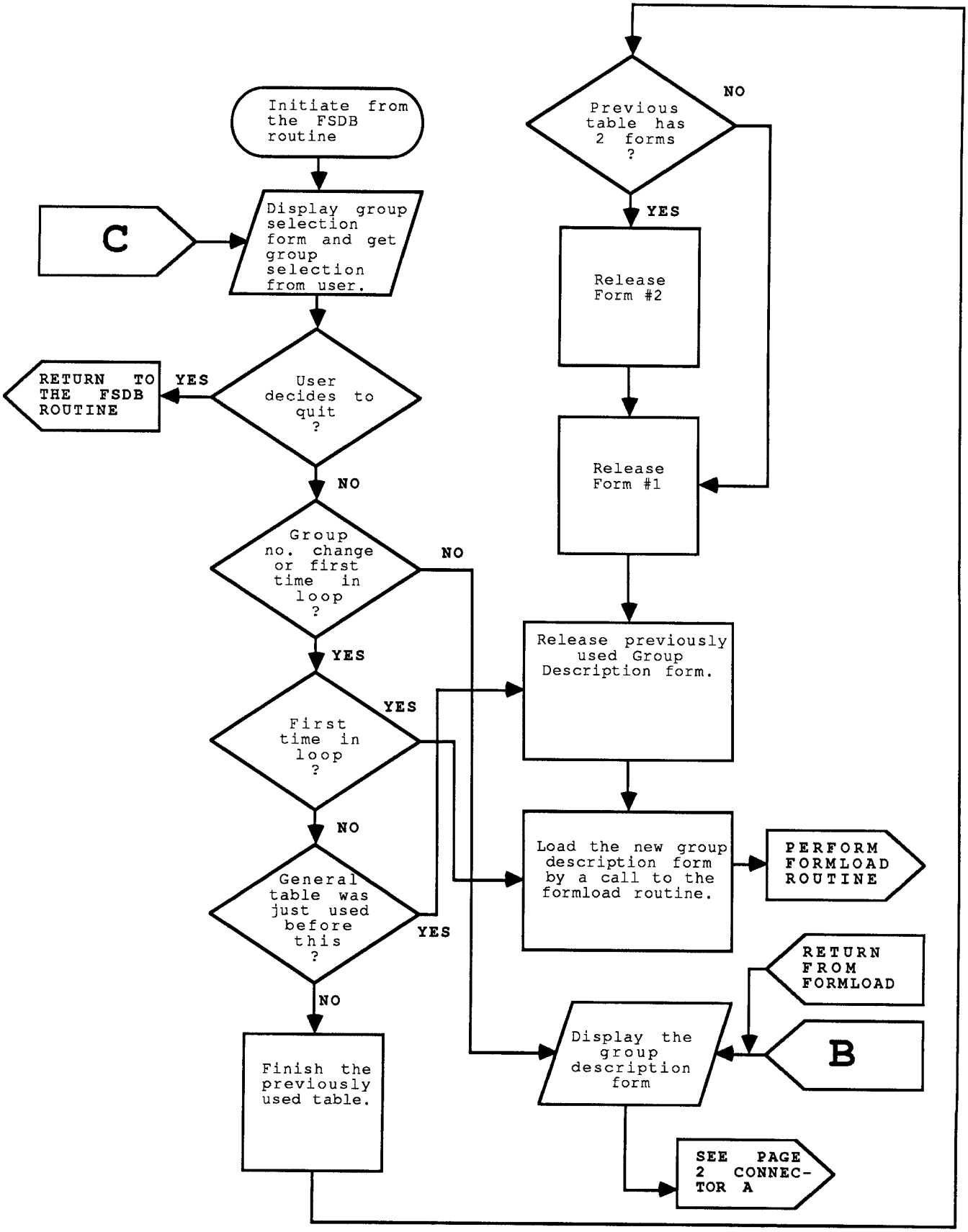
APPENDIX C

FLOWCHARTS OF THE MAIN PROCESSING ROUTINES

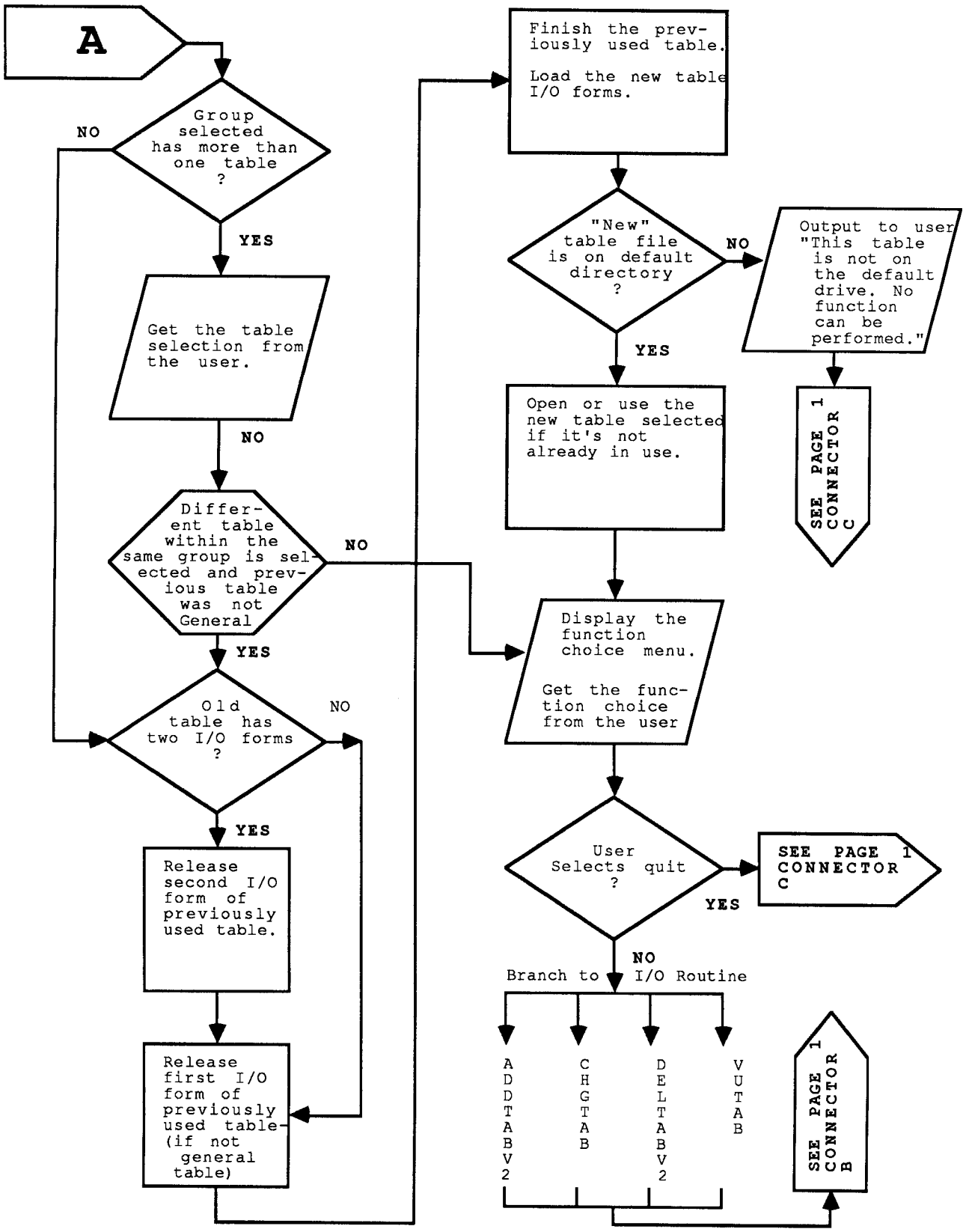
Overall Program Flow Diagram



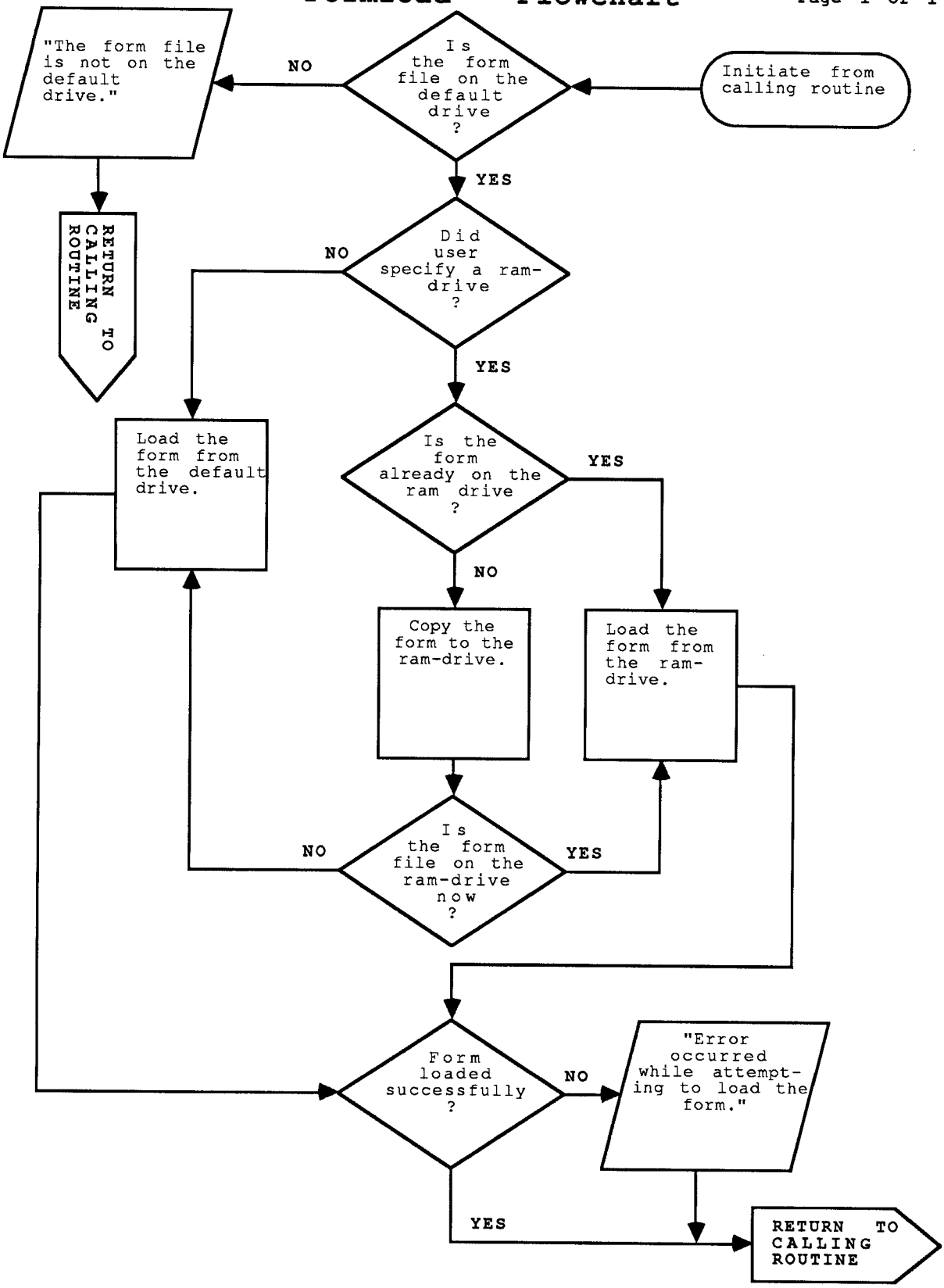
Maincomm Flowchart



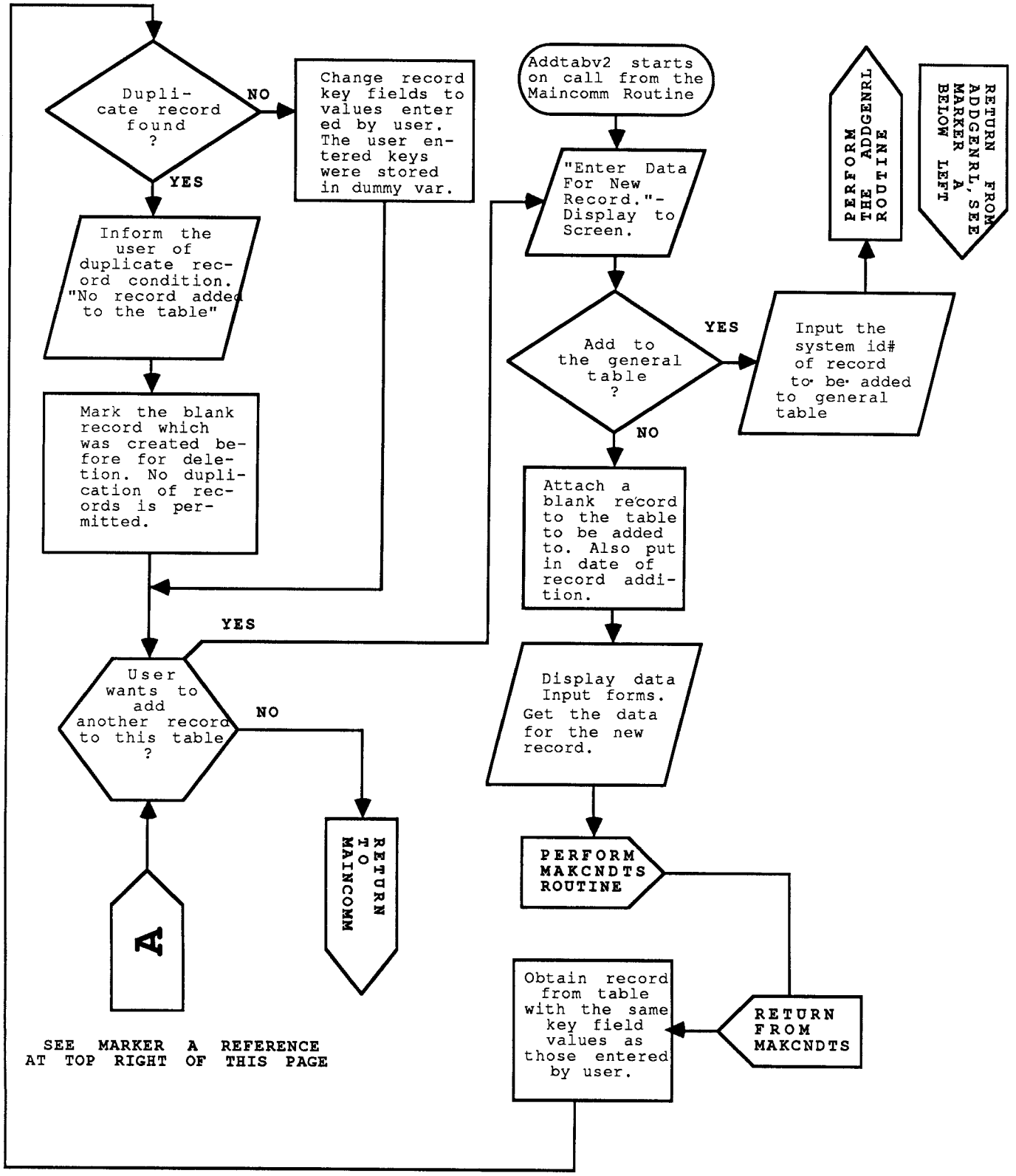
Maincomm Flowchart



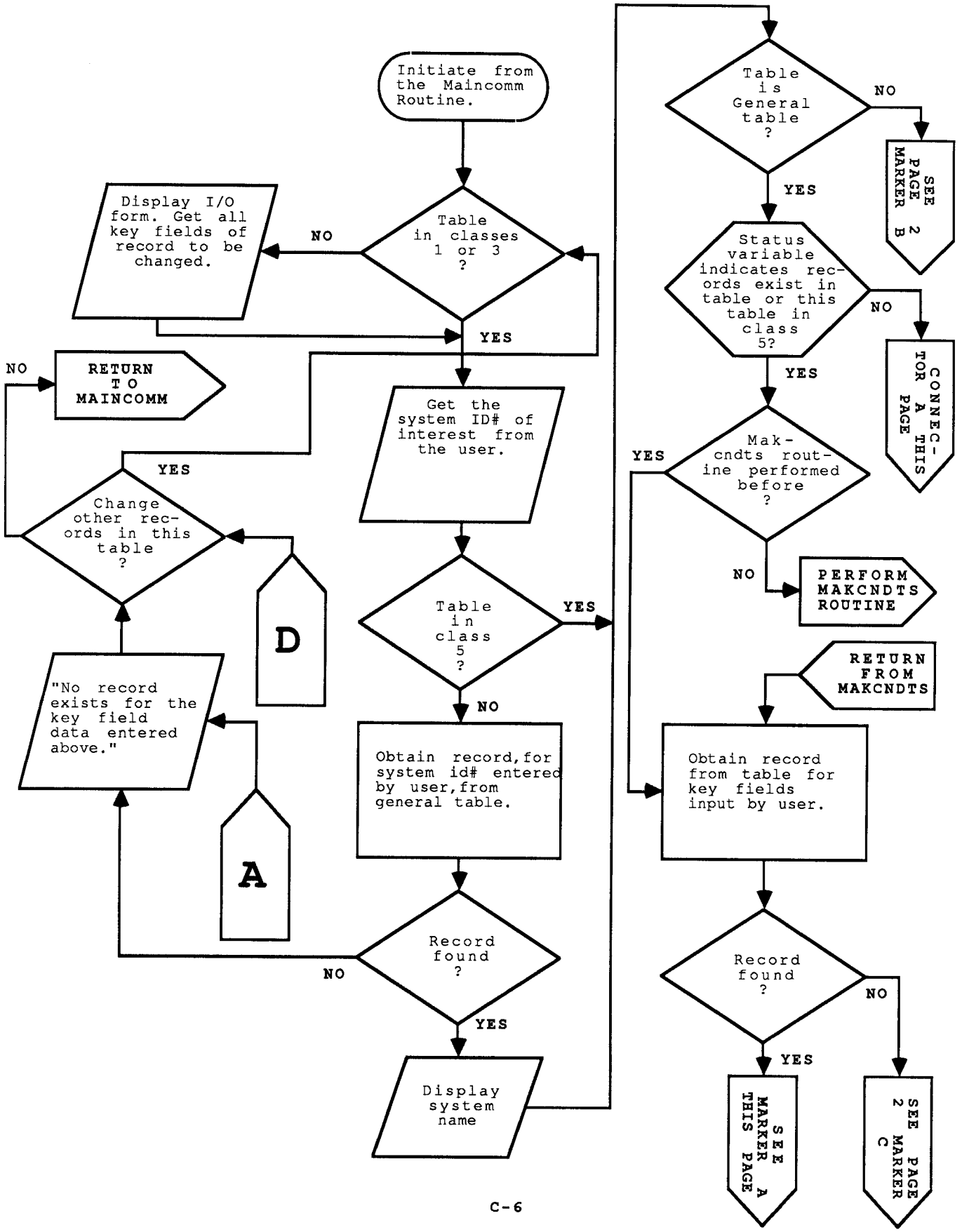
Formload Flowchart



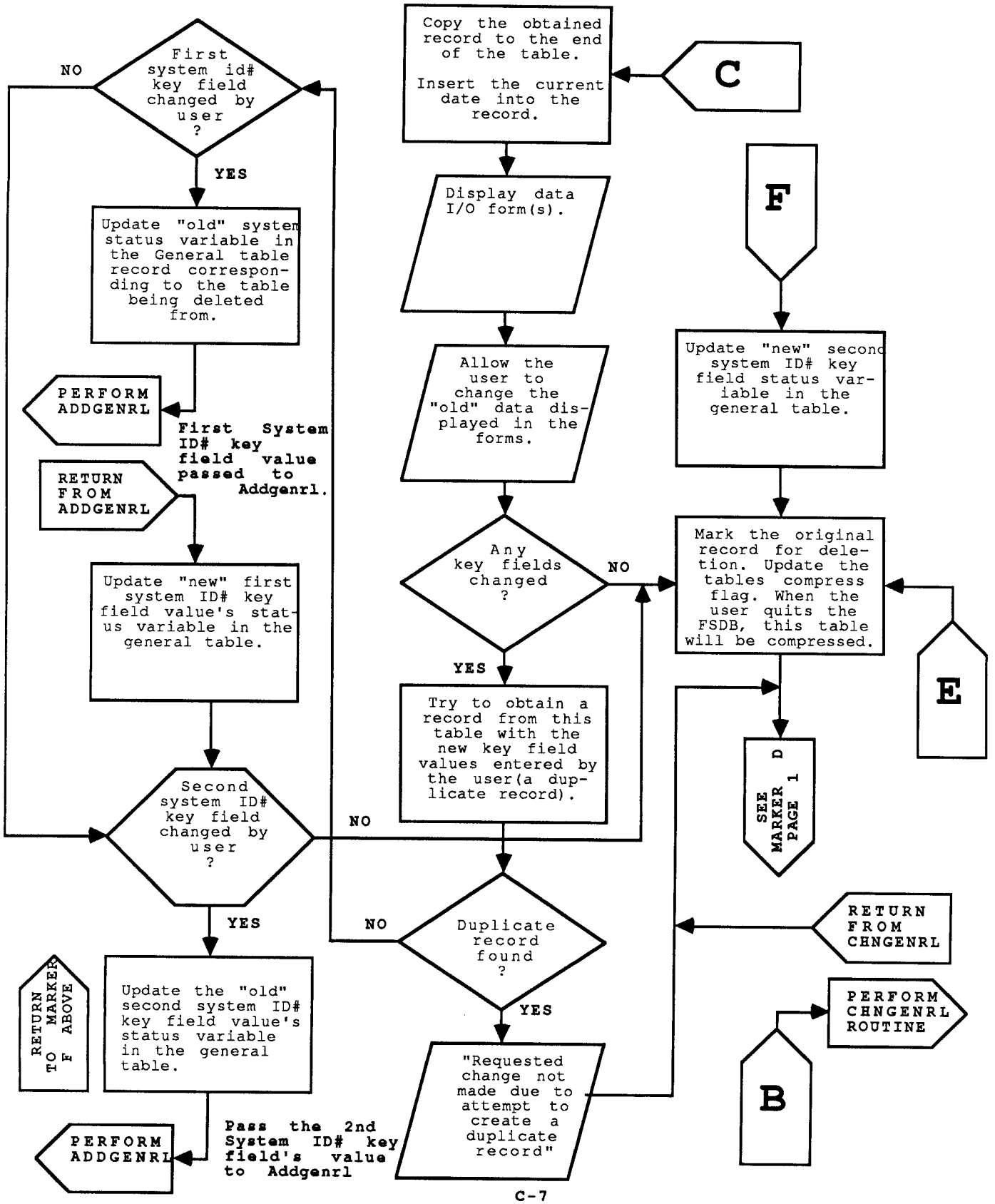
Addtabv2 FlowChart



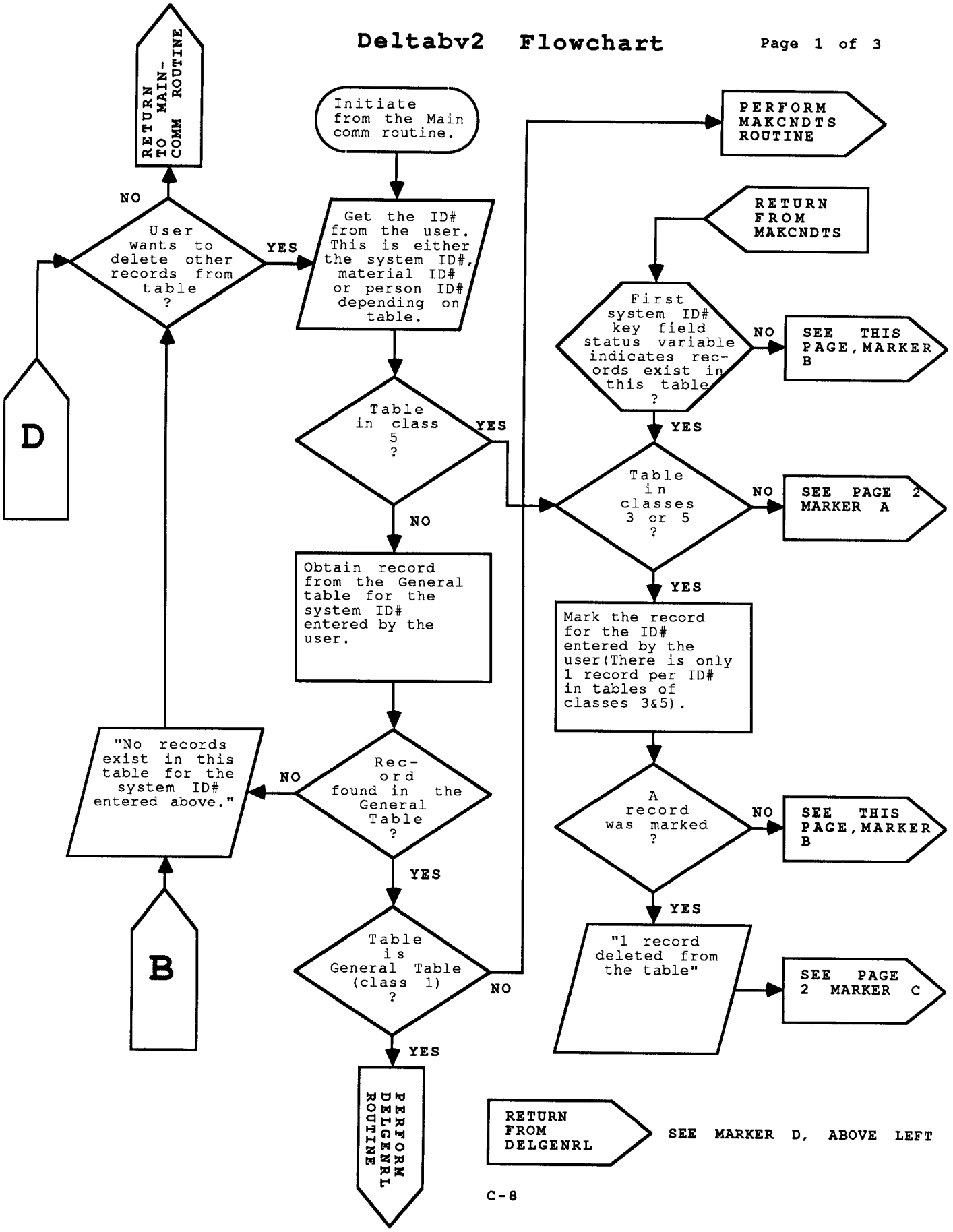
Chgtab Flowchart



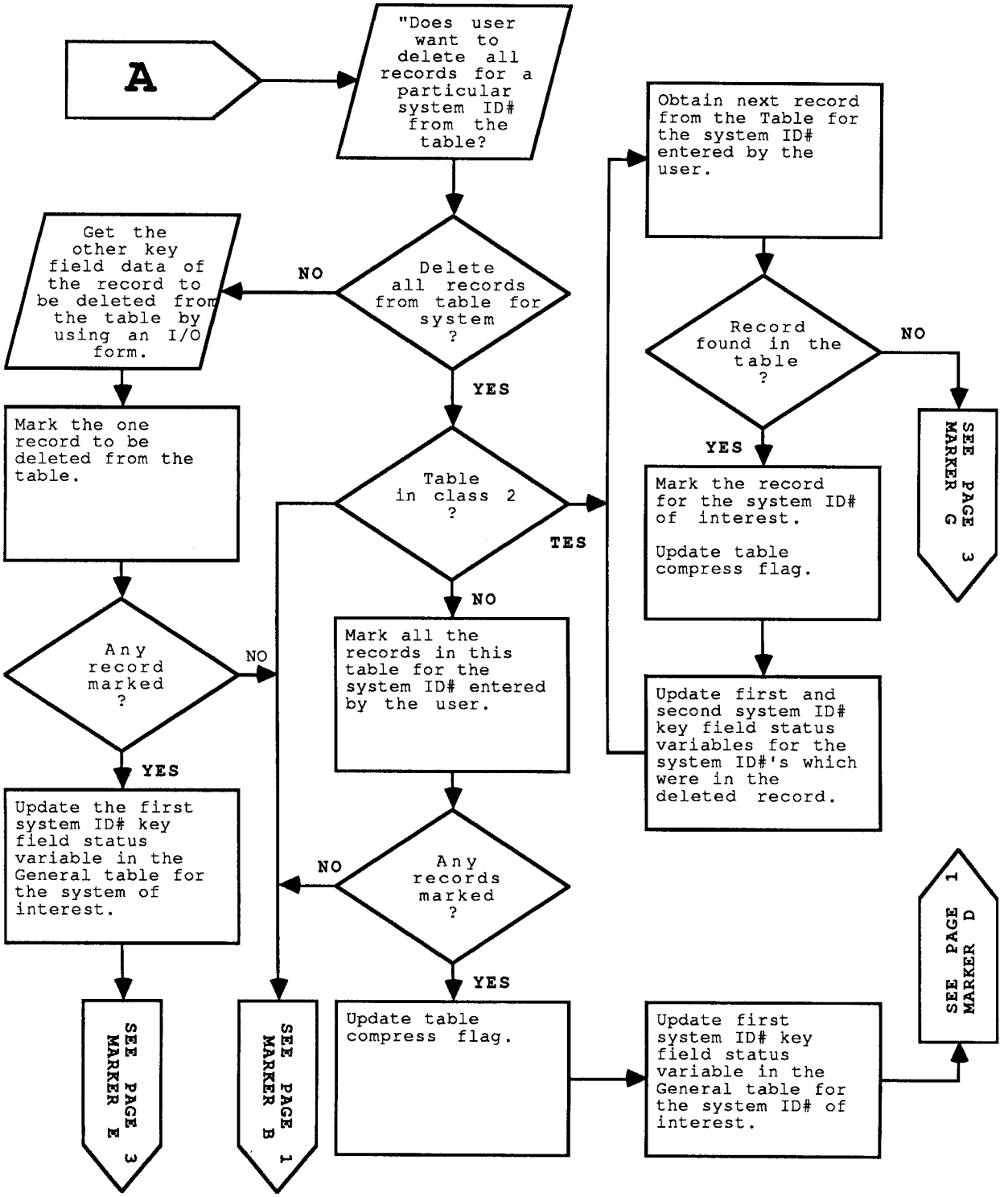
Chgtab Routine Flowchart

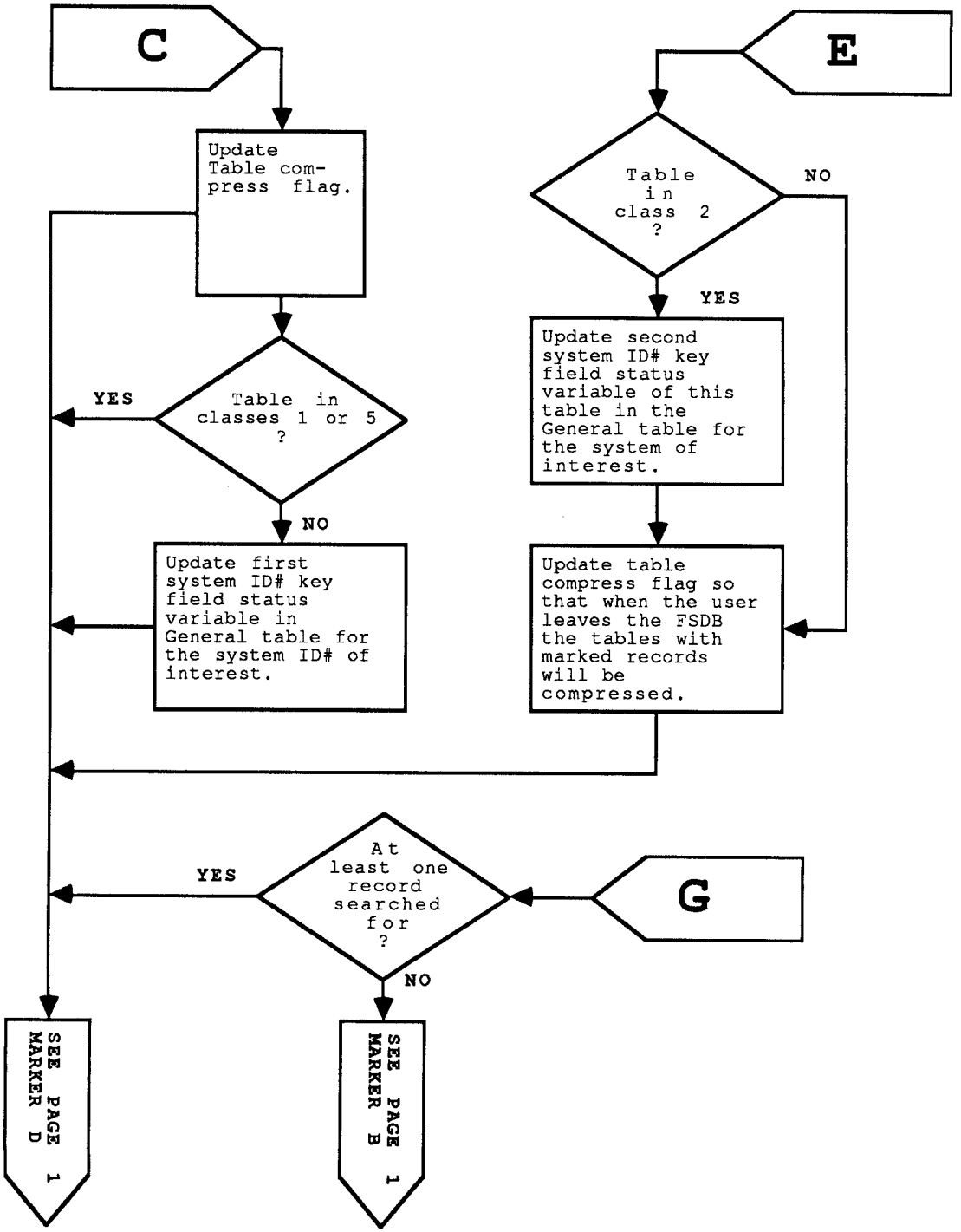


Deltabv2 Flowchart

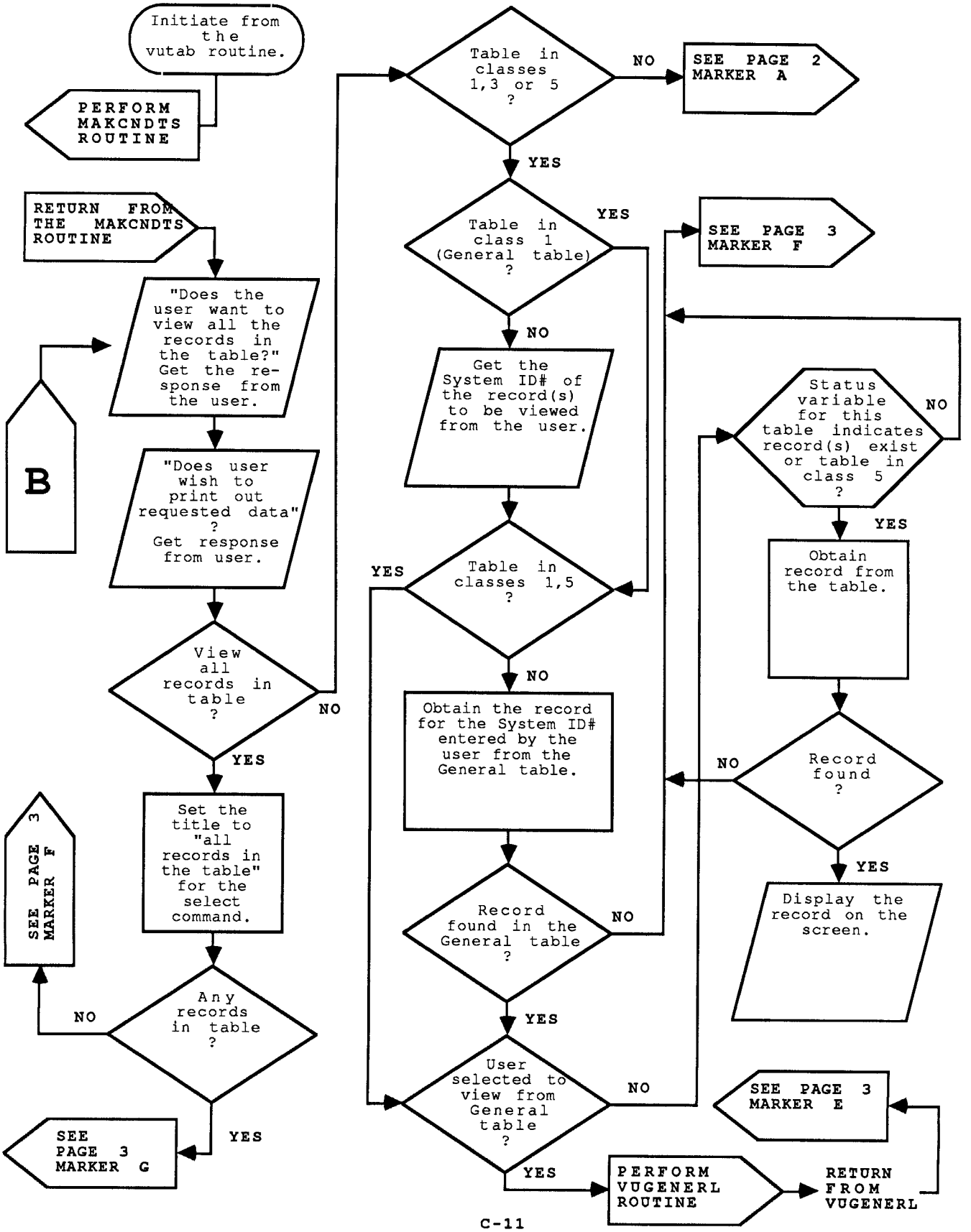


Delatabv2 Flowchart

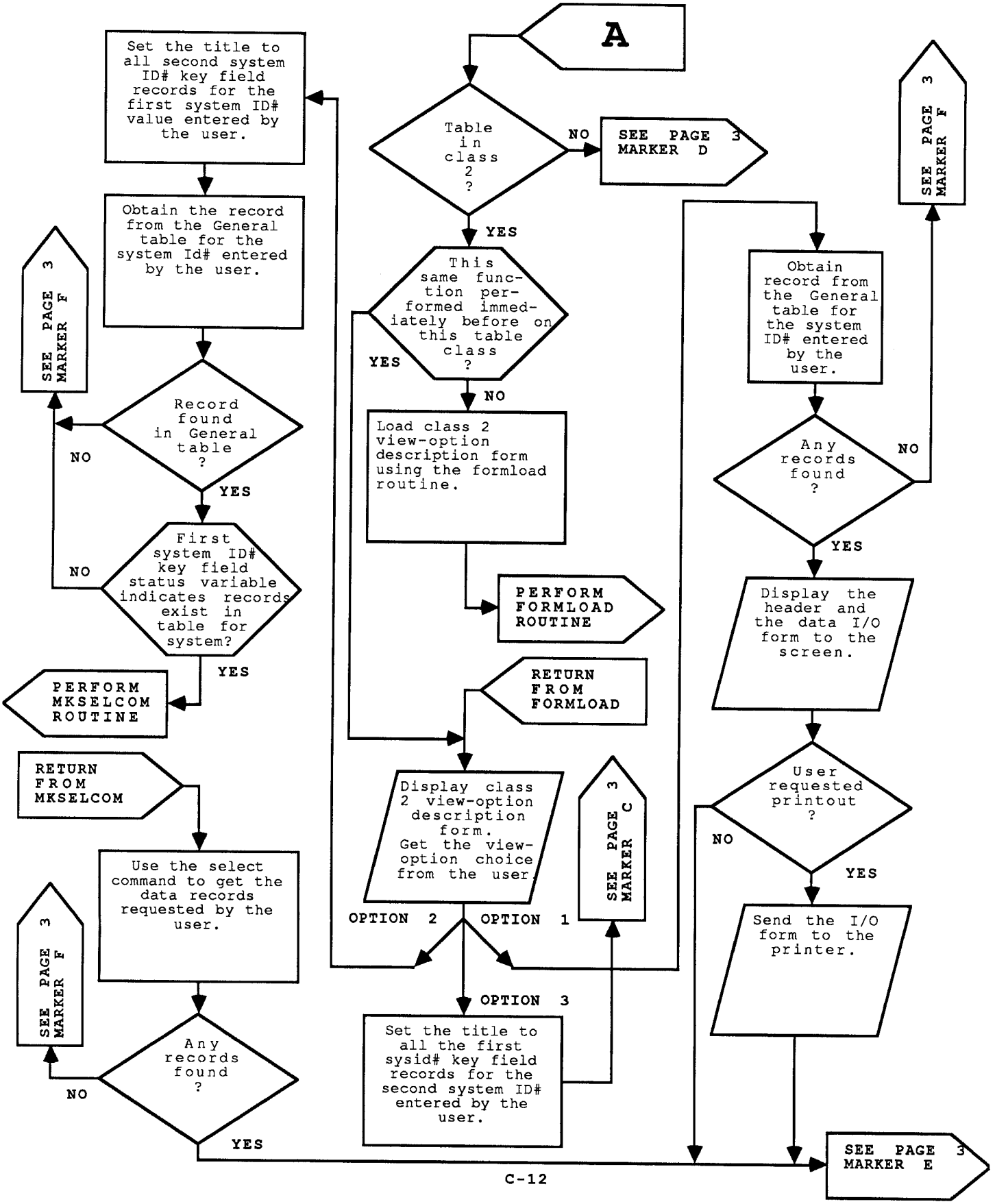



C
Update Table compress flag.
Table in classes 1 or 5 ?
YES
NO
Update first system ID# key field status variable in General table for the system ID# of interest.
E
Table in class 2 ?
NO
YES
Update second system ID# key field status variable of this table in the General table for the system of interest.
Update table compress flag so that when the user leaves the FSDB the tables with marked records will be compressed.
At least one record searched for ?
YES
NO
G
SEE PAGE 1 MARKER D
SEE PAGE 1 MARKER B

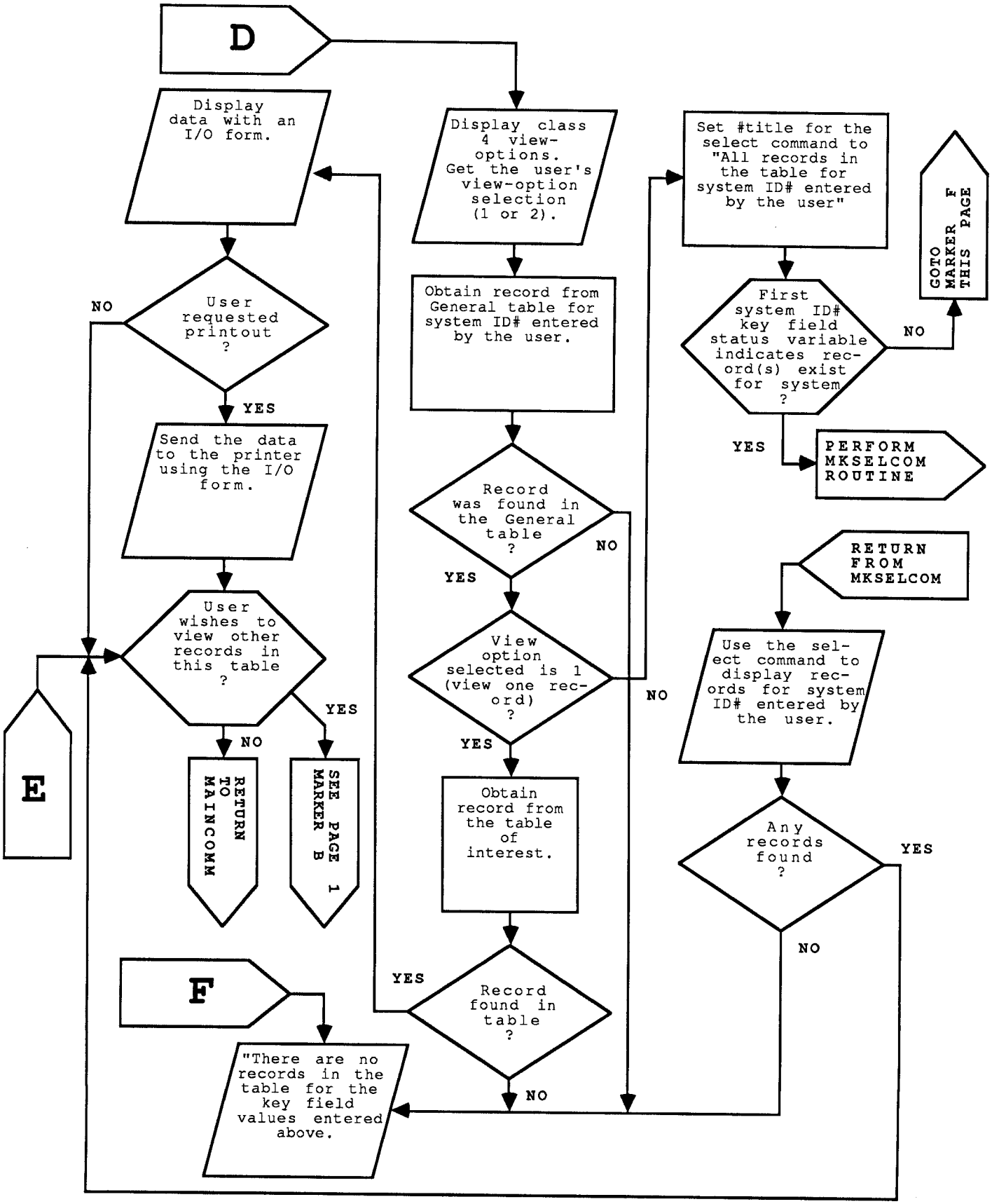
Vutab Flowchart



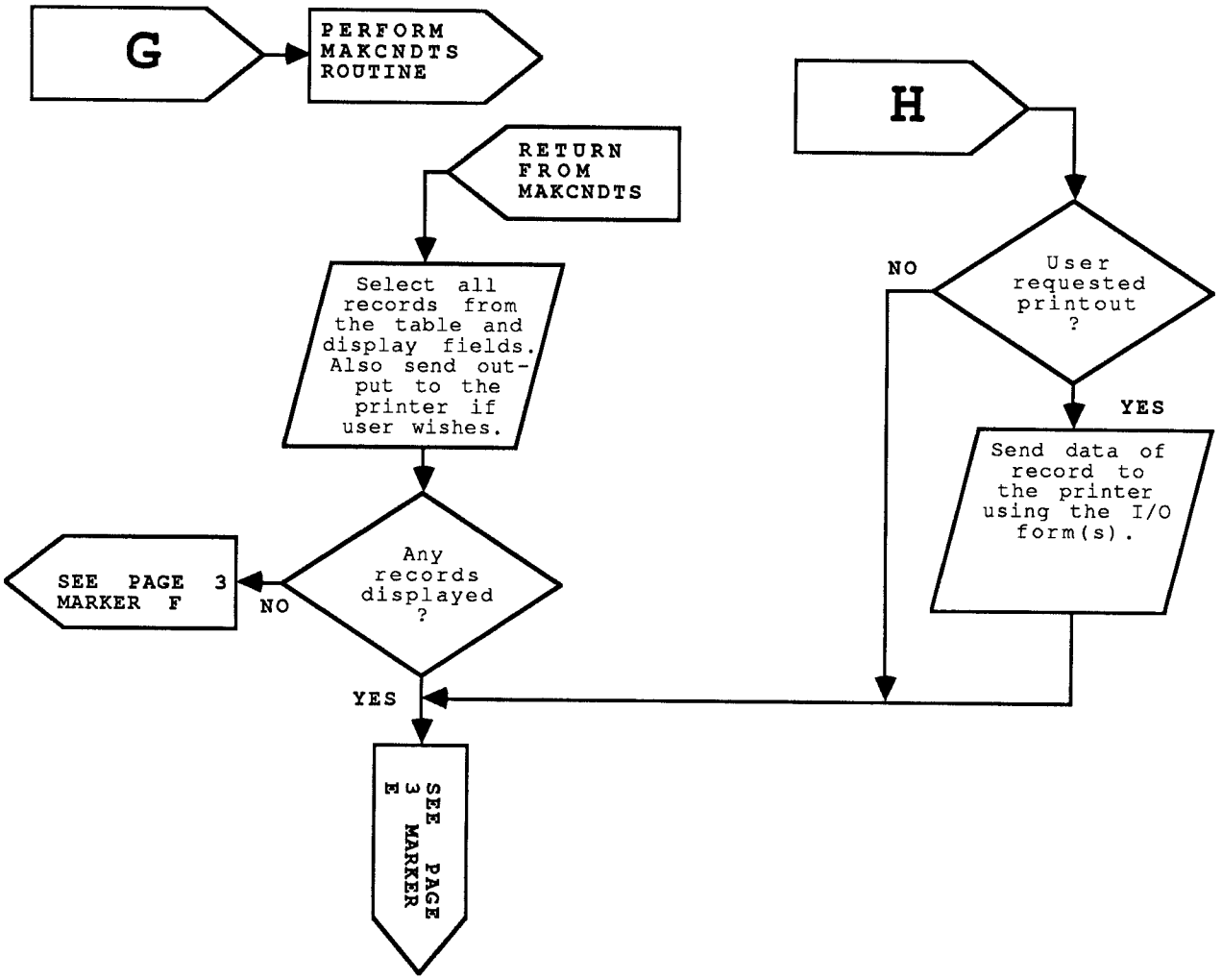
Vutab Flowchart



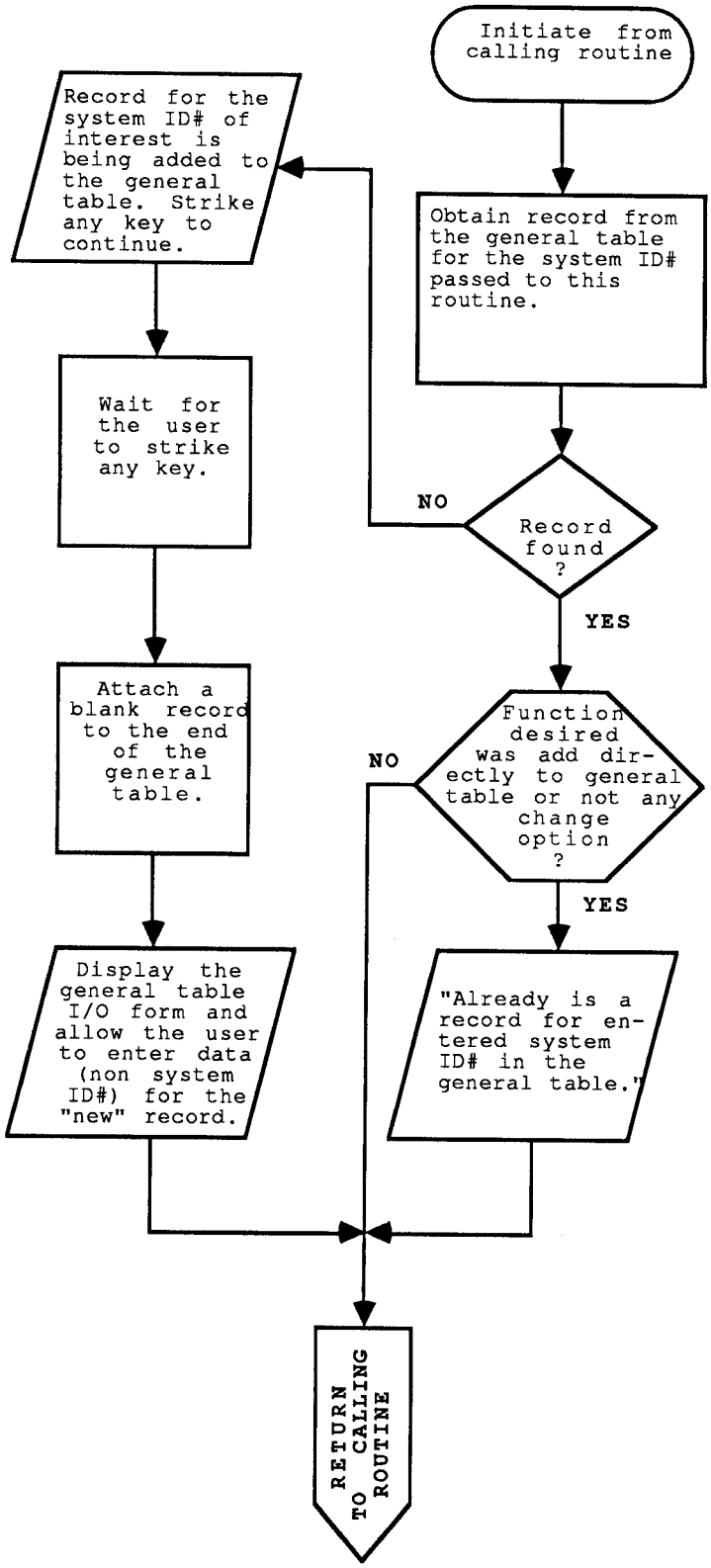
Vutab Flowchart



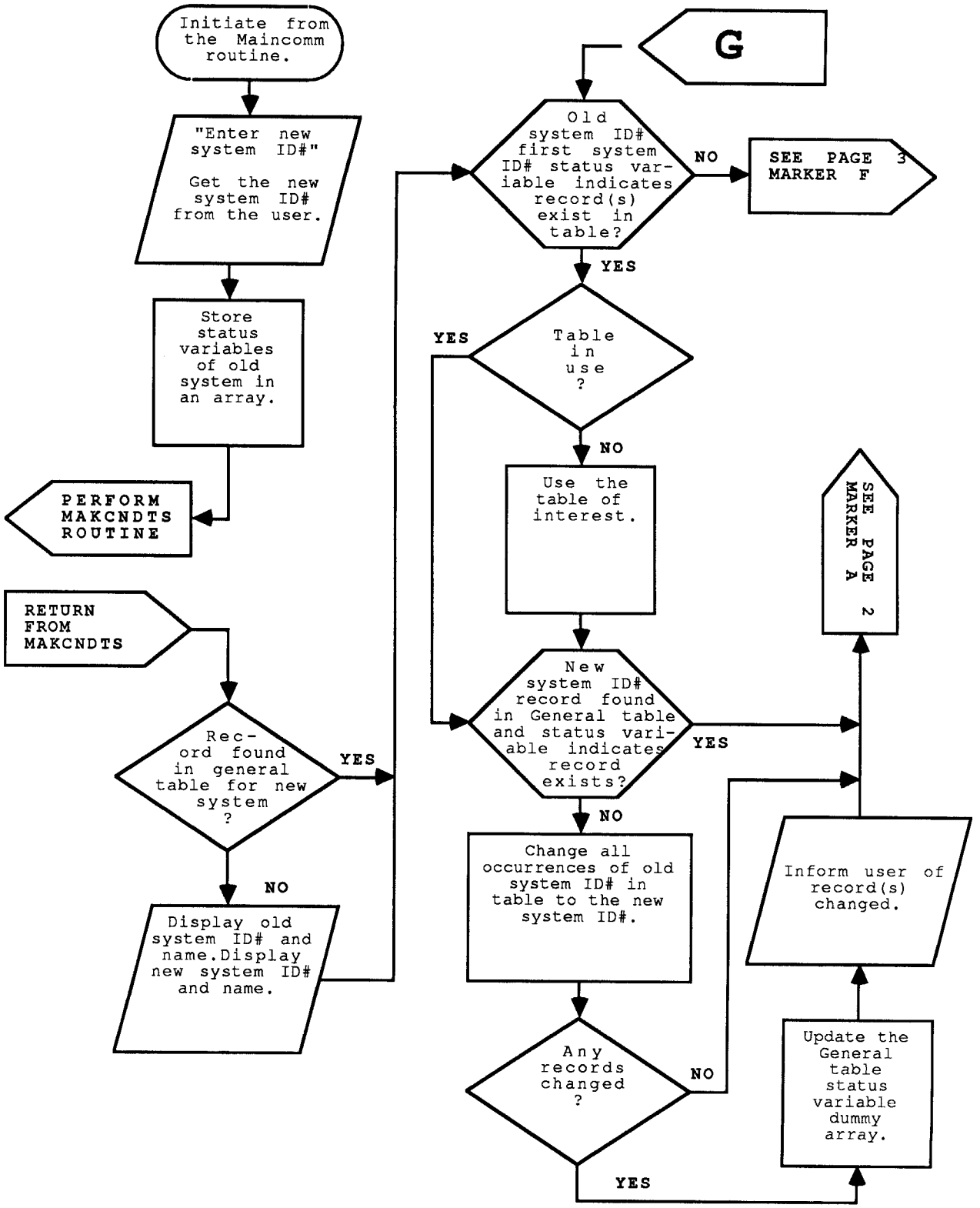
Vutab Flowchart



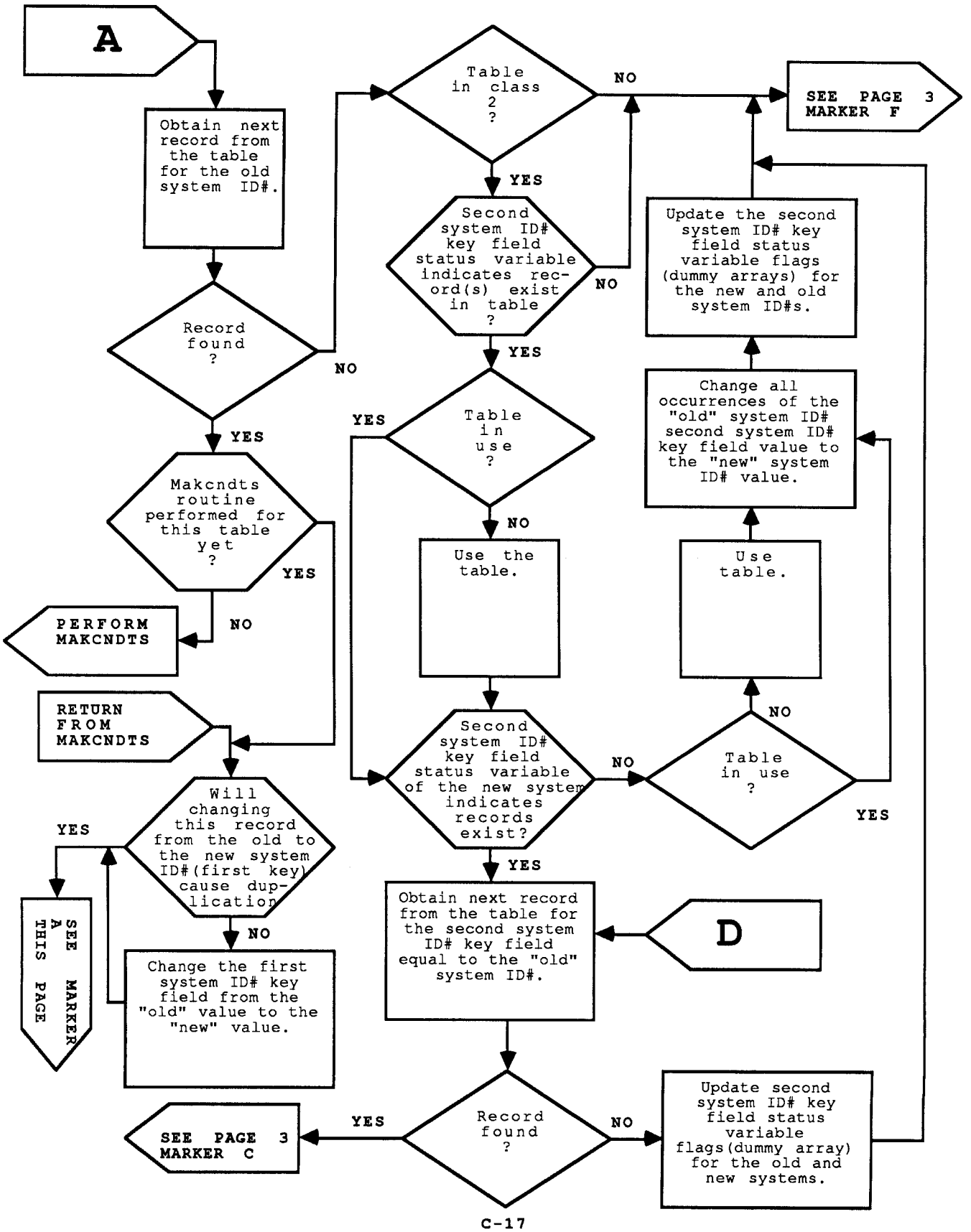
Addgenrl Flowchart



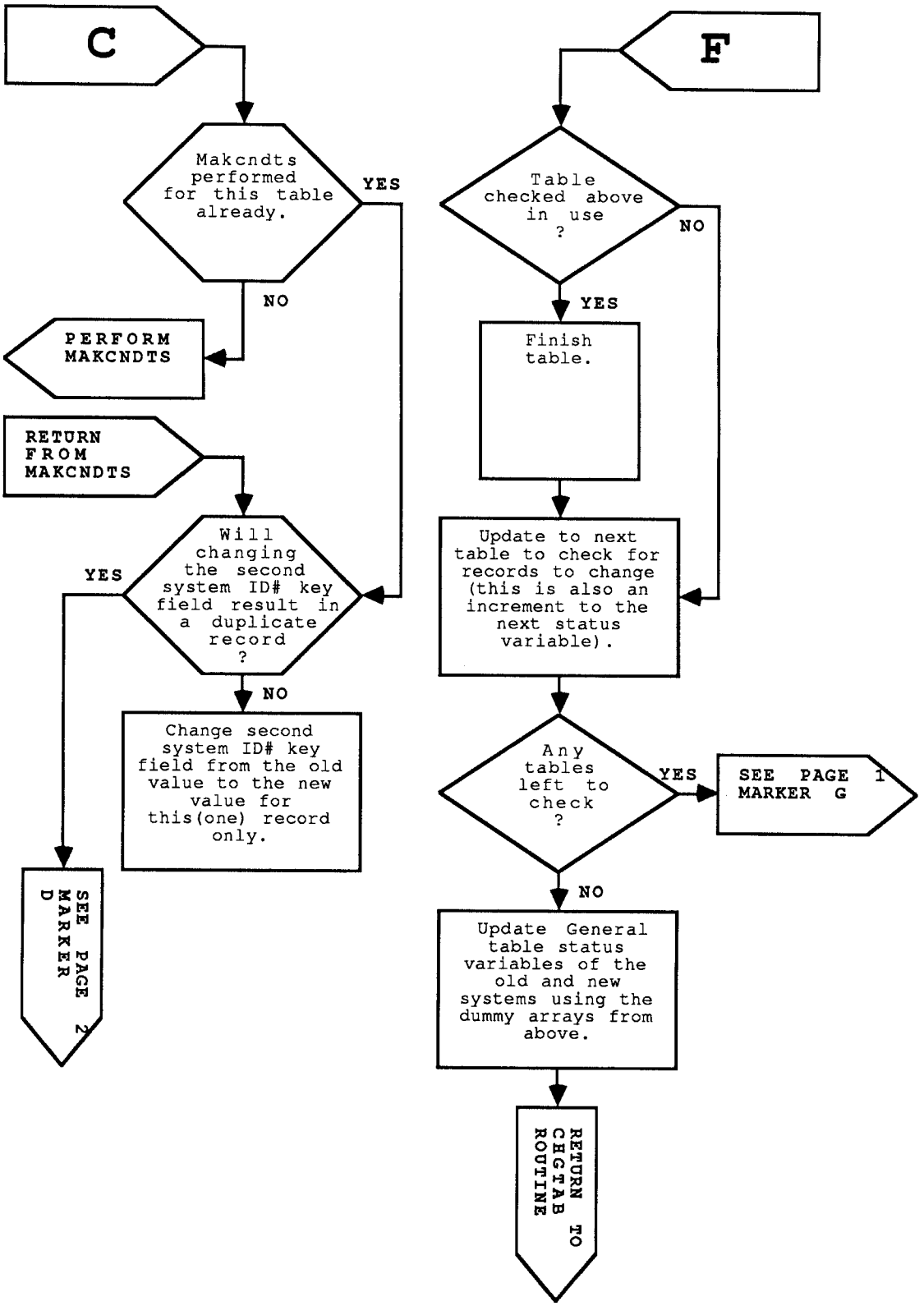
Chngenrl Flowchart



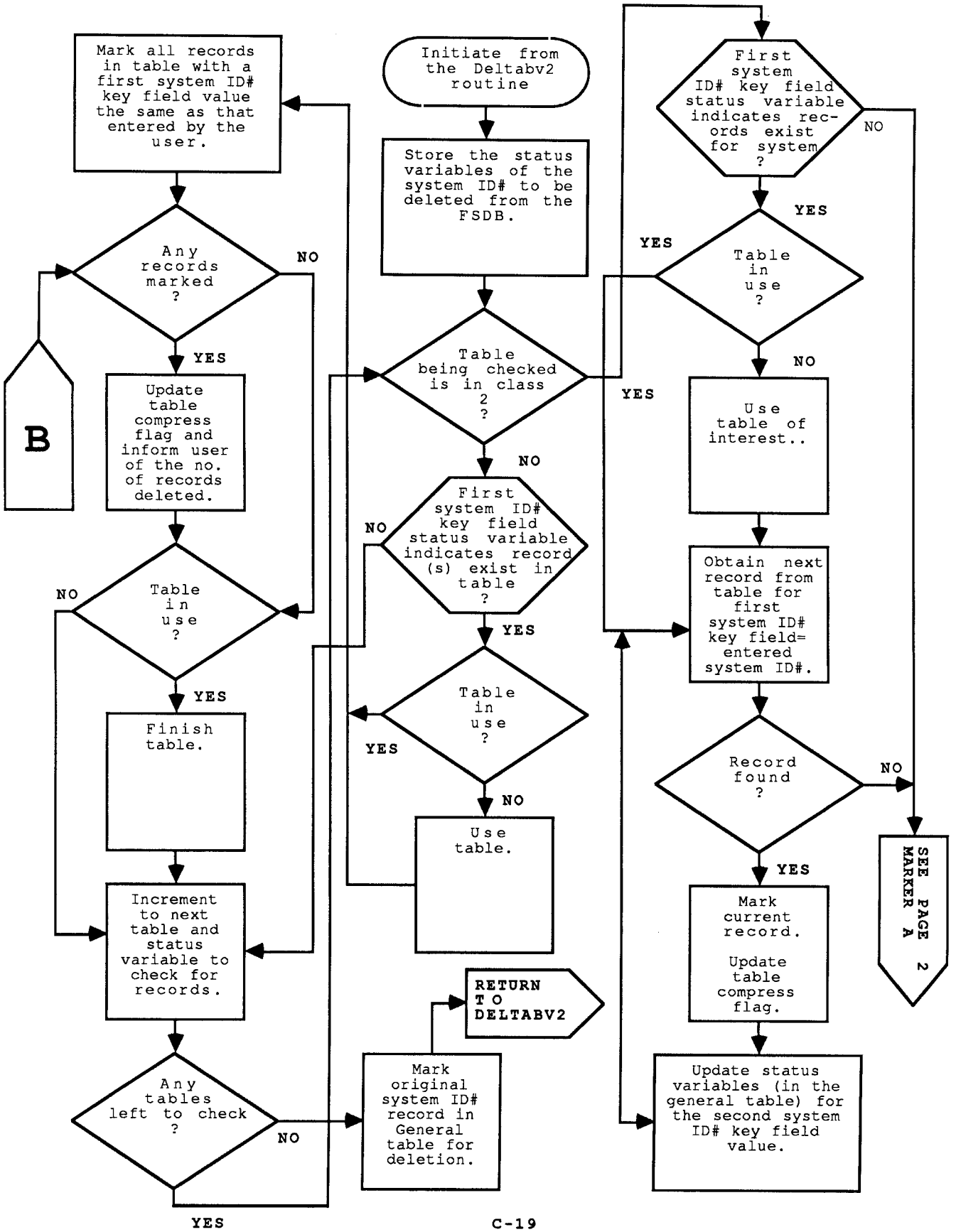
Chngenrl Flowchart



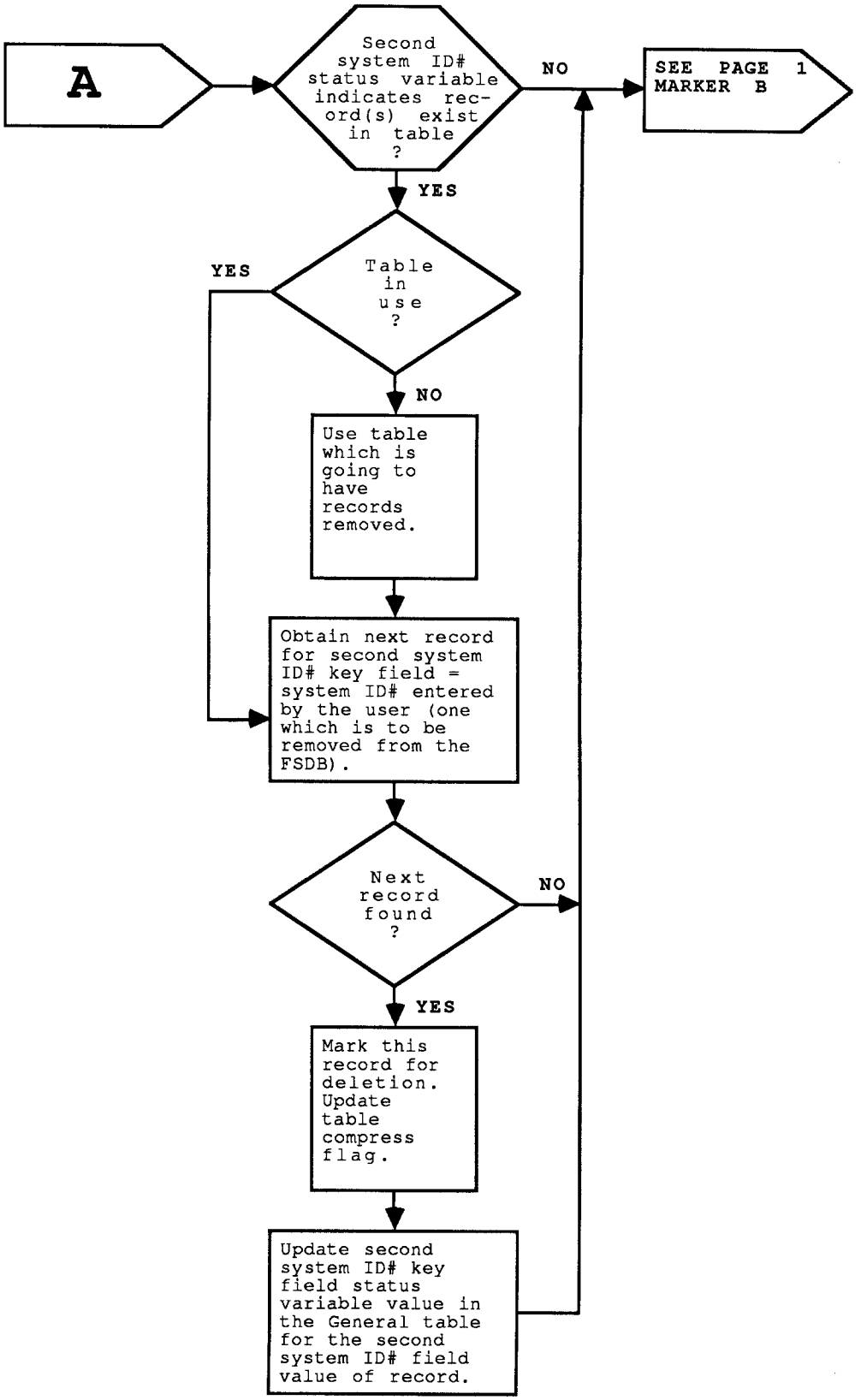
Chngenrl Flowchart



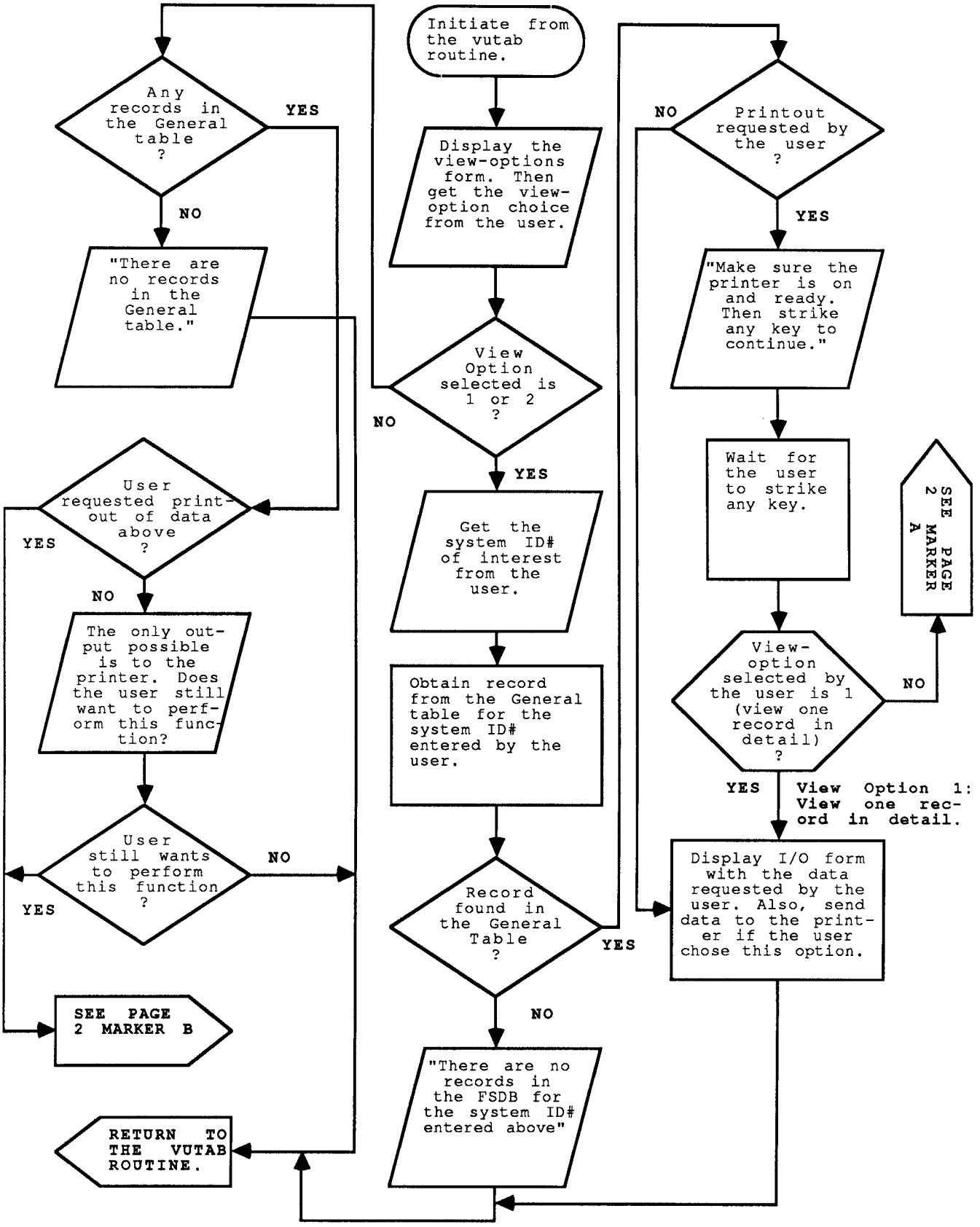
Delgenrl flowchart



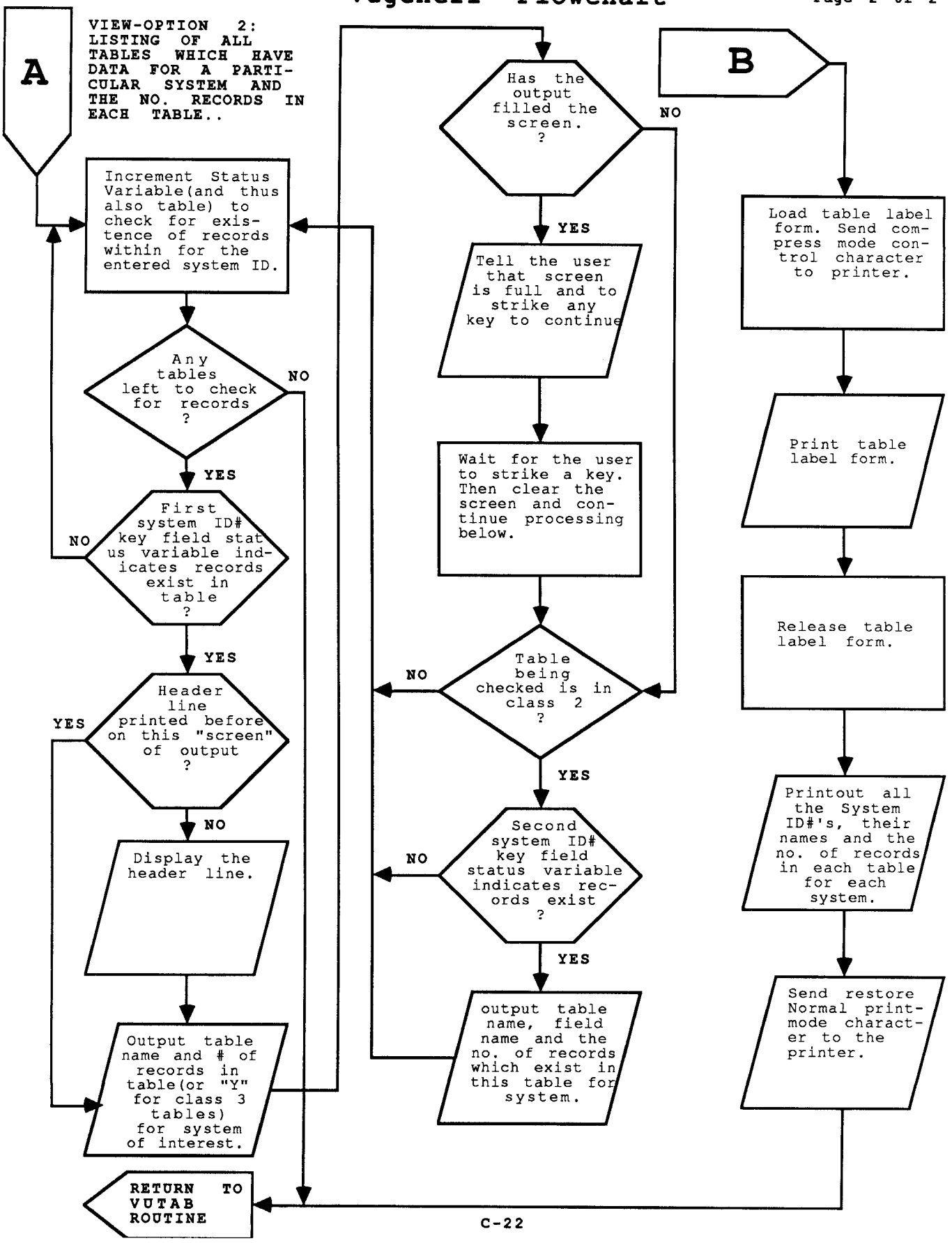
Delgenrl Flowchart



Vugenerl Flowchart



Vugenerl Flowchart



APPENDIX D

FIELDS OF EACH TABLE WHICH ARE DISPLAYED BY THE VIEW-OPTION CHOICES FOR EACH TABLE CLASS.

The MKSELCOM routine uses the arrays (initialized in the FUSIONDB procedure) to build command lines for use by the select command. This command line includes a listing of fields to be displayed, conditions on obtaining the desired data records and specification of fields to order by for ascending or descending display purposes (sort keys). Section D.1 describes the fields which will be displayed for the various table classes. Section D.2 indicates the order field names for each of the tables under different view-options.

D.1 View-All Option Selection

All the tables in logical classes 1-4 have the system ID# and system name (from the General table) listed in the View-all records option. In addition other fields are also displayed. These are listed below. Also, the displayed fields for tables of class 5 are listed.

D.1.1 Tables of Logical Classes 1-4

Table	Fields (in order of display other than the first ID# and name)
General	None
Systems	Subsysid
Functional	Inoutid#, Inoutnam, inoutrat
Geom & Comp	Geomflag, Draw#s, TotWeigh, Totwunit
Reliability	Failmode, Failtype, meanlamb

Common Mode	Id#causy, Fmod#cau, commodid, condprob
Burnin	Meanlamb, Stdevlam, Meanbeta, Stdevbet
Wearout	Meanlamb, Stdevlam, Meanbeta, Stdevbet
Rel. Scaling	Scaltype
Sched Maint.	Mainmod#, Manfreq, Tottime
Unsc. Maint.	Falmod#, Tottime
Timeline	Mantype, Mainmod#, Procid#, Procname
Spec. Equip.	Mode#, Mantype, Procid#, Eqpmntid
Testing	Testid#, Tprocid#, Procname
System Spares	Sparid#, Numspare
Operations	Procid#, Procname
Startup	Procid#, Procname
Shutdown	Procid#, Procname
Environmental	Envirid#, Enquanam, Envrunit
Economics	Aveoscc, Unitoscc, Costyear, Refyear
Econ. Scaling	Scaltype

Class 5 tables (nonsystem ID# key fields)

Table	List Fields (view-all option)
Labor Cost	Persid#, Persname, Avelcost, Unitcost, Refyear
Consumable	Matid#, Matname, Avecost, Costunit, Refyear

D.1.2 Class 2 Tables Special View Options Select Fields

The class 2 tables have two special view options related to multiple record viewing. The first is viewing all the records in the table for a particular first system ID# key field value. The next option is viewing all

the records in the table for a particular second system ID# key field value.

Class 2 view all for a particular first system ID# select fields

Table	Select Fields (other than the second system ID# key field and its name from the General table)
Systems	None
Common Mode	Fmod#cau, Commodid, Condprob
Spec. Eqpt.	Mode#, Mantype, Procid#, Eqptnum
System Spare	Numspare

Class 2 view all for a particular second system ID#, select fields

Table	Select Fields (other than the first system ID# key field and its name from the General table)
Systems	Sysid#, sysname
Commodel	Fmod#cau, Commodid, Condprob
Spec. Eqpt.	Mode#, Mantype, Procid#
System Spare	Numspare

D.1.3 Class 4 Tables (One System ID# Key Field)

These tables have one special view option other than the view-all option. However, the key fields which are used in the select command are the same for both with one exception. Under this view option, the first system ID# key field and its name (from the General table) are not listed. Therefore, see above (under the view-all options select field listings) for the select fields.

D.2 Order by Field List

When displaying data using the KMAN select command, it is possible to specify a sorting key and order (ascending or descending). This makes the output more easy to interpret. The list of the sorting keys for the tables and the different view-options can be found below. Note that all sorting is done from lowest to highest (ascending).

D.2.1 View-All Option Sort Fields

Table	Field Name
General	Sysid#
Systems	Sysid#
Functional	Sysid#
Geom & Comp	None
Reliability	Sysid#, Failmode
Common Mode	Sysid#, ID#causy, Fmod#cau, Commodid
Burnin	None
Wearout	None
Rel. Scal.	Sysid#
Sched. Maint.	Sysid#, Mainmod#
Unsch. Maint.	Sysid#, Failmode
Timeline	Sysid#, Mainmod#, Procid#
Special Eqpt.	Sysid#, Mode#, Procid#
Testing	Sysid#, Testid#, Tprocid#
System Spares	Sysid#
Operations	Sysid#
Startup	Sysid#
Shutdown	Sysid#

Environmental	None
Labor cost	None
Economics	Sysid#
Consumable	None
Econom. Scal.	Sysid#

D.2.2 View-All Records for a Particular System (Applies to Class 2 and 4 Tables Only)

Table	Order by Field(s)
Systems	Subsysid
Functional	Inoutid#
Reliability	Failmode
Common Mode	ID#causy, Fmod#caus
Reli. Scalng.	Scaltype
Sched. Maint.	Mainmod#
Unsc. Maint.	Failmod#
Timeline	Mainmod#, Procid#
Spec. Eqpt.	Mode#, Mantyp, Procid#
Testing	Testid#, Tprocid#
System Spare	Sparid#
Operations	Procid#
Startup	Procid#
Shutdown	Procid#
Econom. Scal.	Scaltype

D.2.3 View-All First System ID# Records for a Given Second System ID# Key Field Value)

For Class 2 Tables only.

Table	Order by Fields
Systems	Sysid#
Common Mode	Sysid#, Fmod#causy, commodid
Spec. Eqpt.	Sysid#, Mode#, Mantyp, Procid#
System Spares	Sysid#

APPENDIX E

FSDB (FUSION SYSTEMS DATABASE) TABLE DEFINITIONS

TABLE 1. GENERAL TABLE

1.	SYSTEM NAME	str 20
2.	SYSTEM ID	str 10
3.	CONCISE SYSTEM DESCRIPTION	str 60
4.	PHYSICAL DESCRIPTION	
	a. Overall description	
	i) length	num 10
	unit	str 10
	ii) width	num 10
	unit	str 10
	iii) height	num 10
	unit	str 10
	b. Overall weight	num 10
	unit	str 10
	c. Material composition	str 60
	d. Manufacturer	str 20
5.	SUBSYSTEMS OF THIS SYSTEM(1)	str 120
6.	PRIMARY INPUT	
	a. Input name	str 20
	b. Design point value	num 10
	unit	str 10
7.	PRIMARY OUTPUT	
	a. Output name	str 20
	b. Design point value	num 10
	unit	str 10
8.	REFERENCE GROUP NUMBERS(2)	str 16
9.	ENVIRONMENTAL CONDITION(3)	str 60
10.	STATUS VARIABLES (26)(4)	
	a. String Type ("Y" or " ")	str 1
	b. Number Type (1-1000)	num 3
11.	COMMENT ID#	num 10
12.	REFERENCE ID#	num 10
13.	DATE OF LAST UPDATE	str 8

---

(1) Names of subsystems at one level below the current system in the hierarchical structure of the system.
(2) Table group numbers (2-9) where data on this system has been compiled.
(3) Environmental conditions under which the system is normally operated.
(4) There are 26 status variables indicating the number of records existing in each table for this system.

TABLE 2. SYSTEMS TABLE

1.	SYSTEM ID	str 10
2.	SUBSYSTEM ID	str 10
3.	MULTIPLE IDENTICAL SUBSYSTEM ID#(1)	num 2
4.	NUMBER OF INPUTS FROM OTHER SYSTEMS	num 3
5.	NUMBER OF OUTPUTS TO OTHER SYSTEMS	num 3
6.	INPUT/OUTPUT CONNECTIONS(2)	str 120
7.	COMMENTS ID#	num 10
8.	REFERENCE ID#	num 10
9.	DATE OF LAST UPDATE	str 8

(1) This field distinguishes between two identical subsystems of the same system.
(2) This field consists of space for 10 inputs/outputs to this subsystem from other subsystems on the same level. The data format is as follows: I/O ID#, system connected to ID#, multiple identical subsystem id ... (repeat 10 times).

TABLE 3. FUNCTIONAL TABLE

1.	OVER-SYSTEM ID#	str 10
2.	SYSTEM ID	str 10
3.	MULTIPLE IDENTICAL SUBSYSTEM ID#	num 2
4.	I/O ID(1)	str 3
5.	NAME OF I/O QUANTITY	str 20
6.	RATE OF I/O (DC VALUE)	num 10
	UNITS	str 10
	MINIMUM VALUE	num 10
	MAXIMUM VALUE	num 10
7.	COMMENT ID#	num 10
8.	REFERENCE ID#	num 10
9.	DATE OF LAST UPDATE	str 8

(1) for input, I01, I02, etc.
for output, 001, 002, etc.
for control, C01, C02, etc.

TABLE 4. GEOMETRY AND COMPOSITION TABLE

1.	SYSTEM ID	str 10
2.	GEOMETRY	
	a. flag for computer graphics availability	str 1
	b. reference numbers for drawing	str 20
3.	MATERIAL COMPOSITION (weight percent)	str 120
4.	TOTAL WEIGHT	num 10
	UNITS	str 10
5.	COMMENT ID#	num 10
6.	REFERENCE ID#	num 10
7.	DATE OF LAST UPDATE	str 8

TABLE 5. OPERATION TABLE

1.	SYSTEM ID	num 10
2.	PROCEDURE NAME	str 20
3.	PROCEDURE ID	num 3
4.	FLAG FOR EQUIPMENT & PERSONNEL TABLE	str 1
5.	COMMENT ID#	num 10
6.	REFERENCE ID#	num 10
7.	DATE OF LAST UPDATE	str 8

TABLE 6. STARTUP PROCEDURE TABLE

1.	SYSTEM ID	str 10
2.	PROCEDURE ID	num 3
3.	PROCEDURE NAME	str 30
4.	PROCEDURE START TIM	num 10
5.	AVERAGE DURATION	num 10
6.	UNITS ON PROCEDURE TIME	str 10
7.	FLAG FOR EQUIPMENT & PERSONNEL TABLE	str 1
8.	COMMENT ID#	num 10
10.	DATE OF LAST UPDATE	str 8

TABLE 7. SHUTDOWN PROCEDURE TABLE

1.	SYSTEM ID	str 10
2.	PROCEDURE ID	num 3
3.	PROCEDURE NAME	str 30
4.	PROCEDURE START TIME	num 10
5.	AVERAGE DURATION	num 10
6.	UNITS ON PROCEDURE TIME	str 10
7.	FLAG FOR EQUIPMENT & PERSONNEL TABLE	str 1
8.	COMMENT ID#	num 10
9.	REFERENCE ID#	num 10
10.	DATE OF LAST UPDATE	str 8

TABLE 8. ENVIRONMENTAL TABLE

1.	SYSTEM ID	str 10
2.	ENVIRONMENTAL PARAMETER ID	str 5
3.	NAME OF ENVIRONMENT QUANTITY	str 20
4.	UNITS	str 15
5.	RANGES	str 60
6.	COMMENT ID#	num 10
7.	REFERENCE ID#	num 10
8.	DATE OF LAST UPDATE	str 8

TABLE 9. EQUIPMENT AND PERSONNEL TABLE

1.	SYSTEM ID	str 10
2.	TYPE(1)	num 1
3.	MODE ID(2)	num 3
4.	PROCEDURE ID	num 3
5.	EQUIPMENT/PERSONNEL ID	str 10
6.	NUMBER OF THE EQUIPMENT/PERSONNEL	num 3
7.	COMMENT ID#	num 10
8.	REFERENCE ID#	num 10
9.	DATE OF LAST UPDATE	str 8

(1) 1 for operation
2 for startup
3 for shutdown
4 for scheduled maintenance
5 for unscheduled maintenance
6 for testing

(2) maintenance mode ID for type 4
failure mode ID for types 5 and 6
0 for types 1, 2, and 3

TABLE 10. RELIABILITY TABLE

1.	SYSTEM ID	str 10
2.	FAILURE MODE NAME	str 20
3.	FAILURE MODE ID	num 2
4.	FAILURE TYPE(1)	num 1
5.	STEADY-STATE FAILURE RATE DISTRIBUTION	
	a. mean of λ	num 13
	b. standard deviation of λ (%)	num 4
	c. maturity age, T_1	num 7
	d. lifetime, T_2	num 7
6.	FLAG FOR COMMON MODE FAILURE TABLE	str 1 (Y or N)
7.	FLAG FOR RELIABILITY SCALING LAW TABLE	str 1
8.	COMMENT ID#	num 10
9.	REFERENCE ID#	num 10
10.	DATE OF LAST UPDATE	str 8

(1) 1 for startup
2 for shutdown
3 for steady-state or continuous operation
4 for demand
5 for residual
6 for other (specify in comments)

TABLE 11. COMMON MODE FAILURE TABLE

1.	SYSTEM ID	str 10
2.	FAILURE MODE ID#	num 2
3.	CAUSING SYSTEM ID	num 10
4.	FAILURE MODE ID OF CAUSING SYSTEM	num 2
5.	COMMON MODE ID FOR THIS FAILURE	num 2
6.	CONDITIONAL PROBABILITY	num 6
7.	COMMENT ID#	num 10
8.	REFERENCE ID#	num 10
9.	DATE OF LAST UPDATE	str 8

TABLE 12. BURN-IN TABLE

1.	SYSTEM ID	str 10
2.	FAILURE MODE ID#	num 2
3.	MEAN OF LAMBDA	num 13
	STANDARD DEVIATION (%)	num 4
4.	MEAN OF BETA	num 13
	STANDARD DEVIATION (%)	num 4
5.	COMMENT ID#	num 10
6.	REFERENCE ID#	num 10
7.	DATE OF LAST UPDATE	str 8

TABLE 13. WEAR-OUT TABLE

1.	SYSTEM ID	str 10
2.	FAILURE MODE ID#	num 2
3.	MEAN OF LAMBDA	num 13
	STANDARD DEVIATION (%)	num 4
4.	MEAN OF BETA	num 13
	STANDARD DEVIATION (%)	num 4
5.	COMMENT ID#	num 10
6.	REFERENCE ID#	num 10
7.	DATE OF LAST UPDATE	str 8

TABLE 14. RELIABILITY SCALING LAW TABLE

1.	SYSTEM ID	str 10
2.	FAILURE MODE ID#	num 2
3.	SCALING LAW TYPE(1)	num 1
4.	A VALUE	num 10
5.	UNIT OF A	str 10
6.	B VALUE	num 10
7.	UNIT OF B	str 10
8.	C VALUE	num 10
9.	UNIT OF C	str 10
10.	D VALUE	num 10
11.	UNIT OF D	str 10
12.	DEFINITION OF X (INCLUDES UNIT)	str 20
13.	RANGE OF X VARIABLE(2)	str 20
14.	DEFINITION OF Y (INCLUDES UNIT)	str 20
15.	RANGE OF Y VARIABLE(2)	str 20
16.	COMMENT ID#	num 10
17.	REFERENCE ID#	num 10
18.	DATE OF LAST UPDATE	str 8

(1) 1 for the formula given by Eq. (3.2)
2 for the formula given by Eq. (3.3)
(2) Ranges of x and y variables for which the given formulas are true.

TABLE 15. SPARE PARTS TABLE

1.	SYSTEM ID	str 10
2.	SPARE ID	str 8
3.	QUANTITY OF SPARE	num 3
4.	COMMENT ID#	num 10
5.	REFERENCE ID#	num 10
6.	DATE OF LAST UPDATE	num 10

TABLE 16. SCHEDULED MAINTENANCE TABLE

1.	SYSTEM ID	str 10
2.	SCHEDULED MAINTENANCE NAME	str 20
3.	MAINTENANCE MODE ID	num 3
4.	FREQUENCY(1)	str 20
5.	STATE OF SYSTEM DURING MAINTENANCE	num 3
6.	TOTAL TIME IN HOURS	num 5
	DISTRIBUTION FLAG(2)	str 1
	STANDARD DEVIATION (%)	num 2
7.	FLAG FOR TIMELINE TABLE	str 1
8.	SPECIAL EQUIPMENT FLAG	str 1
9.	COMMENT ID#	num 10
10.	REFERENCE ID#	num 10
11.	DATE OF LAST UPDATE	str 8

(1) The unit is per year.
(2) 0 for random distribution
1 for log normal
2 for normal

TABLE 17. UNSCHEDULED MAINTENANCE TABLE

1.	SYSTEM ID#	str 10
2.	FAILURE MODE ID	num 3
3.	FAILURE MODE NAM	str 20
4.	TOTAL TIME IN HOURS	num 5
	DISTRIBUTION FLAG(1)	num 1
	STANDARD DISTRIBUTION	num 1
5.	FLAG FOR TIMELINE TABLE	str 1
6.	COMMENT ID#	num 10
7.	REFERENCE ID#	num 10
8.	DATE OF LAST UPDATE	str 8

(1) 0 for random distribution
1 for log normal
2 for normal

TABLE 18. MAINTENANCE TIMELINE TABLE

1.	SYSTEM ID	str 10
2.	TYPE OF MAINTENANCE(1)	num 1
3.	MAINTENANCE/FAILURE MODE ID	num 3
4.	PROCEDURE ID	num 3
5.	PROCEDURE DESCRIPTION	str 60
6.	START TIME(2)	num 6
7.	DURATION IN HOURS	num 6
	FLAG OF DISTRIBUTION	num 1
	STANDARD DEVIATION (%)	num 4
8.	TESTING MODE ID(3)	num 3
9.	TESTING START TIME(4)	num 1
10.	FLAG FOR EQUIPMENT & PERSONNEL TABLE	str 1
11.	COMMENT ID#	num 10
12.	REFERENCE ID#	num 10
13.	DATE OF LAST UPDATE	str 8

(1) S for scheduled maintenance
U for unscheduled maintenance
(2) Hours
(3) If this field is 0, no testing is performed for this maintenance procedure
(4) 1 for testing at the beginning of this procedure
2 for testing at the end of this procedure

TABLE 19. TESTING TABLE

1.	SYSTEM ID	str 10
2.	TESTING MODE(1)	str 60
3.	TESTING MODE ID	num 3
4.	PROCEDURE ID#	num 3
5.	PROCEDURE DESCRIPTION	str 60
6.	PROCEDURE DURATION	num 10
	UNIT	str 5
7.	NEXT ACTION(3)	str 50
8.	COMMENT ID#	num 10
9.	REFERENCE ID#	num 10
10.	DATE OF LAST UPDATE	str 8

(1) This describes which test is performed.
(2) Total number of procedures of this testing.
(3) This indicates what the next action is if a failure is detected during this testing procedure. The data may be system ID number and unscheduled mode ID so that a specific repair mode is specified.

TABLE 20. ECONOMIC TABLE

1.	SYSTEM ID		str 10
2.	CAPITAL COST (constant dollars)		
	a. Off-shelf	average	num 13
		unit	str 5
		minimum	num 13
		maximum	num 13
	b. Installation	average	num 13
		unit	str 5
		minimum	num 13
		maximum	num 13
3.	COST SCALING LAW TABLE FLAG		str 1
4.	REFERENCE YEAR DOLLARS		num 4
5.	COMMENT ID#		num 10
6.	REFERENCE ID#		num 10
7.	DATE OF LAST UPDATE		str 8

TABLE 21. CONSUMABLE MATERIAL TABLE

1.	MATERIAL NAME	str 20
2.	MATERIAL ID	str 10
3.	COST	
	a. Average	num 13
	Unit	str 5
	b. Minimum	num 13
	c. Maximum	num 13
4.	FLAG FOR COST SCALING LAW TABLE	str 1
5.	REFERENCE YEAR DOLLARS	num 4
6.	COMMENT ID#	num 10
7.	REFERENCE ID#	num 10
8.	DATE OF LAST UPDATE	str 8

TABLE 22. LABOR COST TABLE

1.	PERSONNEL TYPE	str 20
2.	PERSONNEL ID	str 10
3.	TYPE OF WORK	str 60
4.	LABOR COST - average	num 10
	- unit	str 10
	- minimum	num 10
	- maximum	num 10
5.	REFERENCE DOLLAR YEAR	num 4
6.	COMMENT ID#	num 10
7.	REFERENCE ID#	num 10
8.	DATE OF LAST UPDATE	str 8

TABLE 23. COST SCALING LAW TABLE

1.	SYSTEM ID	str 10
2.	SCALING LAW TYPE(1)	num 1
3.	A VALUE	num 10
4.	UNIT OF A	str 10
5.	B VALUE	num 10
6.	UNIT OF B	str 10
7.	C VALUE	num 10
8.	UNIT OF C	str 10
9.	D VALUE	num 10
10.	UNIT OF D	str 10
11.	DEFINITION OF X (INCLUDES UNIT)	str 20
12.	RANGE OF X VARIABLE(2)	str 20
13.	DEFINITION OF Y (INCLUDES UNIT)	str 20
14.	RANGE OF Y VARIABLE(2)	str 20
15.	COMMENT ID#	num 10
16.	REFERENCE ID#	num 10
17.	DATE OF LAST UPDATE	str 8

(1) 1 for the formula given by Eq. (3.4)
2 for the formula given by Eq. (3.5)
(2) ranges of x and y variables for which the given formulas are true.

TABLE 24. REFERENCE TABLE

1.	REFERENCE ID#	num 10
2.	REFERENCE ORDER NUMBER	num 2
3.	AUTHORS	str 60
4.	TITLE	str 60
5.	NAME OF PUBLICATION	str 60
6.	DATE OF PUBLICATION	num 6
7.	VOLUME	num 5
8.	PAGE NUMBERS	str 12
9.	DATE OF LAST UPDATE	str 8

TABLE 25. COMMENTS TABLE

1.	COMMENT ID#	num 10
2.	COMMENT ORDER NUMBER	num 2
3.	COMMENT STATEMENT	str 60
4.	DATE OF LAST UPDATE	str 8

TABLE 26. COMREFNO TABLE

1.	NEXTCOMM	num 10
2.	NEXTREFER	num 10